O’ZBEKISTON RESPUBLIKASI OLIY VA O’RTA
MAXSUS TA`LIM VAZIRLIGI

NAMANGAN MUXANDISLIK-TEXNOLOGIYA
INSTITUTI

S.S.QAXAROV I.T.RAJAPOV

ELEKTROTEXNIKA, ELEKTRONIKA VA

ELEKTR YURITMALARI FANIDAN

XISOB KITOB GRAFIK ISHLARINI BAJARISH BO’YICHA

УСЛУБИЙ КЎРСАТМА

Namangan - 2016

Mazkur uslubiy ko’rsatma «Elektrotexnika, elektronika va elektr yuritmalari» kursining dasturiga muvofiq yozildi.

Ko’rsatmada ayni kursga oid o’zgarmas tok zanjirlari, bir fazali o’zgaruvchan tok zanjirlari, uch fazali tok zanjirlari bo’limidan mustaqil va amaliy ishlarni o’tkazish uslubi, ularning mazmuni va bajarilish tartibi va xisoblash formulalari berildi.

Tuzuvchilar: dos. S.Qaxarov
k.oq. I.Rajapov

Taqrizchilar: fizika-matematika f.-doktori
Usmanov Pazliddin Nuriddinovich
fizika-matematika f.-n., dotsent
Qo’chqarov Xoshimjon Ortiqovich

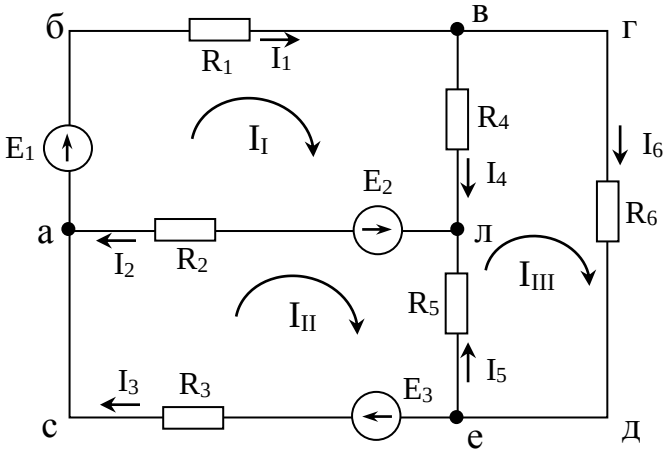
Ushbu uslubiy qo’llanma “Fizika” kafedrasi professor-o’qituvchilarining yig’ilishida muxokama qilingan va chop etishga tavsiya etilgan
(2016 yil _____, ____-sonli bayonnoma).

Uslubiy qo’llanma institut o’quv-uslubiy kengashida muxokama qilingan va chop etishga tavsiya etilgan (2016 yil _____, _____-sonli bayonnoma).

1- Masala.

1 - rasmdagi murakkab zanjir uchun quyidagilar berilgan:

E_1=72 V; E_2=12 V; E_3=4 V; r_1=6 Om; r_2=1 Om; r_3=10 Om; r_4=4 Om; r_5=12 Om; r_6=4 Om. Energiya manbalarining ichki qarshiliklari e`tiborga olinmasin.



1 – rasm.

Bu berilgan qiymatlar asosida quyidagilar bajarilsin:

1. Kirxgofning birinchi va ikkinchi qonunlari asosida tarmoq toklarini aniqlash uchun zarur bo'lgan tenglamalar sistemasini tuzing.
2. Kontur toklar usulidan foydalanib elektr sxemasidagi xama toklar aniqlansin.
3. Quvvatlar balansin xisoblansin.
4. Tashqi kontur uchun masshtabda zanjirning ayrim nuqtalarida potensiallar taqsimlanishi xisoblansin va **a** nuqtaning potensialini nol deb olib, zanjir uchun potensiallar diagrammasi qurilsin.

Masalaning echilishi:

1. Berilgan murakkab zanjirda uchta kontur, ya`ni I (abvl), II (ales), III (vgdel) konturlar va to'rtta tugun – *a, v, l, e* bor. Aniqlanuvchi toklar – I_1, I_2, I_3, I_4, I_5, I_6.

Avvalo, xar bir konturda kontur toklari - I_I, I_{II}, I_{III} ning yo'nalishini ixtiyoriy ko'rsatamiz. Kirxgofning I – qonuni asosida tugunlar uchun tugunlar sonidan bitta kam tenglamalar tuzamiz:

a tugun uchun: $I_2 + I_3 – I_1 = 0$;

v tugun uchun: $I_1 – I_4 – I_6 = 0$;

e tugun uchun: $I_6 – I_5 – I_3 = 0$;

Kirxgofning II – qonuni asosida xar bir kontur uchun tenglamalar tuzamiz:

I – kontur uchun: $E_1 – E_2 = I_1 \cdot R_1 + I_4 \cdot R_4 + I_2 \cdot R_2$ (1)

II – kontur uchun: $E_2 + E_3 = I_3 \cdot R_3 – I_2 \cdot R_2 – I_5 \cdot R_5$ (2)

III – kontur uchun: $0 = I_5 \cdot R_5 + I_6 \cdot R_6 – I_4 \cdot R_4$ (3)

2. Kontur toklar usulidan foydalanib tarmoqdagi barcha toklarni aniqlaymiz:

Bunda tarmokdagi barcha toklar yuq, konturdan faqat bita kontur toki o'tadi deb faraz kilinadi.

Kirxgofning II – qonuni asosida xar bir kontur uchun tenglamalar tuzamiz:

I – kontur uchun: $E_1 – E_2 = I_I \cdot (R_1 + R_4 + R_2) – I_{II} \cdot R_2 – I_{III} \cdot R_4$ (4)

II – kontur uchun: $E_2 + E_3 = I_{II} \cdot (R_2 + R_5 + R_3) – I_I \cdot R_2 – I_{III} \cdot R_5$ (5)

III – kontur uchun: $0 = I_{III} \cdot (R_4 + R_5 + R_6) – I_I \cdot R_4 – I_{II} \cdot R_5$ (6)

Endi, masalaning shartida berilganlarni (4), (5) va (6) tenglamalarga qo'yamiz:

$72 – 12 = I_I \cdot (6 + 4 + 1) – I_{II} \cdot 1 – I_{III} \cdot 4$ (4^I)

$12 + 4 = I_{II} \cdot (1+10+12) – I_I \cdot 1 – I_{III} \cdot 12$ (5^I)

$0 = I_{III} \cdot (4 + 12 + 4) – I_I \cdot 4 – I_{II} \cdot 12$ (6^I)

(4^I), (5^I), (6^I) larni ixchamlashtirib, quydagi tenglamalar sistemasini xosil qilamiz:

$60 = 11 \cdot I_I – I_{II} – 4 \cdot I_{III}$ (4^{II})

$16 = – I_I + 23 \cdot I_{II} – 12 \cdot I_{III}$ (5^{II})

$0 = – 4 \cdot I_I – 12 \cdot I_{II} + 20 \cdot I_{III}$ (6^{II})

(4 ^{II}), (5 ^{II}) va (6 ^{II}) lar uch noma`lumli uchta tenglamalar sistemasidir. Bu tenglamalar sistemasini determinant usulidan foydalanib echamiz:

Unda

$$\Delta = \begin{vmatrix} 11 & -1 & -4 \\ -1 & 23 & -12 \\ -4 & -12 & 20 \end{vmatrix} = 11\cdot 23\cdot 20 + (-1)\cdot(-12)\cdot(-4) + (-1)\cdot(-12)\cdot(-4) -$$

$$-(-4)\cdot(-4)\cdot 23 - (-12)\cdot(-12)\cdot 11 - (-1)\cdot(-1)\cdot 20 = 5060 - 48 - 48 -$$

$$-368 - 1584 - 20 = 2992$$

$$\Delta_I = \begin{vmatrix} 60 & -1 & -4 \\ 16 & 23 & -12 \\ 0 & -12 & 20 \end{vmatrix} = 60\cdot 23\cdot 20 + (-1)\cdot(-12)\cdot 0 + (-4)\cdot 16\cdot(-12) -$$

$$-(-4)\cdot 23\cdot 0 - 60\cdot(-12)\cdot(-12) - (-1)\cdot 16\cdot 20 = 27600+0+768+0 -$$

$$-8640 + 320 = 20048.$$

$$\Delta_{II} = \begin{vmatrix} 11 & 60 & -4 \\ -1 & 16 & -12 \\ -4 & 0 & 20 \end{vmatrix} = 11\cdot 16\cdot 20 + 60\cdot(-12)\cdot(-4) + (-4)\cdot(-1)\cdot 0 - \quad -(-4)\cdot 16\cdot(-4) - (11)\cdot(-$$

$$12)\cdot 0 - 60\cdot(-1)\cdot 20 = 3520 + 2880 + 0 - \quad -256 - 0 + 1200 = 7344.$$

$$\Delta_{III} = \begin{vmatrix} 11 & -1 & 60 \\ -1 & 23 & 16 \\ -4 & -12 & 0 \end{vmatrix} = 11\cdot 23\cdot 0 + (-1)\cdot 16\cdot(-4) + 60\cdot(-1)\cdot(-12) - \quad -60\cdot 23\cdot(-4) - 11\cdot 16\cdot(-$$

$$12) - (-1)\cdot(-1)\cdot 0 = 0 + 64 + 720 + 5520 + 2112 - 0 = 8416$$

Kontur toklarining qiymatlari:

$$I_I = \frac{\Delta_I}{\Delta} = \frac{20048}{2992} = 6{,}7 \text{ A}; \qquad I_{II} = \frac{\Delta_{II}}{\Delta} = \frac{7344}{2992} = 2{,}46 \text{ A}.$$

$$I_{III} = \frac{\Delta_{III}}{\Delta} = \frac{8416}{2992} = 2{,}8 \text{ A} \quad \text{bo'ladi.}$$

Endi xaqiqiy I_1, I_2, I_3, I_4, I_5 va I_6 toklarini aniqlaymiz:

konturning tashqarisidagi qarshiliklar (R_1, R_6, R_3) dan o'tayotgan tok kuchlari (I_1, I_6, I_3) o'sha kontur toklariga teng bo'ladi;

konturning abv qismidan faqat I_I kontur toki o'tadi va bu tok zanjirning shu qismidan o'tayotgan xaqiqiy I_1 tokiga teng bo'ladi, ya`ni $I_I = I_1 = 6{,}7$ A. Xuddi shunday II va III - kontur toklari $I_{II} = I_3 = 2{,}45$ A; $I_{III} = I_6 = 2{,}8$ A bo'ladi. Qolgan $I_2$, $I_4$, $I_5$ toklari Kirxgofning I – qonuni asosida aniqlanadi, ya`ni:

$I_2 = I_I - I_{II} = 6{,}7 - 2{,}45 = 4{,}25$ A.

$I_4 = I_I - I_{III} = 6{,}7 - 2{,}8 = 3{,}9$ A.

$I_5 = I_{III} - I_{II} = 2{,}8 - 2{,}45 = 0{,}35$ A.

Izlanayotgan barcha toklar aniqlandi.

3. Quvvatlar balansini tuzish.

Xar qanday elektr zanjirida e.yu.k. manbalarining umumiy quvvati iste`molchilarda sarflanadigan quvvatlar yig''indisiga teng bo'lishi kerak, ya`ni:

$$\sum E\cdot I = \sum I^2 R = \sum U\cdot I$$

1.1 - rasmda keltirilgan elektr zanjiri uchun quvvatlar balansini tuzamiz:

$$E_1 I_1 - E_2 I_2 + E_3 I_3 = I_1^2 R_1 + I_2^2 R_2 + I_3^2 R_3 + I_4^2 R_4 + I_5^2 R_5 + I_6^2 R_6$$

e.yu.k. manbalarining umumiy quvvati:

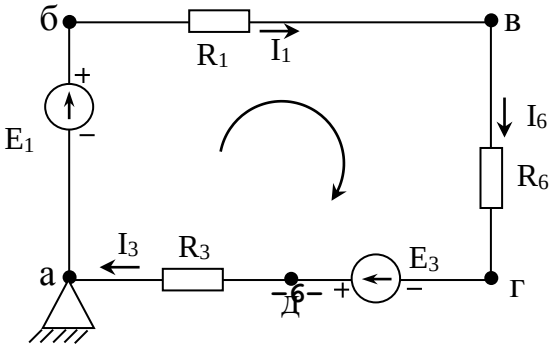
$$E_1 I_1 - E_2 I_2 + E_3 I_3 = 72\cdot 6{,}7 - 12\cdot 4{,}25 + 2{,}45 = 441{,}2 \text{ Vt}.$$

Iste`molchilarni umumiy quvvati:

$I_1^2R_1 + I_2^2R_2 + I_3^2R_3 + I_4^2R_4 + I_5^2R_5 + I_6^2R_6 = (6,7)^2 \cdot 6 + (4,25)^2 \cdot 1 + (2,45)^2 \cdot 10 + (3,9)^2 \cdot 4 + (0,35)^2 \cdot 12 + (2,8)^2 \cdot 4 = 441,2$ Vt. Demak, 441,2 = 441,2 Vt.

4. Potensiallar diagrammasini qurish.

Potensiallar diagrammasi, asosiy murakkab zanjirning tashqi konturi uchun quriladi (2 - rasm); zanjirda biror nuqta (**a**) ning potensiali nolga teng deb olinib, shu nuqtaga nisbatan boshqa nuqtalarning potensiallari xisoblanadi. Buning uchun, soat mili xarakati yo'nalishida, **a** nuqtasidan boshlab konturni aylanib chiqiladi;



2 – rasm

a nuqtaning potensiali nolga teng:

$\varphi_a = 0.$

b nuqtaning potensiali **a** nuqtaning potensalidan E_1 ga katta:

$\varphi_b = \varphi_a + E_1 = 0 + 72 = 72$ V.

v nuqtasining potensiali **b** nuqtasining potensialidan $I_1 \cdot R_1$ ga kichik bo'ladi, chunki R_1qarshiligida kuchlanish pasayishi $\varphi_b - \varphi_v = I_1 \cdot R_1$ bo'ladi. Bundan,

$\varphi_v = \varphi_b - I_1 \cdot R_1 = 72 - 6,7 \cdot 6 = 31,8$ V.

g nuqtasining potensiali xam **v** nuqtaning potensialidan $I_6 \cdot R_6$ ga kichik bo'ladi:

$\varphi_g = \varphi_b - I_6 \cdot R_6 = 31,8 - 2,8 \cdot 4 = 20,6$ V.

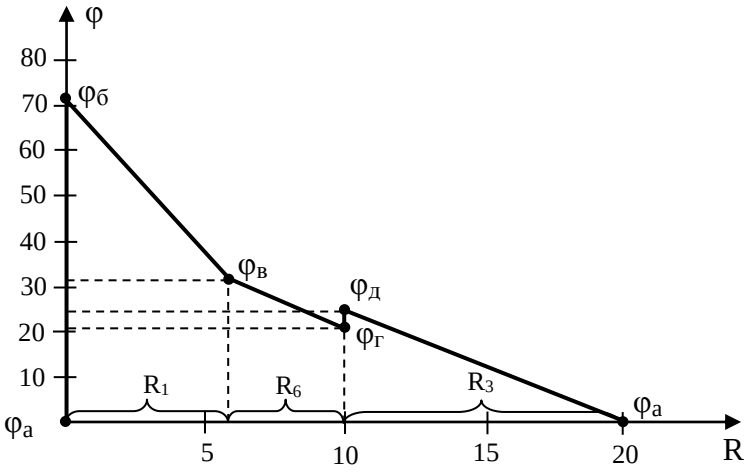
d nuqtasining potensiali **g** nuqtaning potensialidan E_3 ga katta bo'ladi:

$\varphi_d = \varphi_g + E_3 = 20,6 + 4 = 24,6$ V.

yana, **a** nuqtasining potensialini tekshirsak, bunda u **d** nuqtasining potensialidan $I_3 \cdot R_3$ ga kichik bo'ladi:

$\varphi_a = \varphi_d - I_3 \cdot R_3 = 24,6 - 2,46 \cdot 10 = 0.$

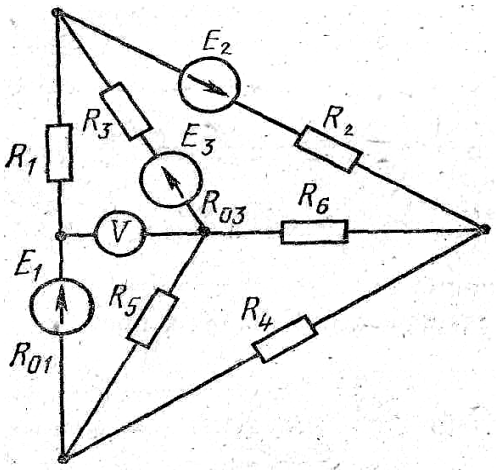
Endi, masshtabda potensiallar diagramma [$\varphi = f(R)$] sini quramiz (3 - rasm).



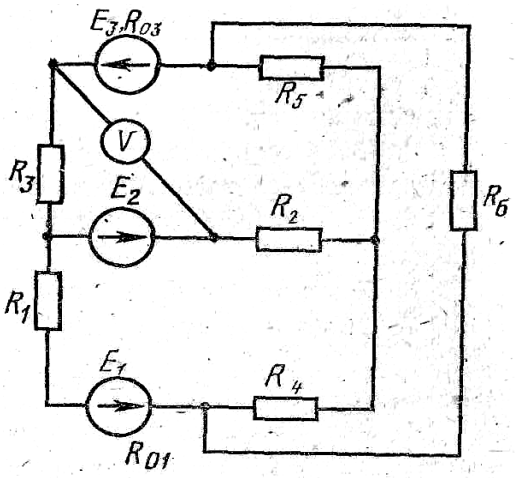
3 - rasm.

1- masala bo’yicha variantlar.

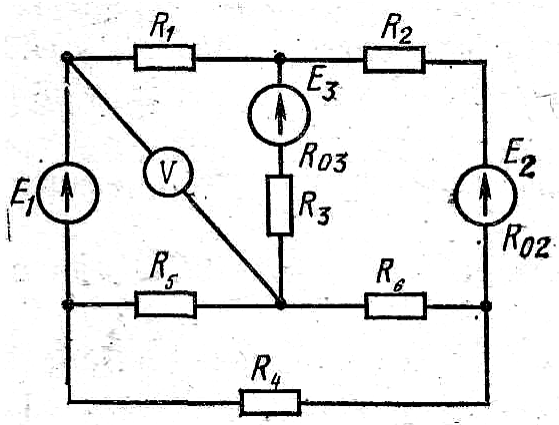
Raqamlar		E_1, V	E_2, V	E_3, V	R_{01}, Om	R_{02}, Om	R_{03}, Om	R_1, Om	R_2, Om	R_3, Om	R_4, Om	R_5, Om	R_6, Om
Variantlar	Rasmlar												
1	**1.1**	22	24	10	0.2	---	1.2	2	1	8	4	10	6
2	**1.2**	55	18	4	0.8	---	0.8	8	4	3	2	4	4
3	**1.3**	36	10	25	---	0.4	0.5	4	8	3	1	2	7
4	**1.4**	16	5	32	---	0.6	0.8	9	3	2	4	1	5
5	**1.5**	14	25	28	0.9	1.2	---	5	2	8	2	2	6
6	**1.6**	20	22	9	0.1	---	1.1	1	2	6	3	8	4
7	**1.7**	5	16	30	0.4	---	0.7	6	4	3	2	5	3
8	**1.8**	10	6	24	0.8	0.3	---	3.5	5	6	6	3	1
9	**1.9**	6	20	4	---	0.8	1.2	4	6	4	4	3	1
10	**1.10**	21	4	10	---	0.2	0.6	5	7	2	8	1	1
11	**1.11**	4	9	18	0.8	---	0.7	2.7	10	4	8	10	2
12	**1.12**	4	24	6	0.9	---	0.5	9	8	1	6	10	4
13	**1.13**	16	8	9	0.2	0.6	---	2.5	6	6	5	10	5
14	**1.14**	48	12	6	0.8	1.4	---	4.2	4	2	12	6	2
15	**1.15**	12	36	12	---	0.4	1.2	3.5	5	1	5	6	9
16	**1.16**	12	6	40	1.2	0.6	---	2	3	8	5	7	8
17	**1.17**	8	6	36	1.3	---	1.2	3	2	1	6	8	6
18	**1.18**	72	12	4	0.7	1.5	---	6	1	10	4	12	4
19	**1.19**	12	48	6	---	0.4	0.4	2.5	1	4	15	2	2
20	**1.20**	12	30	9	0.5	---	0.5	3.5	2	3	3	1	3
21	**1.21**	9	6	27	---	1	0.8	4.5	2	8	13	4	3
22	**1.22**	15	63	6	1	---	1.2	5	3	1	2	12	3
23	**1.23**	54	27	3	1.2	0.9	---	8	3	1	4	2	2
24	**1.24**	36	9	24	---	0.8	0.8	3	4	2	1	5	1
25	**1.25**	3	66	9	---	0.7	1.2	1	4	2	2	7	3
26	**1.26**	30	16	10	0,6	0,8	–	2,0	5	3	1	8	5
27	**1.27**	10	32	10	0,6	-	1,0	1,5	6	1	7	1	5
28	**1.28**	5	10	36	0,3	–	0,8	1,2	6	3	2	2	2
29	**1.29**	40	25	8	–	0,2	0,2	3,0	3	2	4	3	2
30	**1.30**	8	40	10	0,8	1.0	-	5,0	3	3	3	2	1
31	**1.31**	22	24	10	0,2	-	1,2	2	1	8	4	10	6
32	**1.32**	55	18	4	0,8	-	0,8	8	4	3	2	4	4
33	**1.33**	36	10	25	–	0,4	0,5	4	8	3	1	2	7
34	**1.34**	16	5	32	–	0,6	0,8	9	3	2	4	1	5
35	**1.35**	14	25	28	0,9	1,2	-	5	2	8	2	2	6
36	**1.36**	5	16	30	0,4	-	0,7	6	4	3	2	5	3
37	**1.37**	10	6	24	0,8	0,3	–	3,5	5	6	6	3	1
38	**1.38**	6	20	4	–	0,8	1,2	4	6	4	4	3	3
39	**1.39**	21	4	10	—	0,2	0,6	5	7	2	8	1	1
40	**1.40**	4	9	18	0,8	-	0,7	2,7	10	4	8	10	2
41	**1.41**	4	24	6	0,9	–	0,5	9,0	8	1	6	10	4
42	**1.42**	16	8	9	0,2	0,6	-	2,5	6	6	5	10	5
43	**1.43**	48	12	6	-	1,4	-	4,2	4	2	12	6	2
44	**1.44**	12	36	12	0,8	0,4	1,2	3,5	5	1	5	6	9
45	**1.45**	12	6	40	1,2	0,6	-	2,0	3	8	5	7	8
46	**1.46**	8	6	36	1,3	-	0,4	3,0	2	1	6	8	6
47	**1.47**	72	12	4	0,7	1,5	-	6,0	1	10	4	12	4
48	**1.48**	12	48	6	-	0,4	0,5	2,5	1	4	15	2	2
49	**1.49**	12	30	9	0,5	-	-	3,5	2	3	3	1	3
50	**1.50**	9	6	27	-	1,0	0,8	4,5	2	8	13	4	3



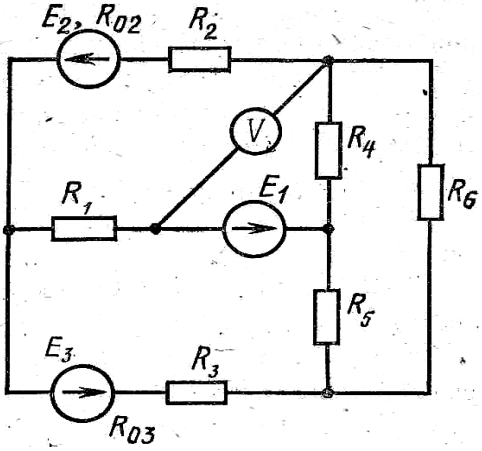
1.1 – rasm



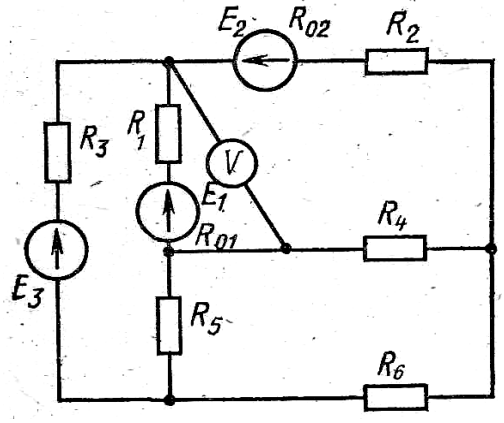
1.2 – rasm



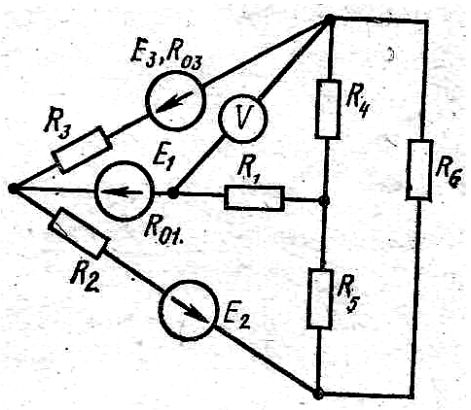
1.3 – rasm



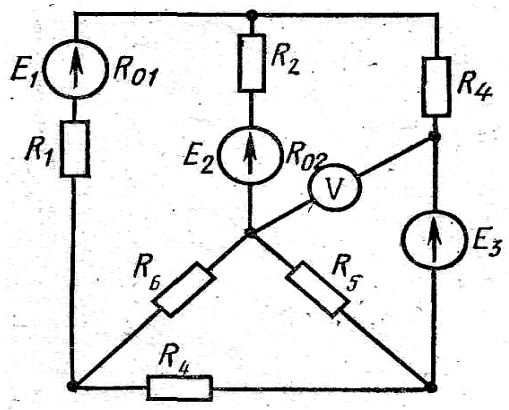
1.4 – rasm

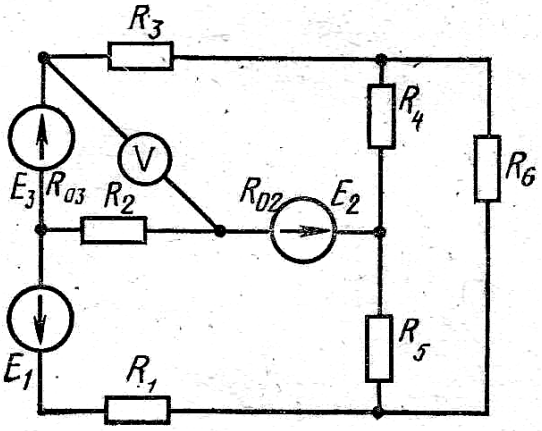


1.5 – rasm

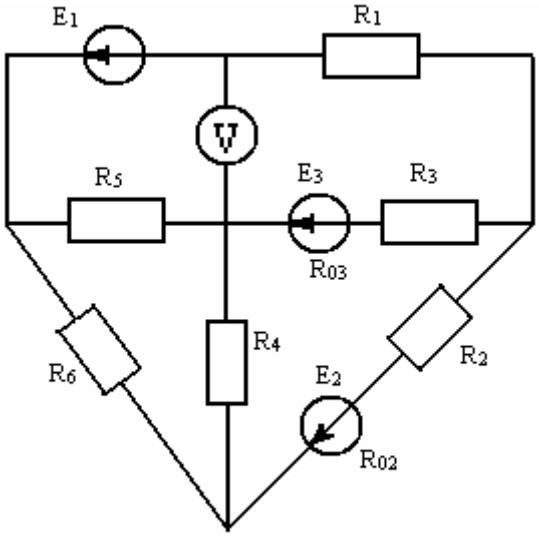


1.6 – rasm



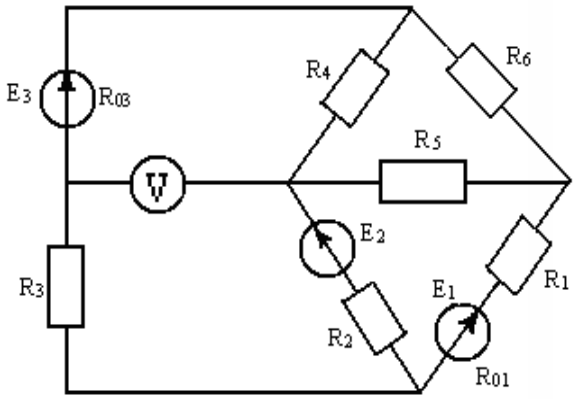


1.7 – rasm

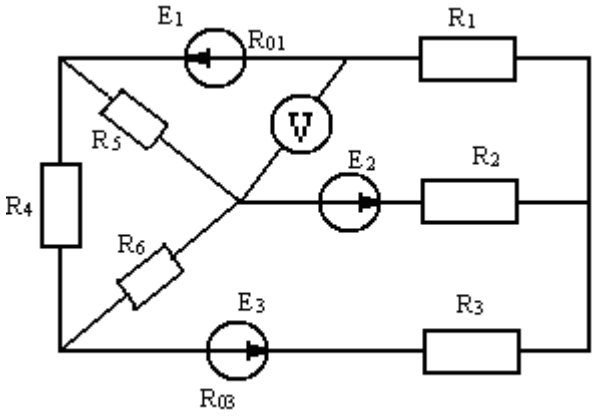


Расм 1.9

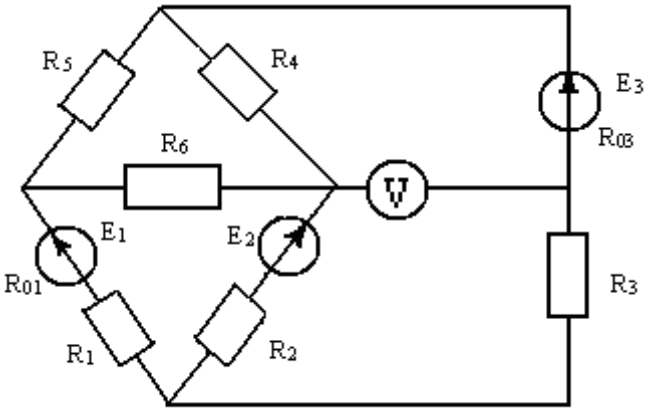
1.8 – rasm



Расм 1.10



Расм 1.11



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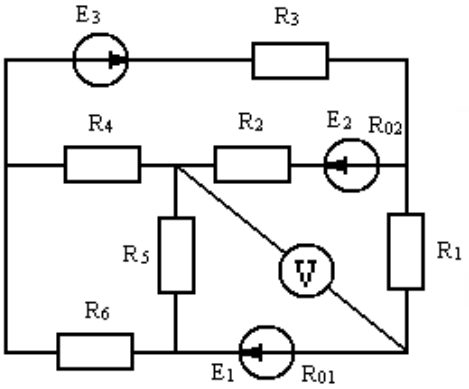

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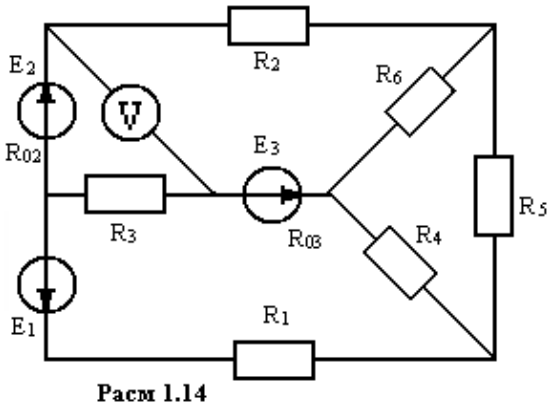

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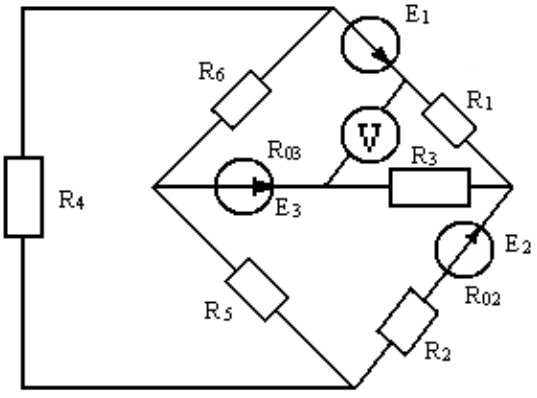

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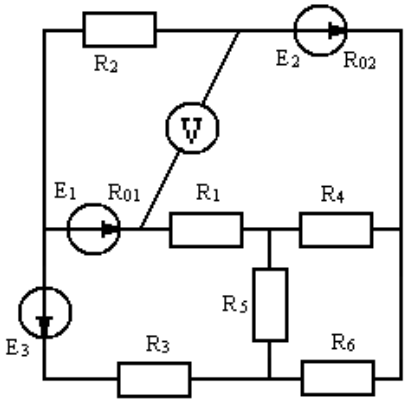

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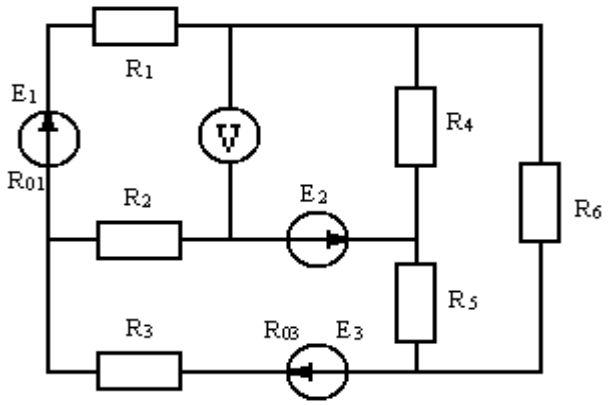

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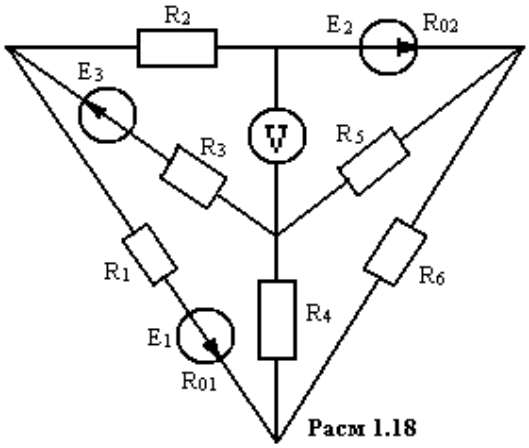

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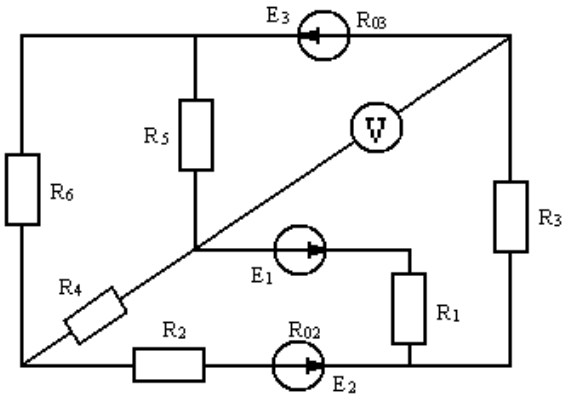

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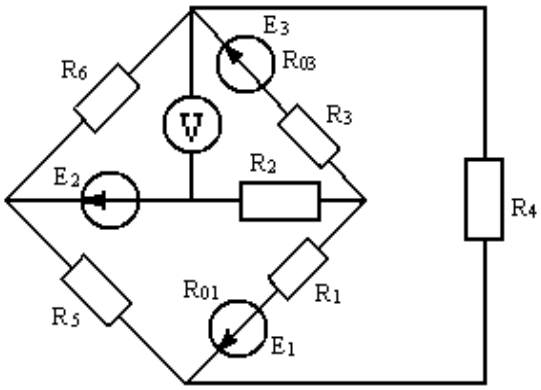

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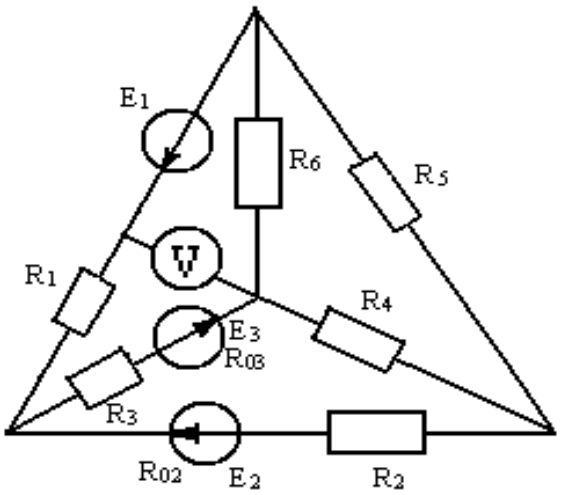

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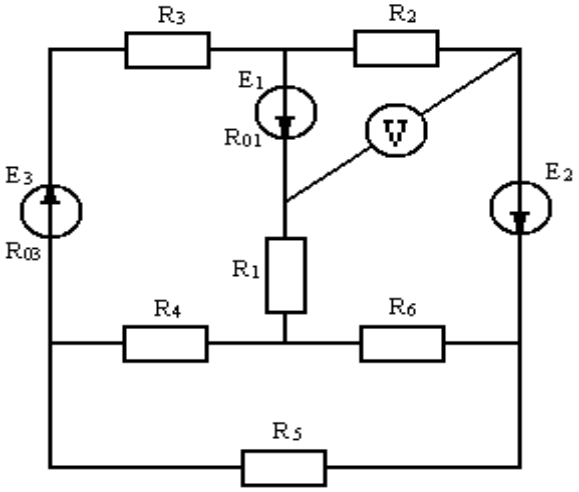

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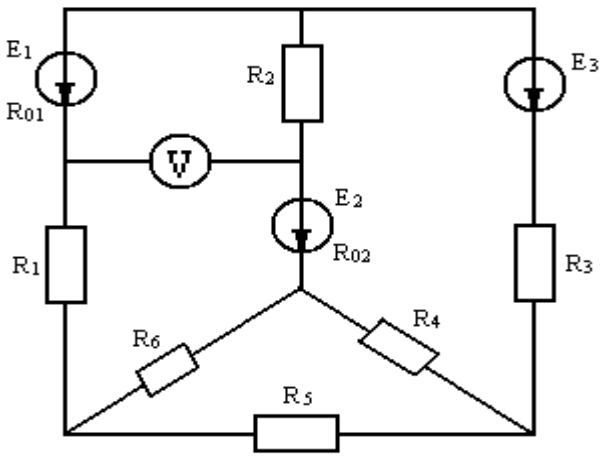

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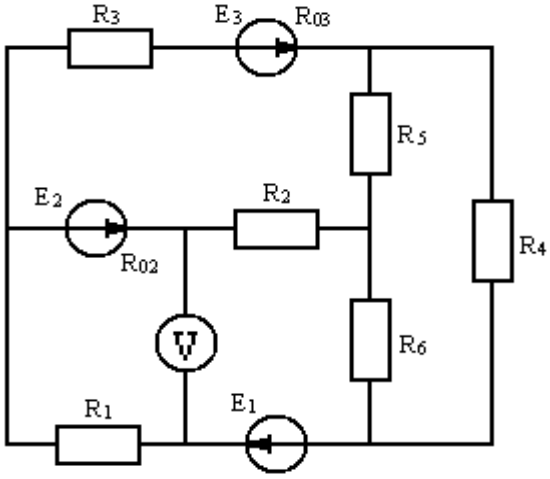

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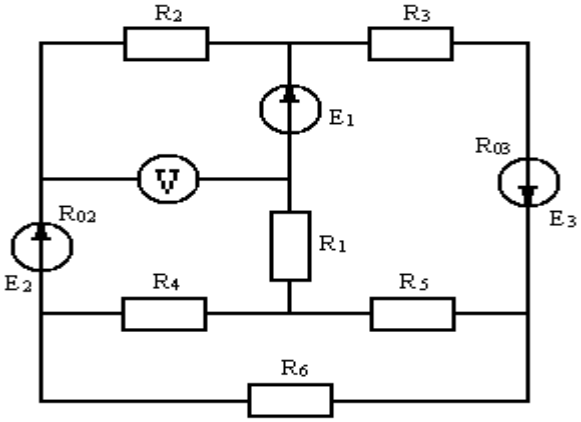

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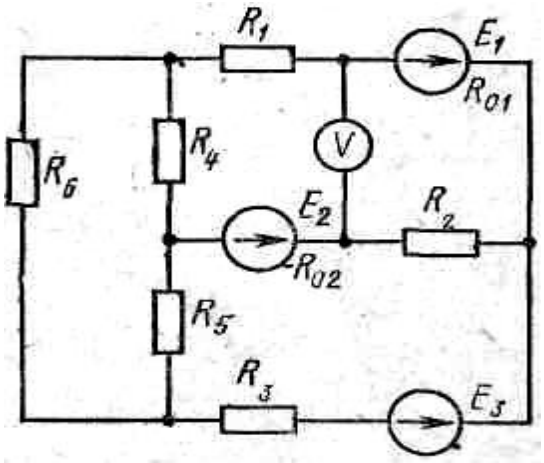

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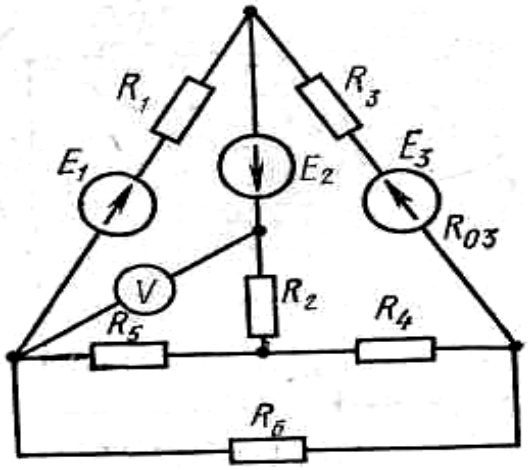

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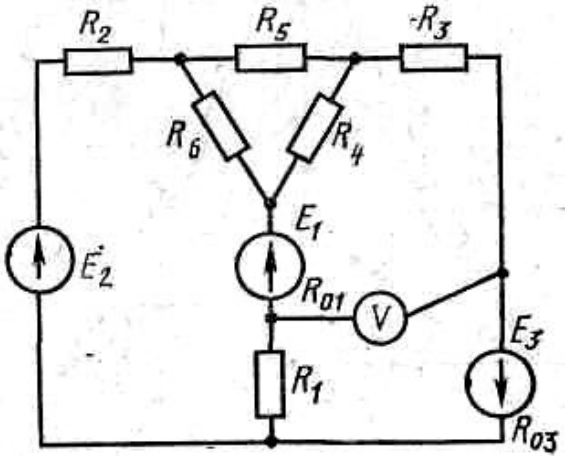

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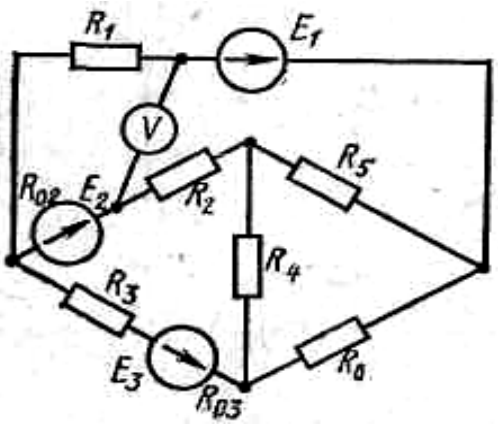

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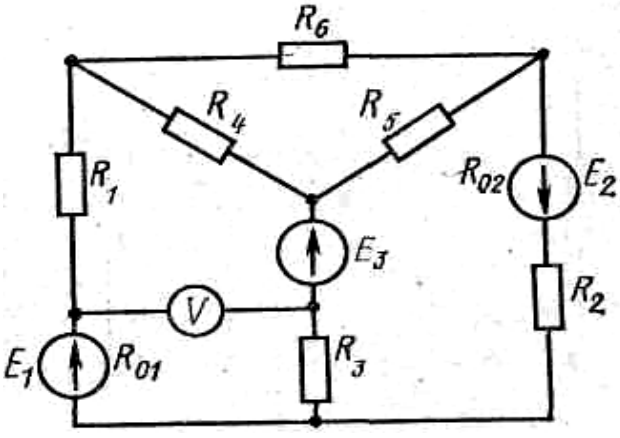

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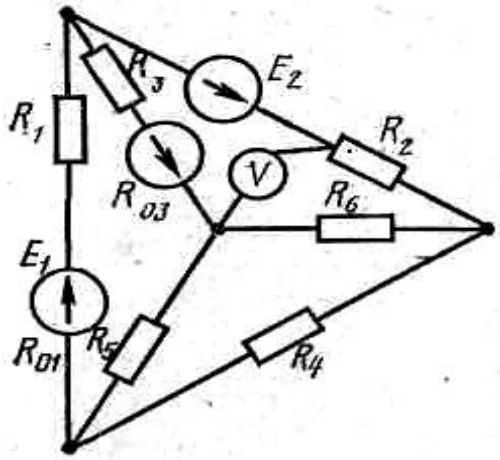

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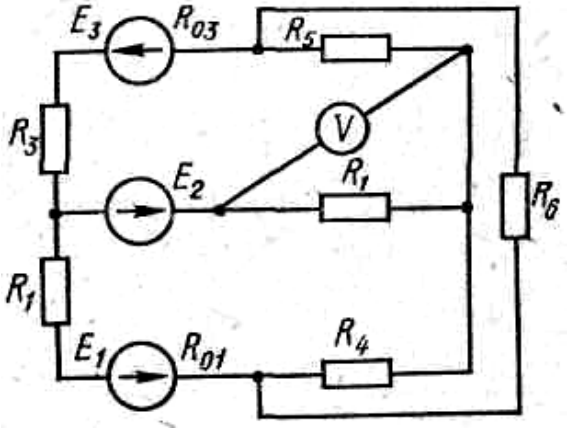

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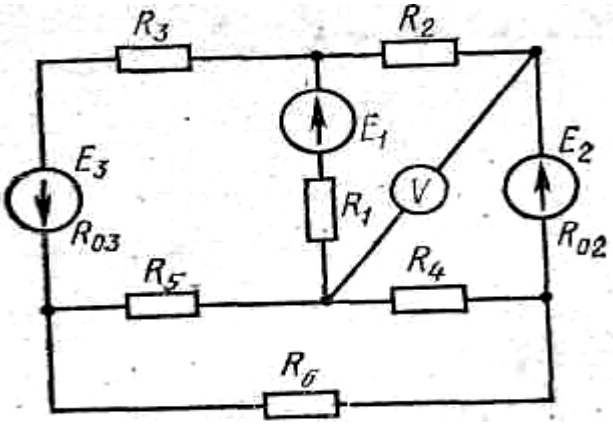

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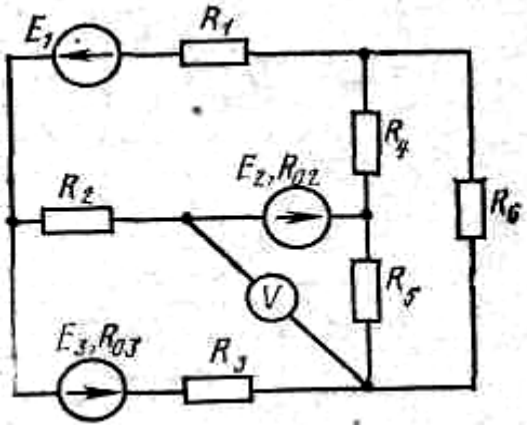

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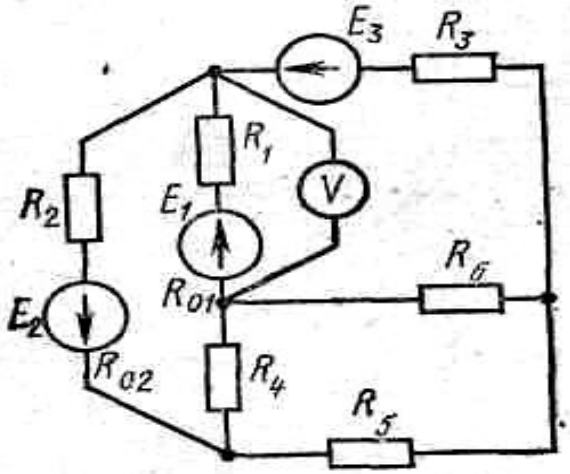

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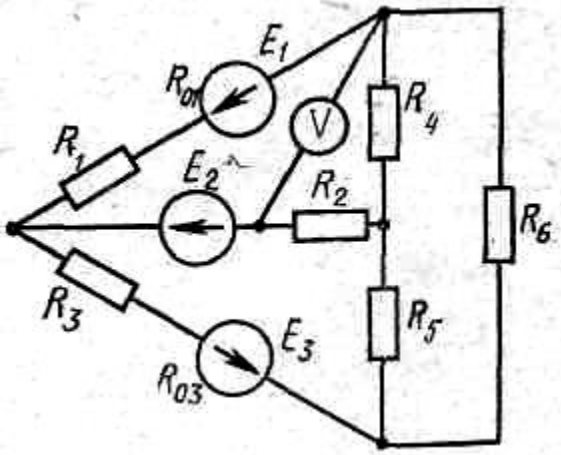

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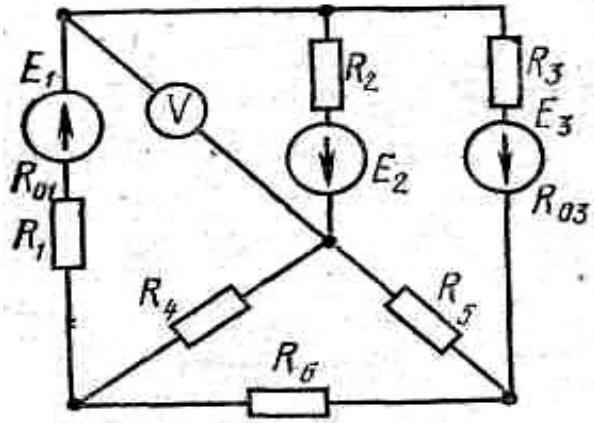

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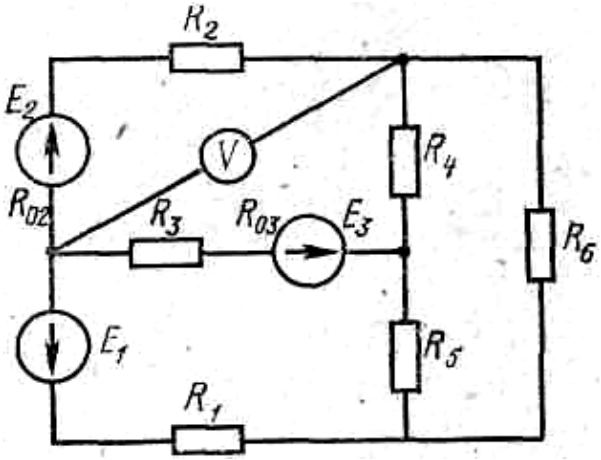

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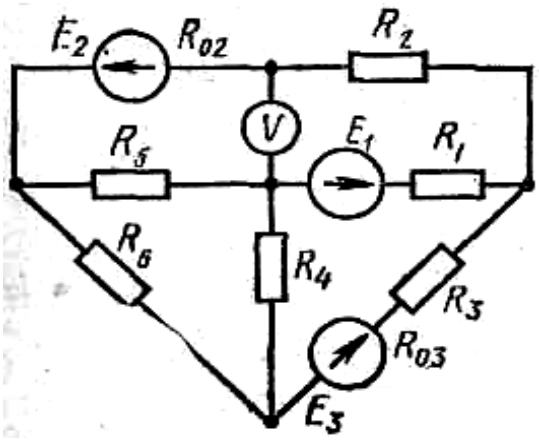

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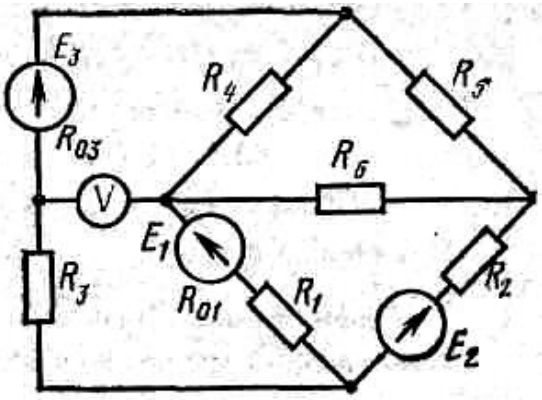

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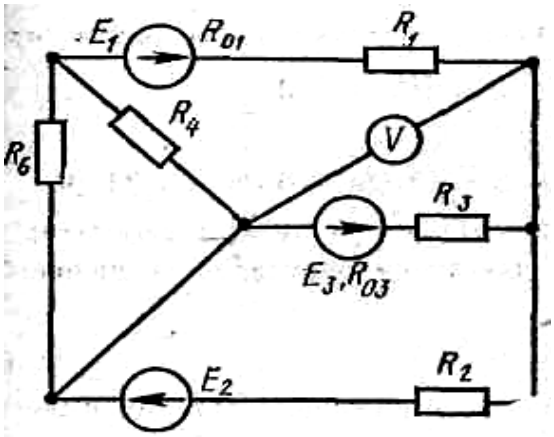

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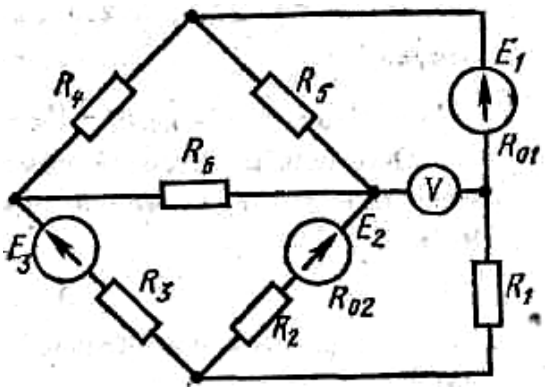

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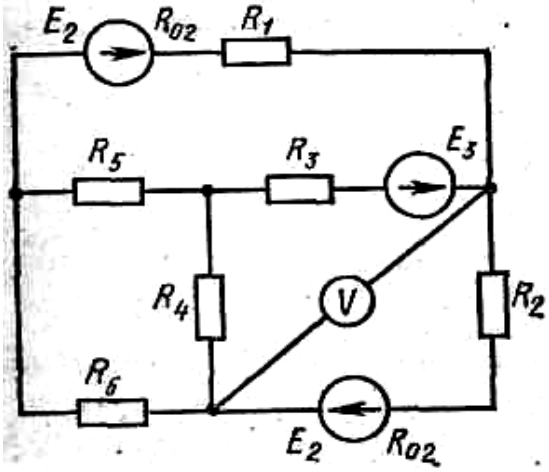

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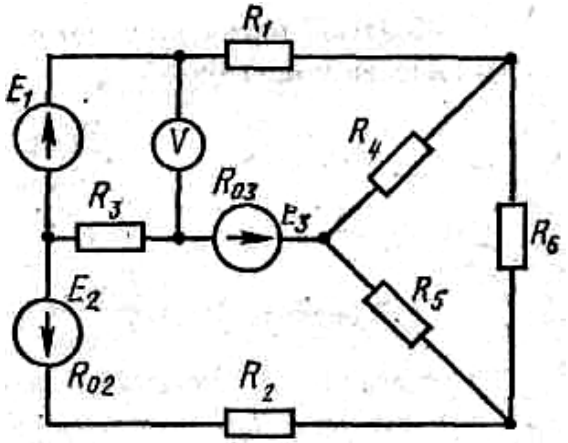

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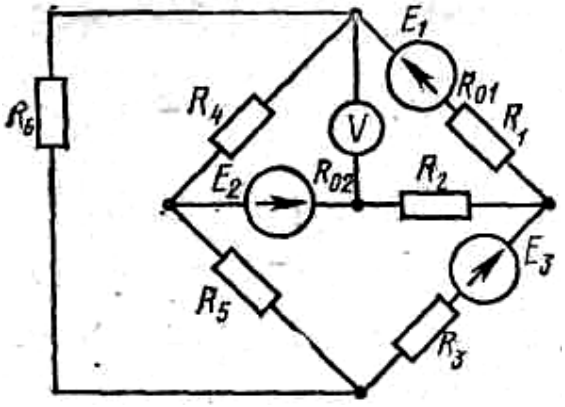

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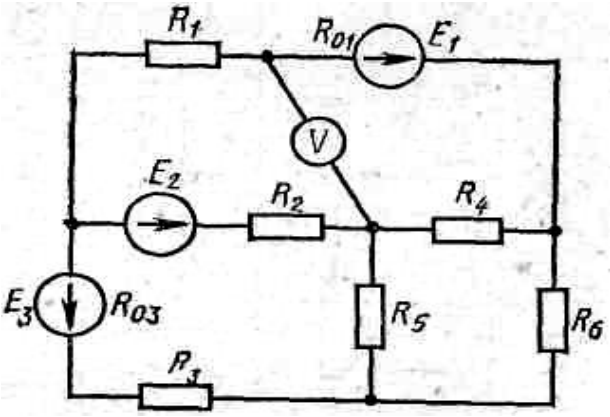

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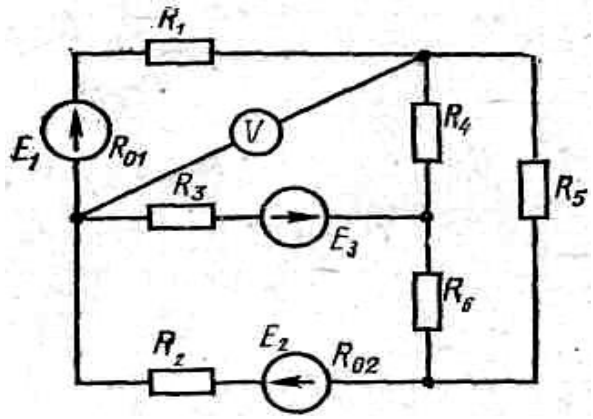

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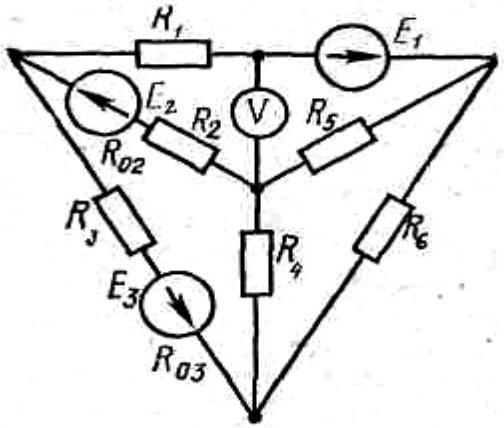

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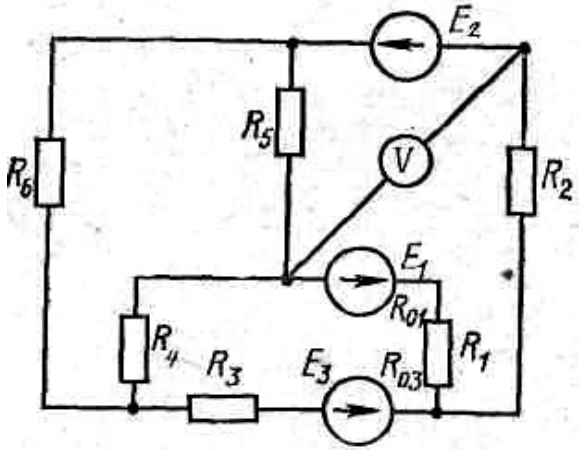

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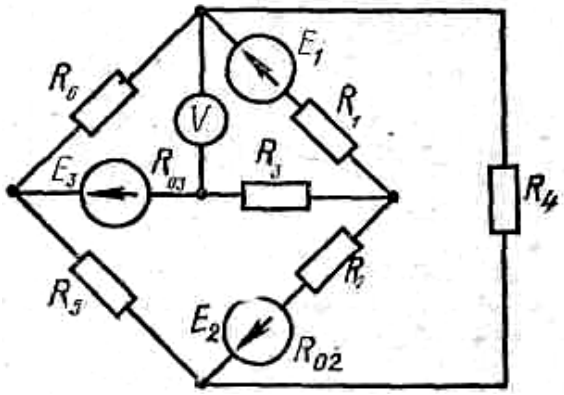


Rasm 1.50

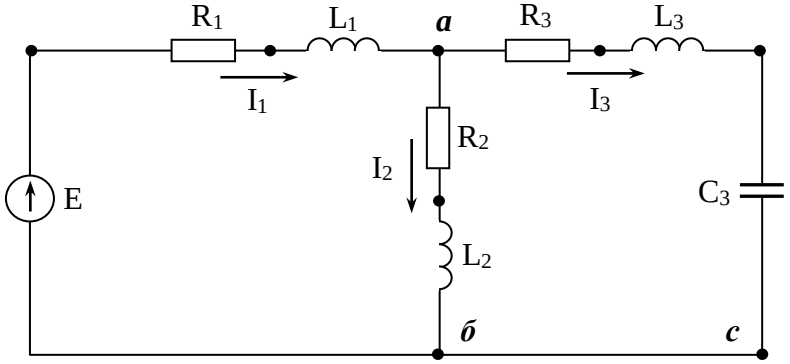
2 – Masala.

4 – rasmda keltirilgan sxema uchun quyidagilar berilgan:

E = 200 V; R_1 = 5 Om; L_1 = 31,8 mGn; R_2 = 10 Om; L_2 = 15,9 mGn; R_3 = 8 Om; L_3 = 95 mGn; S_3 = 637 mkF; f = 50 Gs.

Quyidagilar aniqlansin:

1. I_1, I_2, I_3 toklari, ***ab*** shaxobchaning kuchlanishi aniqlansin.
2. Aktiv va reaktiv quvvatlari balansi tuzilsin.
3. Tok va kuchlanishlarning vektor diagrammalari masshtabda qurilsin.



4 – rasm.

Masalaning echilishi:

1. I_1, I_2, I_3 toklari, *ab* shoxobchaning kuchlanishi aniqlash.

Berilgan zanjir sxemasida, qarshiliklar aralash ulanganligi uchun, avvalo parallel ulangan shaxobchalar (R_2; L_2 // R_3 ;L_3; S_3) ni ketma-ket ulangan ekvivalent qarshiliklar bilan almashtirish yo'li bilan masala oson echiladi.

1) Parallel ulangan shaxobchalar (R_2; L_2 va R_3 ;L_3; S_3) ning o'tkazuvchanligini aniqlaymiz:

a) ***ab*** va ***as*** uchastkalarning to'la qarshiliklari:

$$Z_2 = \sqrt{R_2^2 + X_{L_2}^2} = \sqrt{R_2^2 + (\omega \cdot L_2)^2} = \sqrt{R_2^2 + (2 \cdot \pi \cdot f \cdot L_2)^2} =$$

$$= \sqrt{10^2 + (2 \cdot 3{,}14 \cdot 50 \cdot 0.016)^2} = 11.19 \text{ Ом};$$

$$Z_3 = \sqrt{R_3^2 + (X_{L_3} - X_{C_3})^2} = \sqrt{R_3^2 + (\omega \cdot L_3 - \frac{1}{\omega \cdot C_3})^2} =$$

$$= \sqrt{64 + (29.83 - 5)^2} = 26 \text{ Ом}.$$

b) aktiv o'tkazuvchanliklar:

$$g_2 = \frac{R_2}{Z_2^2} = \frac{10}{11^2} = 0.09 \text{ См}; \qquad g_2 = \frac{R_3}{Z_3^2} = \frac{8}{26^2} = 0.012 \text{ См}.$$

v) reaktiv o'tkazuvchanliklar:

$$b_{L_2} = \frac{X_{L_2}}{Z_2^2} = \frac{5}{11^2} = 0.04 \text{ См}; \quad b_3 = \frac{X_{L_3} - X_{C_3}}{Z_3^2} = \frac{30 - 5}{26^2} = 0.036 \text{ См}.$$

$X_{L_3} > X_{C_3}$ bo'lganligi uchun reaktiv o'tkazuvchanlik b_3 induktiv xarakterga ega bo'ladi.

2) Parallel ulangan qismining ekvivalent o'tkazuvchanliklarini aniqlash:

a) aktiv o'tkazuvchanligi: $g_э = g_2 + g_3 = 0.09 + 0.012 = 0.102$ См;

b) reaktiv o'tkazuvchanligi: $b_э = b_2 + b_3 = 0.04 + 0.036 = 0.076$ См.

v) to'la o'tkazuvchanligi: $У_э = \sqrt{g_э^2 + b_э^2} = \sqrt{0.102^2 + 0.076^2} = 0.127$ См.

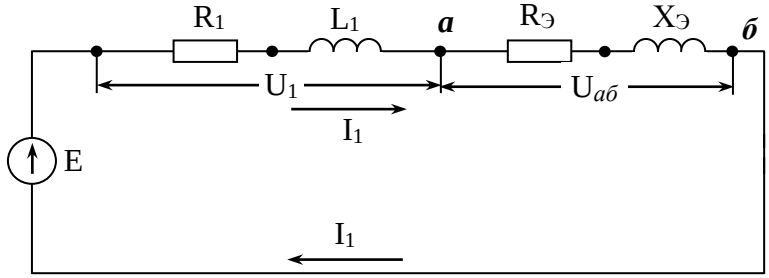
3) Zanjirning shaxobchalari parallel ulangan qismining ekvivalent qarshiliklari aniqlash:

a) aktiv qarshiligi: $R_э = \frac{g_э}{R_э^2} = \frac{0.102}{(0.127)^2} = 6.375 \text{ Ом}$;

b) reaktiv qarshiligi: $X_э = \frac{b_э}{У_э^2} = \frac{0.076}{(0.127)^2} = 4.75$ Ом ;

v) to'la qarshiligi: $Z_э = \frac{1}{y_э} = 7.87$ Ом.

Endi qarshiliklari aralash ulangan zanjir, qarshiliklari ketma-ket ulangan (5 - rasm) ga aylanib qoldi.



5 – rasm.

4) Zanjirning umumiy qarshiliklarini aniqlash:

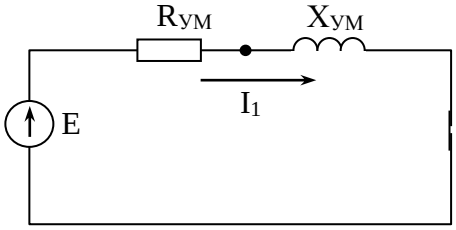
a) aktiv qarshiligi: $R_{ум} = R_1 + R_э = 5 + 6.375 = 11.375$ Ом;

b) reaktiv qarshiligi: $X_{ум} = X_{L_1} + X_э = 10.05 + 4.75 = 14.8$ Ом.

Bunda: $X_{L_1} = 2 \cdot \pi \cdot f \cdot L_1 = 2 \cdot 3.14 \cdot 50 \cdot 0.032 = 10.05$ Ом;

v) to'la qarshiligi: $Z_{ум} = \sqrt{R_{ум}^2 + X_{ум}^2} = \sqrt{11.375^2 + 14.8^2} = 18.66$ Ом.

Endi zanjir quyidagi (6 - rasm) ga keltiriladi:



6 – rasm.

5) Umumiy tok Om qonuni yordamida aniqlanadi:

$$I_1 = \frac{E}{Z_{ум}} = \frac{200}{18.66} = 10.7 \text{ A}.$$

Zanjirning quvvat koeffisienti: $\cos\varphi = \frac{R_{ум}}{Z_{ум}} = 0.60$.

6) ***ab*** shaxobchaning kuchlanishi:

$U_{ab} = U_2 = U_3 = I_1 \cdot Z_E = 10.7 \cdot 7.87 = 84.4$ V.

7) Parallel ulangan shaxobchalardan o'tayotgan toklar va quvvat koeffisientlari:

$$I_2 = \frac{U_2}{Z_2} = \frac{84.4}{11.19} = 7.55 \text{ A}; \quad \cos\varphi_2 = \frac{R_2}{Z_2} = \frac{10}{11.19} = 0.894; \quad \varphi_2 = 26^\circ 36'$$

$$I_3 = \frac{U_3}{Z_3} = \frac{84.4}{26.09} = 3{,}24 \text{ A}; \quad \cos\varphi_3 = \frac{R_3}{Z_3} = \frac{8}{26.09} = 0.3075; \quad \varphi_3 = 72^\circ 6'$$

8) U_1 kuchlanishni aniqlash:

$$U_1 = I_1 \cdot Z_1 = I_1 \cdot \sqrt{R_1^2 + X_{L_1}^2} = 10.7 \cdot \sqrt{126} = 120.3 \text{ B}.$$

U_1 kuchlanishi ikkita tashkil etuvchilardan iborat bo'ladi:

$\dot{U}_1 = \dot{U}_{R_1} + \dot{U}_{L_1}$;

Bunda: $\dot{U}_{R_1} = I_1 \cdot R_1 = 10.7 \cdot 5 = 53.6$ B; $\dot{U}_{L1} = I_1 \cdot X_{L_1} = 10.7 \cdot 10.05 = 107.7$ B.

2. Aktiv va reaktiv quvvatlar balansini tuzish.

a) Aktiv quvvatlar balansini tuzish:

$$P = \sum(P_1 + P_2 + P_3)$$

$$E \cdot I_1 \cdot \cos\varphi = I_1^2 \cdot R_1 + I_2^2 \cdot R_2 + I_3^2 \cdot R_3$$

$200 \cdot 10.7 \cdot 0.60 = (10.7)^2 \cdot 5 + (7.54)^2 \cdot 10 + (3.24)^2 \cdot 8;$

$1286.4 = 574.6 + 570.0 + 84.5;$

1286.4 = 1229.1 Vt.

Xatosi % larda: $\gamma\% = \frac{1286.4 - 1229.1}{1286.4} \cdot 100\% = 4.3\%$.

b) Reaktiv quvvatlar balansini tuzish:

Reaktiv quvvat sig''im xarak`eriga ega bo'lgan quvvat (Q_C) oldiga (–) ishorasi qo'yiladi.

$Q = \Sigma(Q_{L_1} + Q_{L_2} + Q_{L_3} - Q_{C_3})$;

$E \cdot I_1 \cdot \sin\varphi = I_1^2 \cdot X_{L_1} + I_2^2 \cdot X_{L_2} \cdot I_3^2 \cdot X_{L_3} - I_3^2 \cdot X_{C_3}$;

$\sin\varphi = \frac{X_{УМ}}{Z_{УМ}} = \frac{14.8}{18.66} = 0.79$;

$200 \cdot 10.72 \cdot 0.79 = 10.72^2 \cdot 10.05 + 7.55^2 \cdot 5.02 + 3.24^2 \cdot 29.83 - 3.24^2 \cdot 5$;

1693.8 = 1154.9 + 296.2 + 313.1 – 52.5;

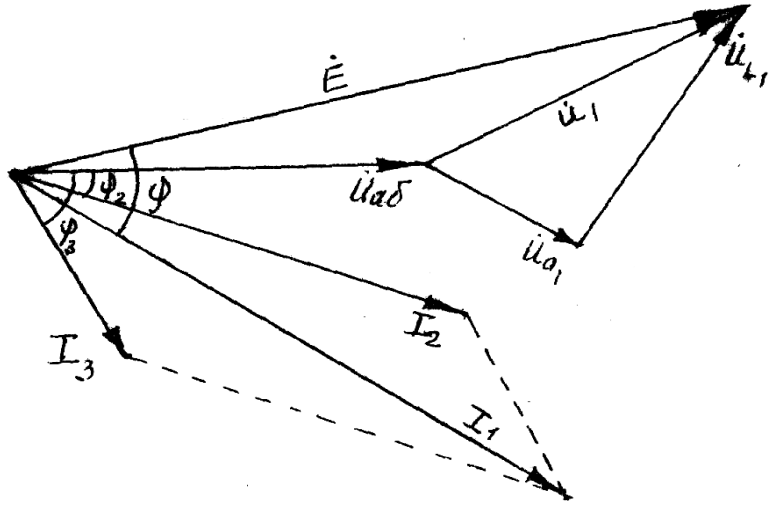
1693.8 = 1701.7.

Xatosi % larda: $\gamma\% = \frac{1701.7 - 1693.8}{1701.7} \cdot 100\% = 0.46\%$.

3. Tok va kuchlanishlar vektor diagrammalari qurish.

Endi tok va kuchlanishlar vektor diagrammasini quramiz. Buning uchun avvalo, tok va kuchlanish uchun masshtab tanlab olamiz. Vektor diagrammani $\dot{U}_{аб}$ kuchlanish vektoridan boshlaymiz (7 - rasm). φ_2 burchak ostida tok I_2 chiziladi. Bu tok induktiv xarakterga ega bo'lganligi uchun φ_2 burchak ostida keyinda chiziladi. I_3 toki xam $X_{L_3} > X_{C_3}$ bo'lganligi uchun φ_3 burchak ostida keyinda chiziladi. $\dot{I}_2$ va $\dot{I}_3$ tok vektorlarining geometrik yig''indisidan umumiy tok I_1 ni aniqlaymiz.

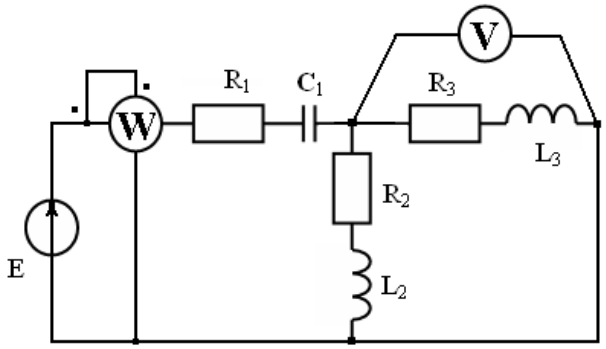
Endi manba e.yu.k.i vektori $\dot{E}$ ni topamiz. Buning uchun $\dot{U}_{аб}$ vektoriga $\dot{U}_1$ vektorini qo'shamiz. $\dot{U}_1$ kuchlanishi ikkita tashkil etuvchilardan iborat bo'lgani uchun, avvalo $\dot{U}_{R_1}$ ni $\dot{I}_1$ vektori yo'nalishida $\dot{U}_{аб}$ vektori oxiridan chiziladi. So'ngra, $\dot{U}_{L_1}$ vektori induktiv xarakterga ega bo'lganligi uchun uni $\dot{U}_{R_1}$ vektoriga nisbatan 90° burchak bilan oldinga qarab chizamiz (1.7 - rasm). $\dot{U}_{R_1}$ va $\dot{U}_{L_1}$ vektorlarining geometrik yigindisi $\dot{U}_1$ vektorini beradi $\dot{E} = \dot{U}_{аб} + \dot{U}_1$ bo'lganligi uchun $\dot{U}_1$ vektorini oxiri bilan koordinata o'qining boshini birlashtiriladi va bu vektor e.yu.k. - vektori $\dot{E}$ bo'ladi.



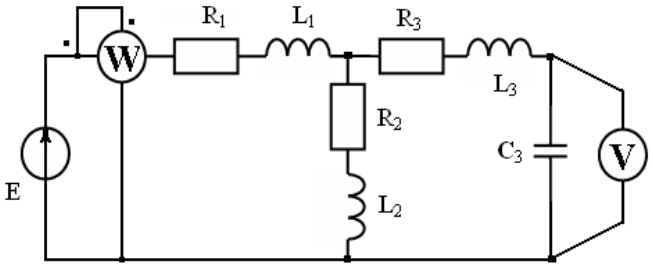
7 – rasm.

2 – masala bo'yicha variantlar

Raqamlar		E, V	f,Gs	S_1,mkf	S_2,mkf	S_3,mkf	L_1,mGn	L_2,mGn	L_3,mGn	R_1,Om	R_2,Om	R_3,Om
Variantlar	Rasmlar											
0	2.1	150	50	637	300	–	–	–	15.9	2	3	4
1	2.2	100	50	–	–	100	15.9	9	15.9	8	3	4
2	2.3	120	50	637	–	–	–	15.9	15.9	8	3	4
3	2.4	200	50	--	300	–	15.9	–	15.9	8	3	4
4	2.5	220	50	637	–	100	–	47.7	–	8	–	4
5	2.1	50	50	100	159	–	–	–	115	10	4	100
6	2.6	100	50	100	300	–	15.9	–	115	10	–	100
7	2.7	120	50	–	–	100	15.9	–	115	–	4	100
8	2.8	200	50	–	159	–	–	–	115	10	4	100
9	2.9	220	50	–	318	–	15.9	–	–	10	4	100
10	2.10	50	50	–	637	–	15.9	–	6.37	5	–	8
11	2.11	100	50	637	–	100	–	15.7	–	–	10	8
12	2.12	120	50	–	300	100	31.8	–	–	5	–	8
13	2.13	200	50	–	–	100	31.8	–	–	5	10	8
14	2.14	220	50	637	–	200	–	15.9	–	5	10	8
15	2.15	150	50	100	–	200	–	15.9	–	10	2	10
16	2.16	100	50	–	1600	200	31.8	–	–	–	8	10
17	2.17	120	50	100	–	200	–	15.9	–	10	8	10
18	2.18	200	50	637	–	200	–	31.8	–	–	8	10
19	2.19	220	50	–	1600	–	31.8	–	95	10	8	–
20	2.20	50	50	–	159	–	31.8	–	95	15	10	10
21	2.21	100	50	–	159	200	15.9	–	–	15	–	10
22	2.22	120	50	–	159	200	15.9	–	–	–	10	20
23	2.23	200	50	637	159	200	–	31.8	95	15	10	20
24	2.24	220	50	637	159	–	–	–	95	–	10	20
25	2.25	150	50	--	159	–	25	–	95	6	10	20
26	2.26	100	50	637	159	637	—	–	95	6	–	20
27	2.27	100	50	—	159	–	25	–	95	6	4	–
28	2.28	200	50	–	159	637	25	–	95	6	–	20
29	2.29	220	50	637	–	637	—	9	–	6	–	20
30	2.30	50	50	318	637	—	—	–	31,8	–	10	40
31	2.31	100	50	318	–	300	–	–	31,8	–	10	10
32	2.32	120	50	–	–	300	19,1	15,9	31,8	40	–	10
33	2.33	200	50	318	–	300	–	15,9	31,8	10	10	40
34	2.34	220	50	318	—	300	–	15,9	31,8	–	10	10
35	2.35	50	50	—	318	—	19,5	—	31,8	8	10	4
36	2.36	100	50	637	–	200	—	31,8	95	8	–	4
37	2.37	150	50	637	–	200	–	31,8	–	8	10	4
38	2.38	200	50	—	318	200	15,9	–	95	8	–	4
39	2.39	220	50	—	—	200	15,9	31,8	95	8	–	4
40	2.40	50	50	637	–	200	—	31.8	95	4	40	40



Расм 2.1



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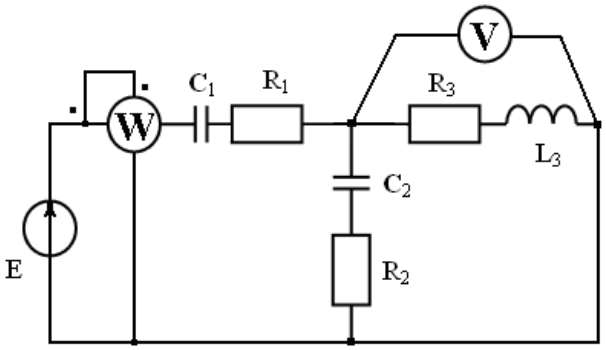

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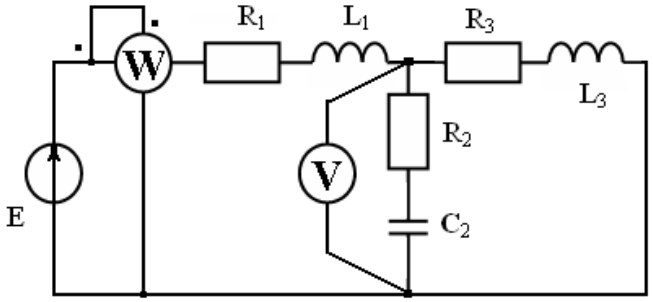

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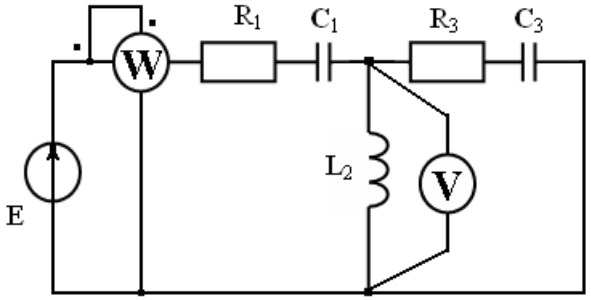

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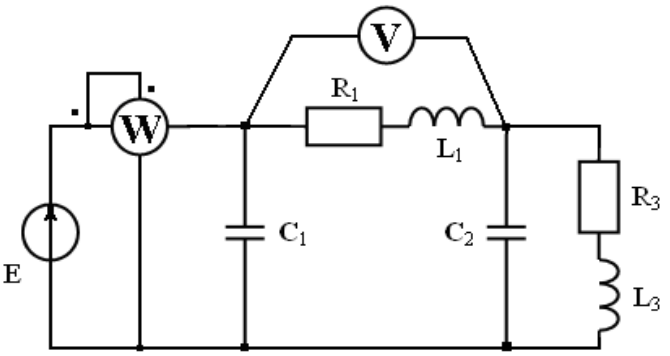

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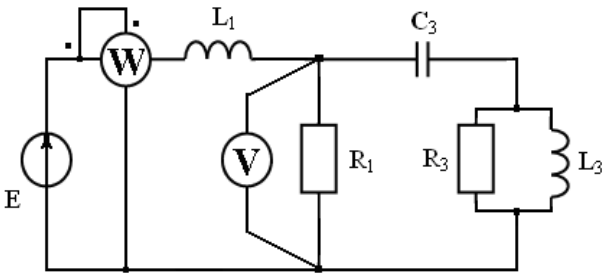

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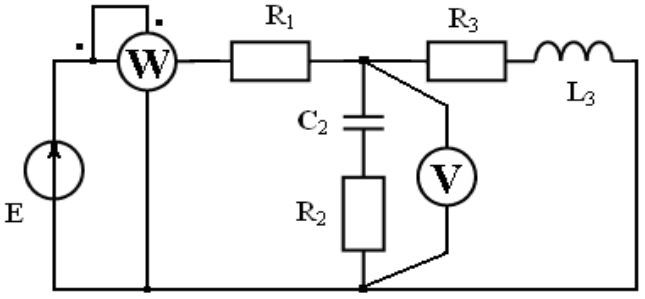

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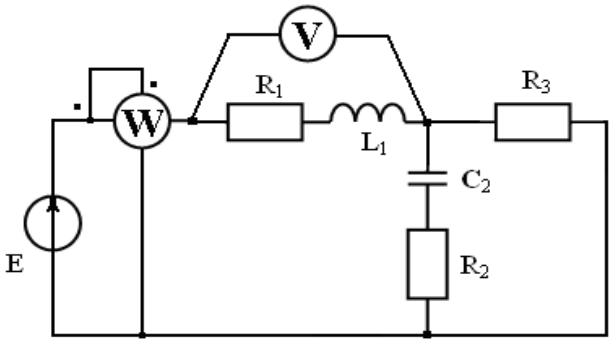

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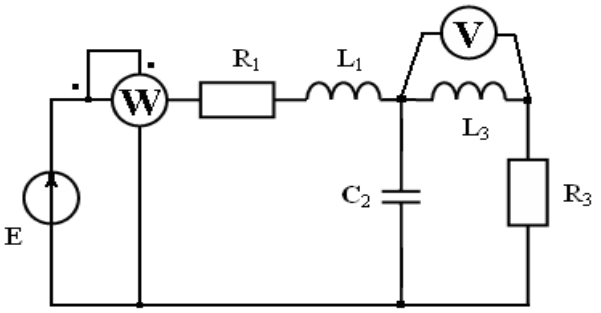

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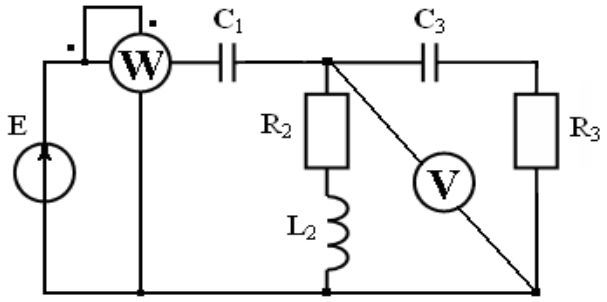

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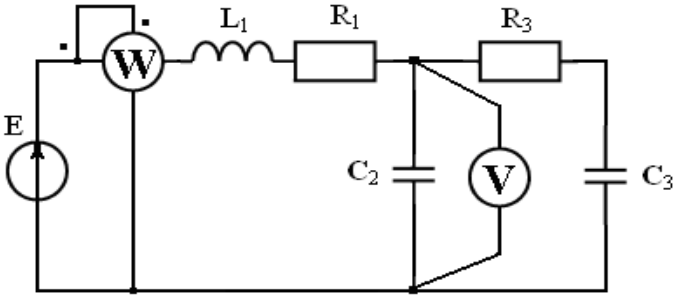

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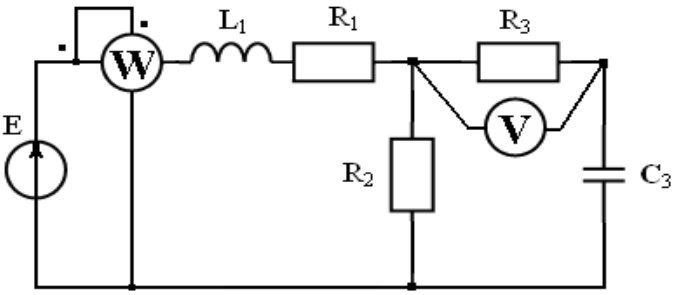

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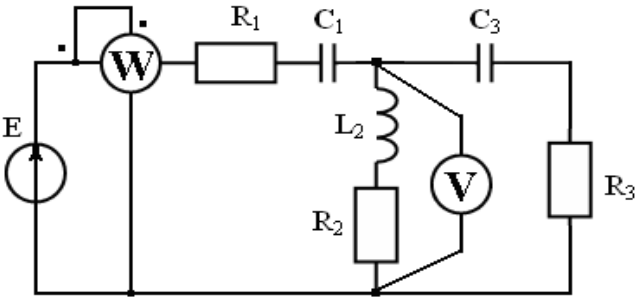

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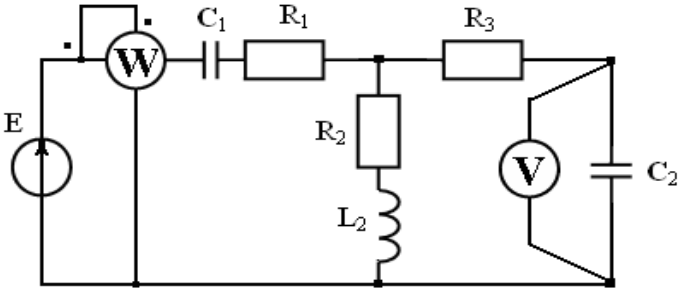

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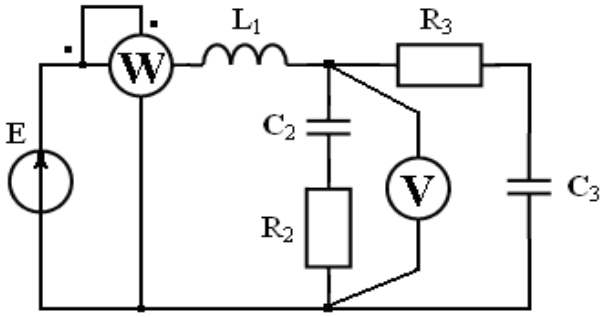

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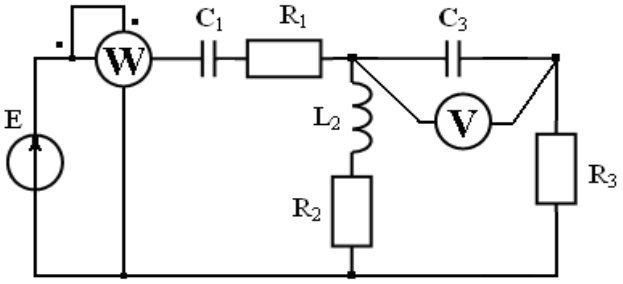

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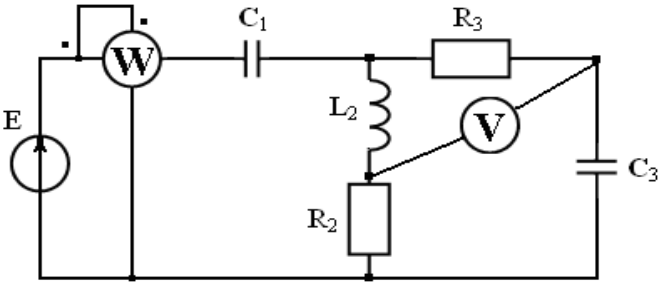

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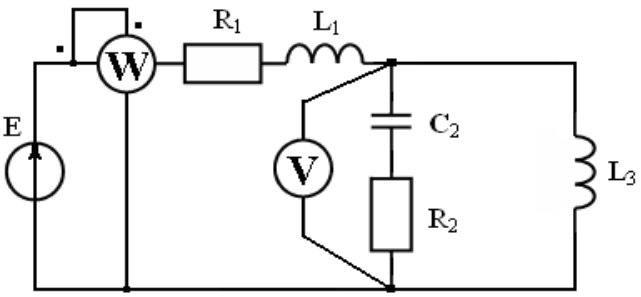

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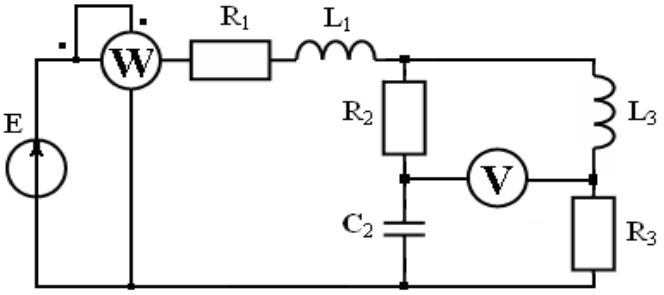

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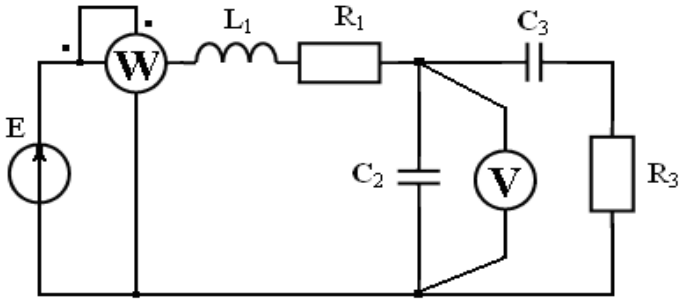

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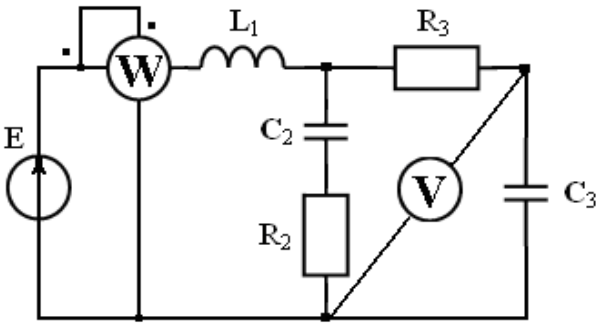

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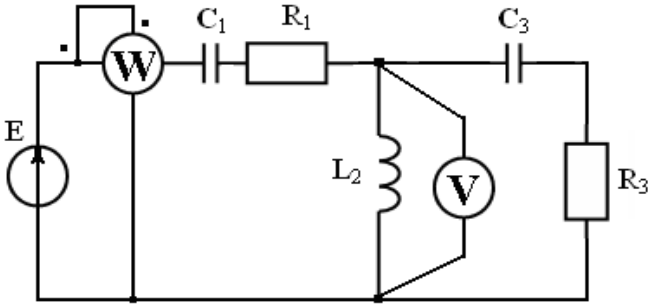

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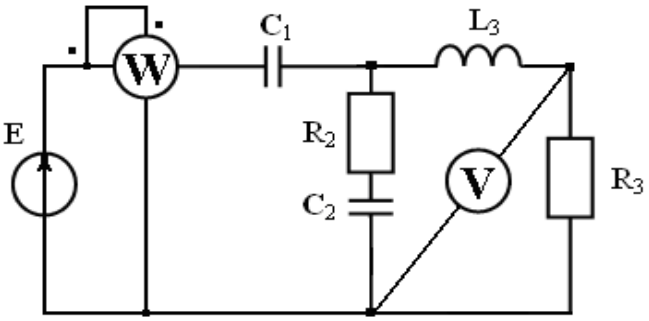

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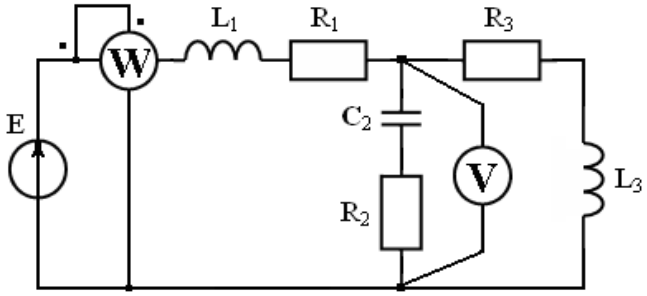

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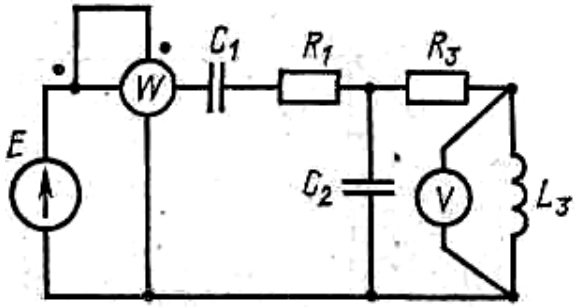
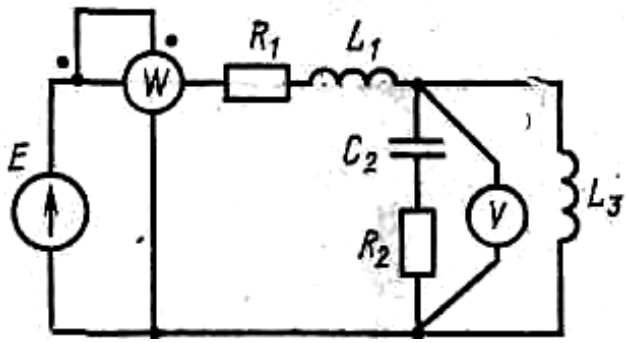


Rasm 2.26



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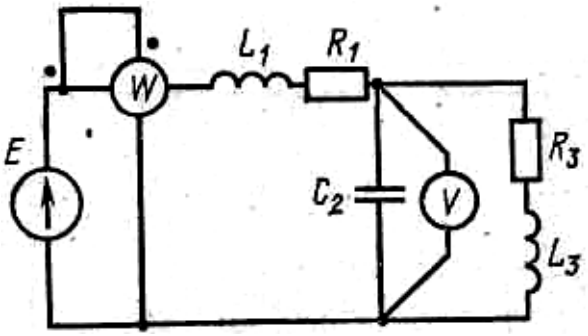

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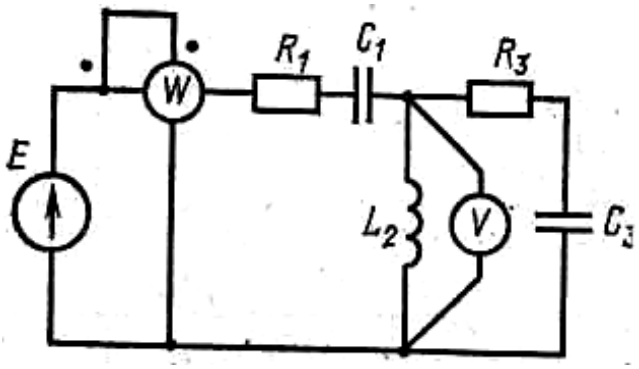

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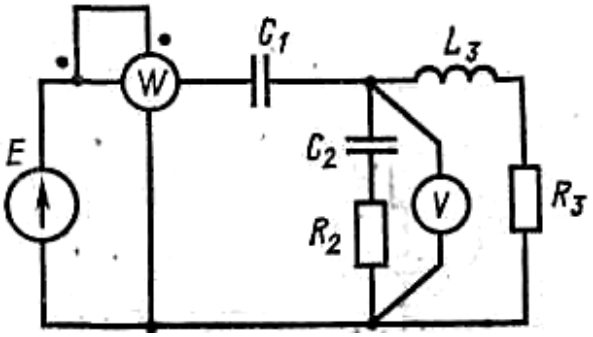

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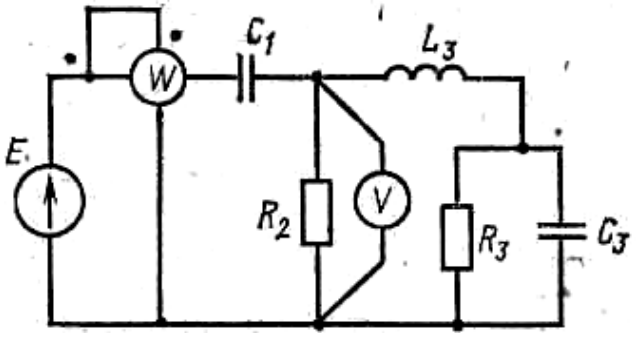

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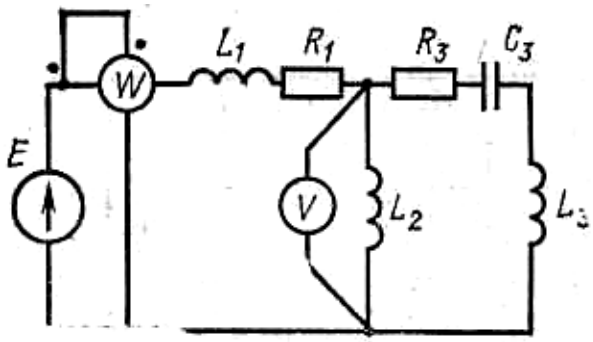

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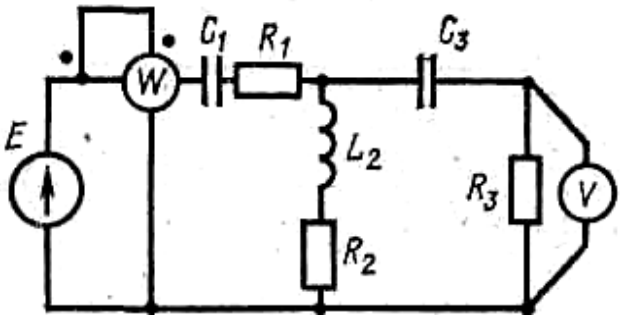
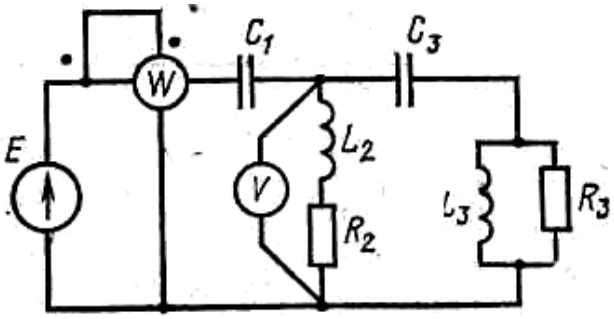


Rasm 2.33



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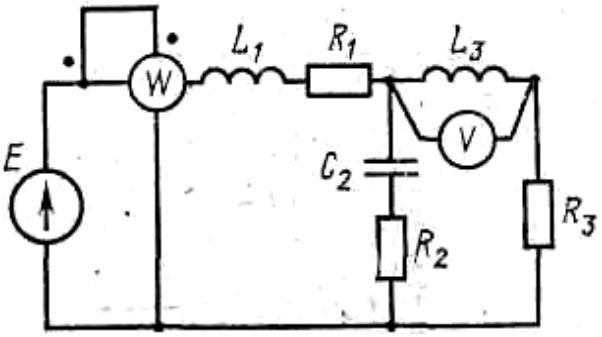

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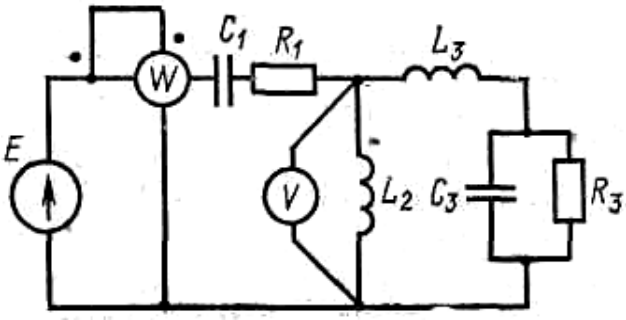

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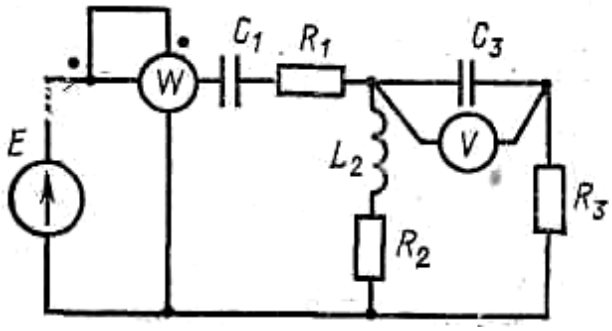
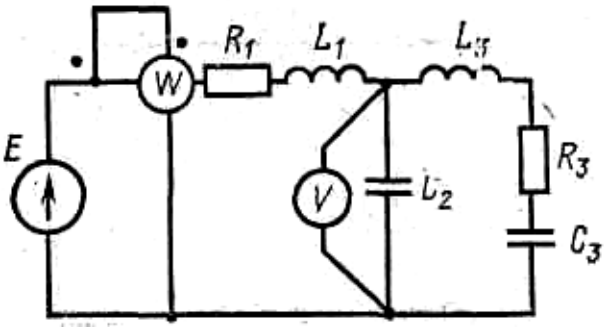
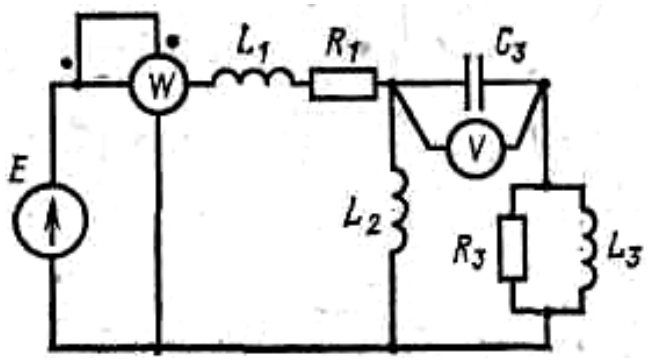


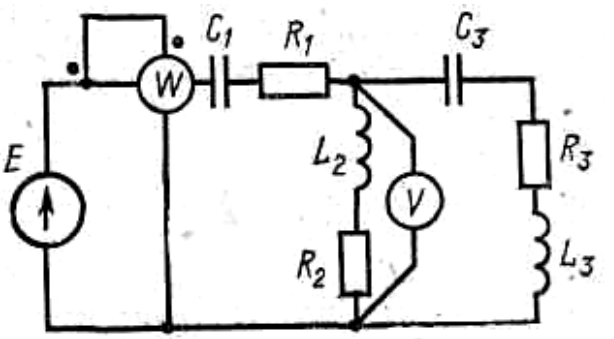
Rasm 2.37



Rasm 2.38



Rasm 2.39



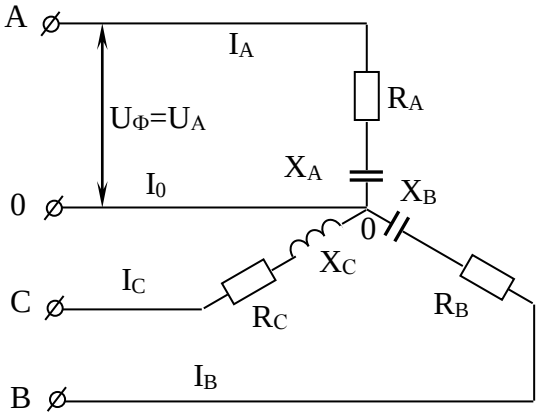
Rasm 2.40

3 – Masala.

8 - rasmda berilgan sxemada liniya kuchlanishi U_L =380 B. Qarshiliklar: R_A=10 Om, R_B =8 Om, R_C =10 Om, X_A =14 Om, X_B =8 Om, X_C =6 Om.

Quyidagilar aniqlansin:

1. Fazaviy va liniyaviy toklar, nol simdagi tok.
2. Ayrim fazalarning va butun zanjirning aktiv va reaktiv quvvatlari aniqlansin.
3. Tok va kuchlanishlarning vektor diagrammasi masshtabda qurilsin.



8 – rasm.

Masalaning echilishi:

1. Fazaviy va liniyaviy toklar, nol simdagi toklarni aniqlash:

1) Fazaviy kuchlanishni aniqlash: $U_Ф = \frac{U_Л}{\sqrt{3}} - = \frac{380}{1.73} = 220$ V.

2) Ayrim fazalarning to'la qarshiliklari:

$$Z_A = \sqrt{R_A^2 + x_A^2} = \sqrt{10^2 + 14^2} = \sqrt{296} = 17.6 \text{ Ом}; \quad Z_B = \sqrt{R_B^2 + x_B^2} = \sqrt{8^2 + 8^2} = \sqrt{128} = 11.2 \text{ Ом};$$

$$Z_C = \sqrt{R_C^2 + x_C^2} = \sqrt{12^2 + 6^2} = \sqrt{180} = 13.3 \text{ Ом}.$$

3) Ayrim fazalarning quvvat koefisienti:

$$\cos\varphi_A = \frac{R_A}{Z_A} = \frac{10}{17.6} = 0.57; \quad \sin\varphi_A = 0.81; \quad \cos\varphi_B = \frac{R_B}{Z_B} = \frac{8}{11.2} = 0.715; \quad \sin\varphi_B = 0.69;$$

$$\cos\varphi_C = \frac{R_C}{Z_C} = \frac{12}{13.3} = 0.9; \quad \sin\varphi_C = 1.42.$$

4) Fazaviy toklar bilan kuchlanishlar orasidagi siljish burchaklari:

$$\angle\varphi_A = 55^0; \qquad \angle\varphi_B = 44^0; \qquad \angle\varphi_C = -25^0.$$

5) Fazaviy toklarni aniqlash:

$$I_A = \frac{U_A}{Z_A} = \frac{220}{17.6} = 12.5 \text{ A}; \qquad I_B = \frac{U_B}{Z_B} = \frac{220}{11.2} = 19.7 \text{ A}; \qquad I_C = \frac{U_C}{Z_C} = \frac{220}{13.3} = 16.5 \text{ A}$$

Yulduz usulida ulashda liniyaviy toklar fazaviy toklarga teng bo'ladi, ya`ni $I_Л = I_Ф$.

2. Ayrim fazalarning va butun zanjirning aktiv va reaktiv quvvatlarini aniqlash:

1) Fazalarning aktiv quvvatlari;

$$P_A = U_A I_A \cos\varphi_A = 220 \cdot 12.5 \cdot 0.57 = 1570 \text{ Вт}; \qquad P_B = U_B I_B \cos\varphi_B = 220. \cdot 9.7 \cdot 0.715 = 3100 \text{ Вт};$$

$$P_C = U_C I_C \cos\varphi_C = 220 \cdot 16.5 \cdot 0.9 = 3275 \text{ Вт}.$$

2) Ayrim fazalarning reaktiv quvvatlari:

$$Q_A = U_A I_A \sin\varphi_A = 220 \cdot 12.5 \cdot 0.81 = -2220 \text{ Bap}; \qquad Q_B = U_B I_B \sin\varphi_B = 220.19.7.0.69 = -3000 \text{ Bap};$$

$$Q_C = U_C I_C \sin\varphi_C = 220 \cdot 16.5 \cdot 0.42 = 1520 \text{ Bap}.$$

3) Uch fazali zanjirning aktiv va reaktiv quvvatlari:

$$P_{3Ф} = P_A + P_B + P_C = 1570 + 3100 + 3275 = 7945 \text{ Вт};$$

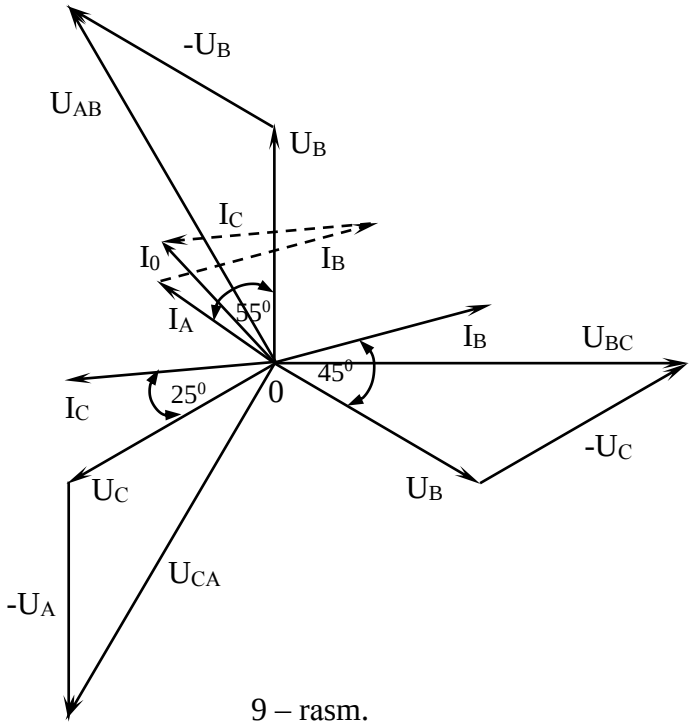
$$Q_{3Ф} = Q_A + Q_B + Q_C = -2220 - 3000 + 1520 = -3700 \text{ Bap}.$$

4) Uch fazali tokning to’la quvvati:

$$S = \sqrt{P_{3\Phi}^2 + Q_{3\Phi}^2} = \sqrt{7945^{\,2} + 3700^{\,2}} = 8765 \ \text{BA} = 8.765 \ \text{kBA}.$$

3. Tok va kuchlanishlarning vektor diagrammasi masshtabda qurish:

Tok va akuchlanishlar vektor diagrammasini qurishdan oldin masshtab tanlanadi. Masalan: kuchlanish vektori uchun 10 mm --- 100 V, tok vektori uchun 10 mm --- 5 A. Oldin simmetrik fazafiy kuchlanishlar vektorlari chiziladi. So’ngra yuk xarakteriga qarab fazaviy tok vektorlari chiziladi, siljish bo’rchaklari ma`lum (9 - rasm).

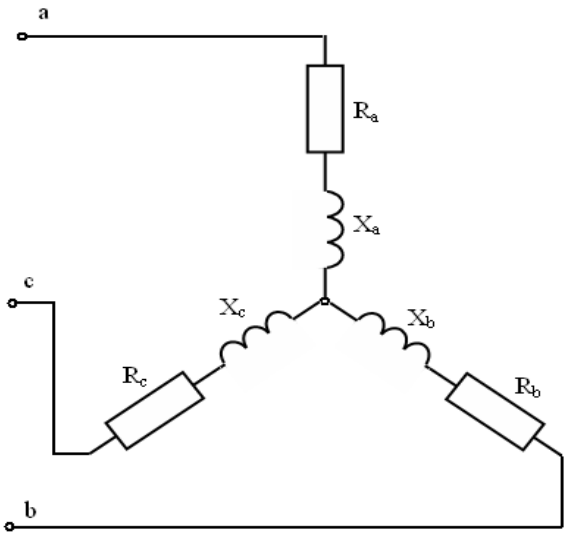


9 – rasm.

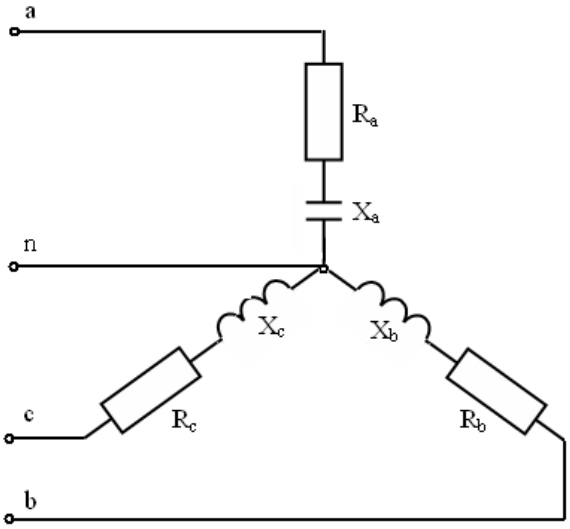
Nol sim toki fazaviy toklarning geometrik yigindisi bilan aniqlanadi, ya`ni $\dot{I}_0 = \dot{I}_A + \dot{I}_B + \dot{I}_C$. Nol sim toki vetorining uzunligini o’lchab, olingan masshtabda nol sim tokining qiymati aniqlanadi: $I_0 \cong 14$ A.

3 – masala bo'yicha variantlar

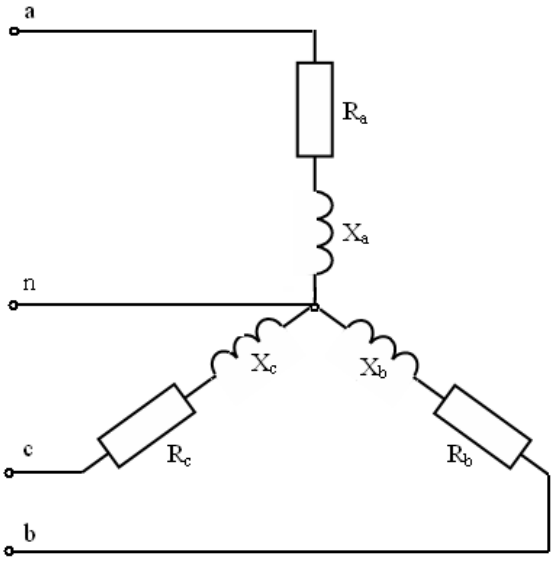
Raqamlar														
Variant	Rasmlar	U_l, V	R_a, Om	R_b, Om	R_c, Om	X_a, Om	X_b, Om	X_c, Om	R_{ab}, Om	R_{bc}, Om	R_{ca}, Om	X_{ab}, Om	X_{bc}, Om	X_{ca}, Om
1	3 1	220	8	8	8	6	6	6	–	–	–	–	–	–
2	3.1	380	8	8	8	6	6	6	–	–	–	–	–	–
3	3.2	127	3	4	6	4	3	8	–	–	–	–	–	–
4	3.2	220	8	4	6	4	3	8	–	–	–	–	–	–
5	3.2	380	8	4	6	4	3	8	–	–	–	–	–	–
6	3.3	127	4	8	6	3	4	8	–	–	–	–	–	–
7	3.3	220	4	8	6	3	4	9	–	–	–	–	–	–
8	3.3	380	4	3	6	8	4	8	–	–	–	–	–	–
9	3.4	127	16,8	8	8	14,2	6	4	–	–	–	–	–	–
10	3.4	220	16,8	8	8	14,2	6	4	–	–	–	–	–	–
11	3.4	380	16,8	8	8	8	6	4	–	–	–	–	–	–
12	3.5	127	10	–	–	–	10	10	–	–	–	–	–	–
13	3.5	220	10	–	–	–	10	10	–	–	–	–	–	–
14	3.5	380	10	–	–	–	10	10	–	–	–	–	–	–
15	3.6	127	–	–	–	–	–	–	8	8	8	6	6	6
16	3.6	220	–	–	–	–	–	–	8	8	8	6	6	6
17	3.6	380	–	–	–	–	–	–	8	8	8	6	6	6
18	3.7	127	–	–	–	–	–	–	8	4	6	4	3	8
19	3.7	220	–	–	–	–	–	–	8	4	6	4	3	8
20	3.7	380	–	–	–	–	–	–	8	4	6	4	3	6
21	3.8	127	–	–	–	–	–	–	4	8	6	3	4	6
22	3.8	220	–	–	–	–	–	–	4	8	6	3	4	8
23	3.8	380	–	–	–	–	–	–	4	8	6	3	4	8
24	3.9	127	–	–	–	–	–	–	16,8	8	3	14,2	6	4
25	3.9	220	–	–	–	–	–	–	16,8	8	3	14,2	6	4
26	3.9	380	–	–	–	–	–	–	16,8	8	3	14,2	6	4
27	3.10	127	–	–	–	–	–	–	–	–	–	–	10	10
28	3.10	220	–	–	–	–	–	–	–	–	–	–	10	10
29	3.10	380	–	–	–	–	–	–	–	–	–	–	10	10
30	3.11	127	10	–	–	–	10	10	–	–	–	–	–	–
31	3.11	220	10	–	–	–	10	10	–	–	–	–	–	–
32	3.11	380	10	–	–	–	10	10	–	–	–	–	–	–
33	3.12	127	15	–	–	–	5	5	–	–	–	–	–	–
34	3.12	220	15	–	–	–	5	5	–	–	–	–	–	–
35	3.12	380	15	–	–	–	5	5	–	–	–	–	–	–
36	3.13	127	–	–	–	–	–	–	–	3	8	4	6	8
37	3.13	220	–	–	–	–	–	–	–	3	8	4	6	8
38	3.13	380	–	–	–	–	–	–	–	3	8	4	6	8
39	3.14	127	–	–	–	–	–	–	8	4	8	–	6	10
40	3.14	220	–	–	–	–	–	–	8	4	8	–	6	10



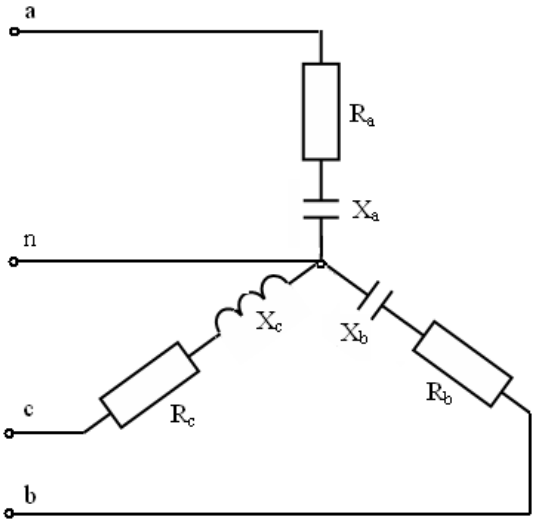
3.1 – rasm



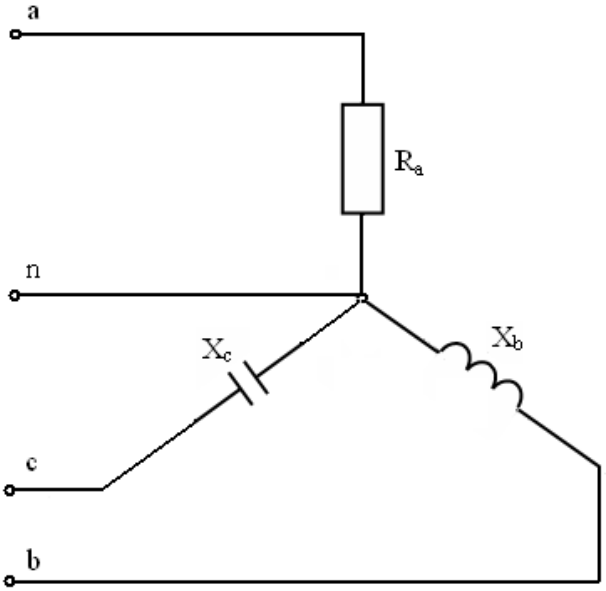
3.2 - rasm



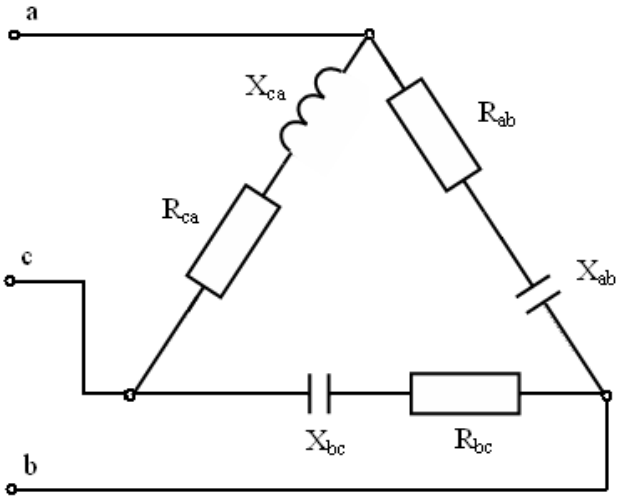
3.3 – rasm



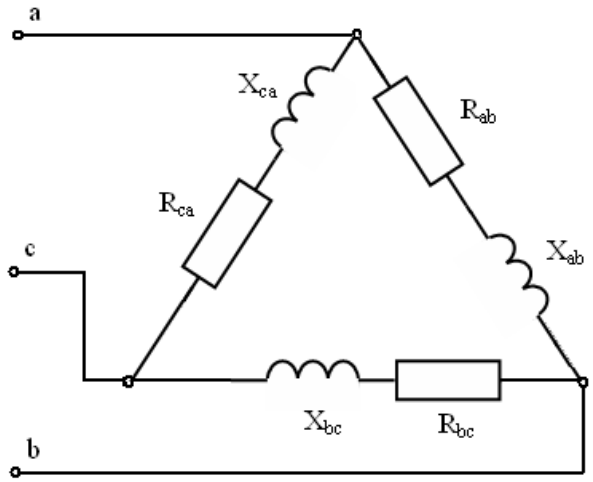
3.4 - rasm



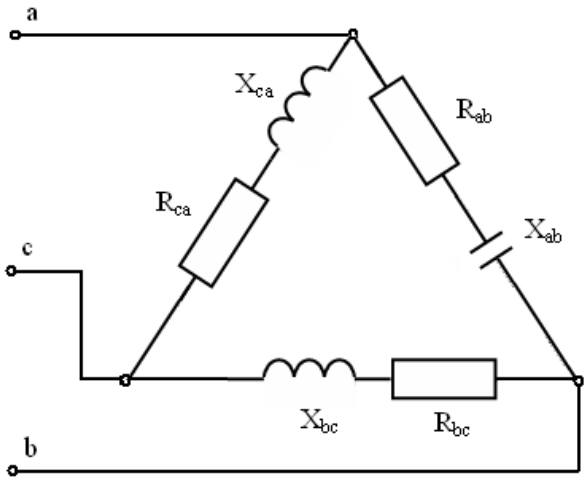
3.5 – rasm



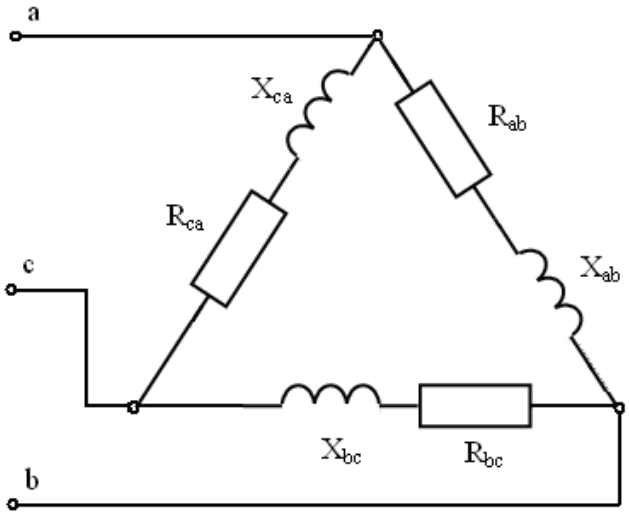
3.6 - rasm



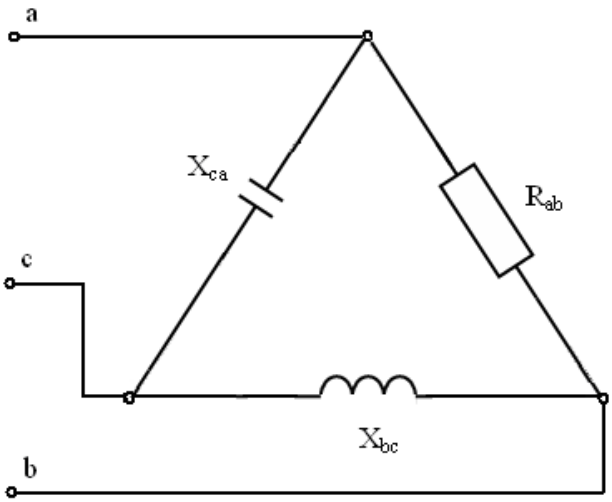
3.7 – rasm



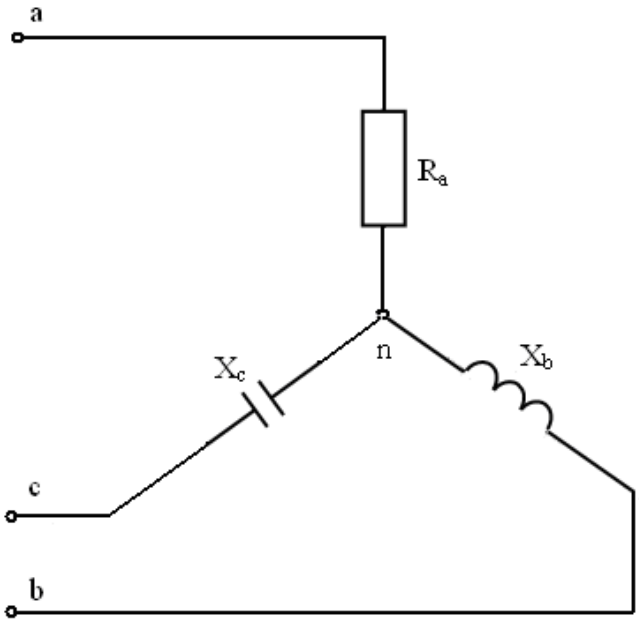
3.8 - rasm



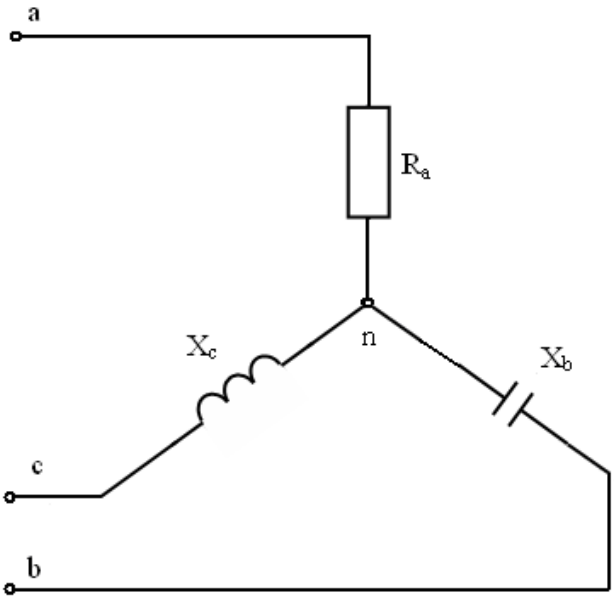
3.9 – rasm



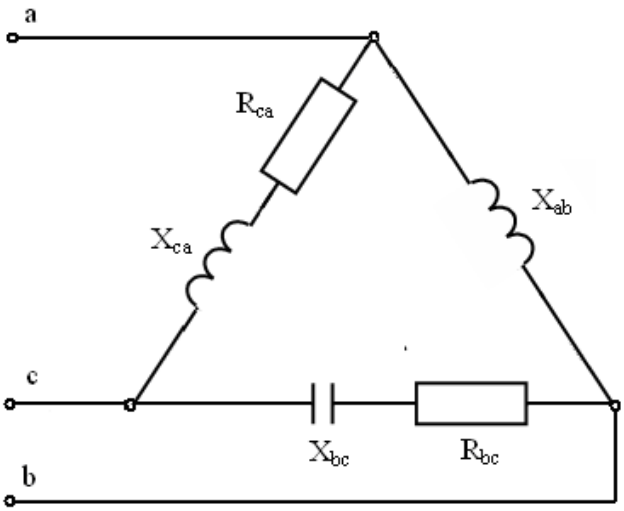
3.10 - rasm



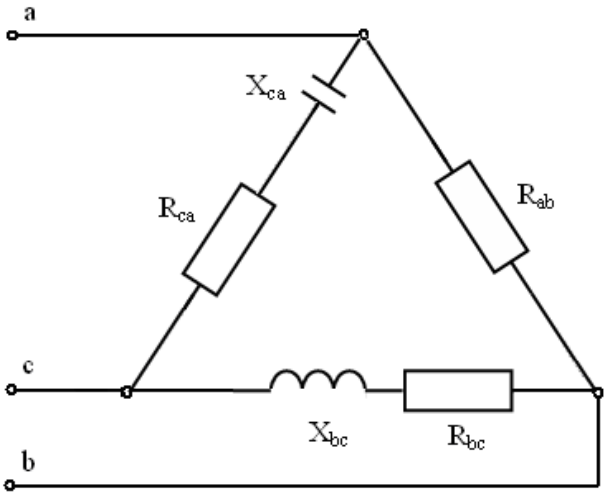
3.11 – rasm



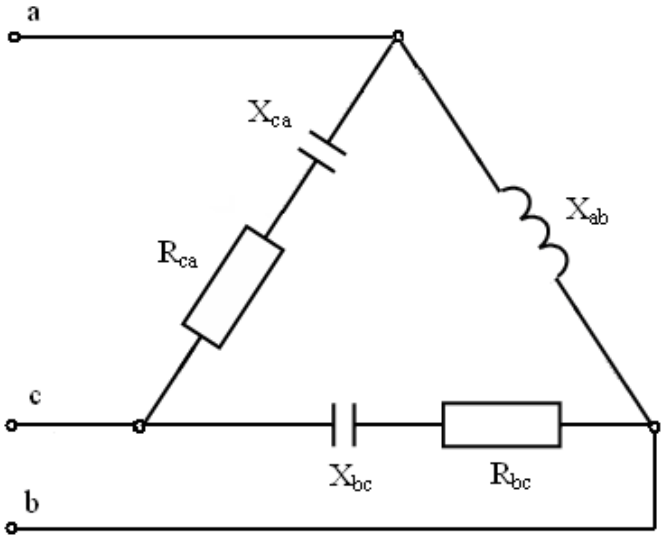
3.12 - rasm



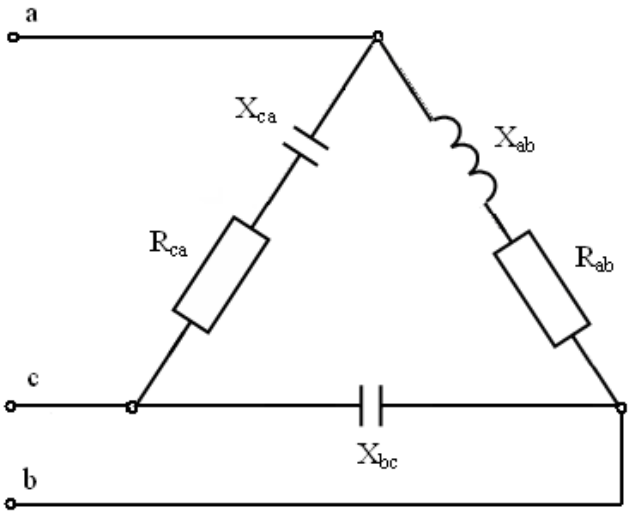
3.13 – rasm



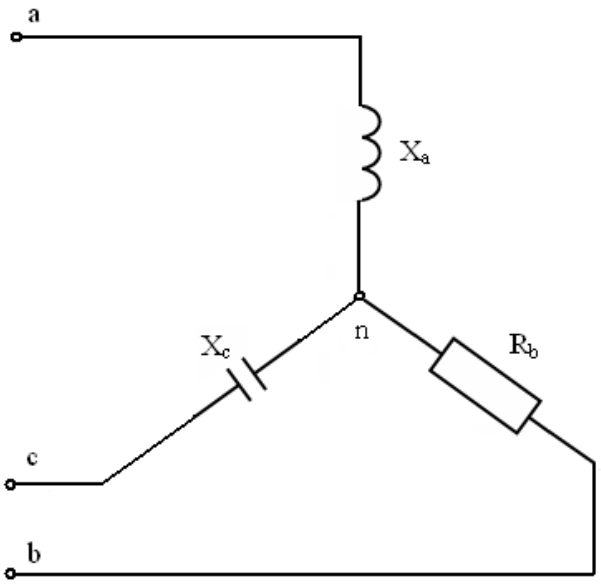
3.14 - rasm



3.15 – rasm



3.16 - rasm



3.17 – rasm