

10.1.

10.1.1.

(, ,)
 (,)

$$\underline{E} = E e^{j\psi_e}, \quad \underline{U} = U e^{j\psi_u}$$

$$\underline{I} = I e^{j\psi_i}$$

Im-Re.

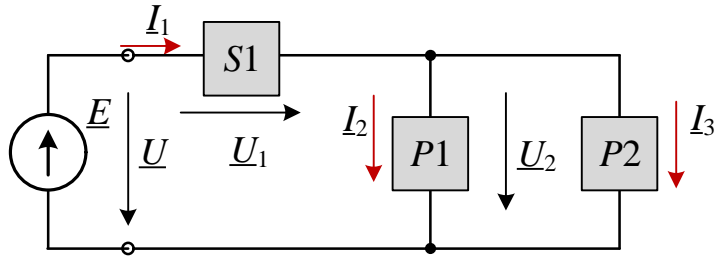
S1, P2 P3 (. 10.1,).
 R, L C (. 10.1,),
 (. . 10.1),
 R, L C (. 10.1,).

(. . 10.1,) S

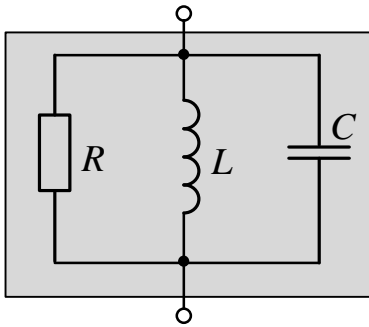
$$\underline{Z} = R + jX_L - jX_C = Z e^{j\varphi},$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad \varphi = \arctg[(X_L - X_C)/R] -$$

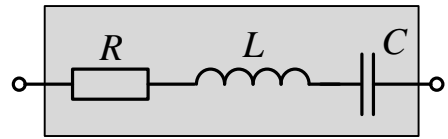
; R, X_L = ωL X_C = 1/ωC -



P (parallel connection)



S (serial connection)



. 10.1 -

(,)

()

Y ()
(. 10.1,)
:

$$\underline{Y} = 1/\underline{Z} = g - jb_L + jb_C = Ye^{-j\varphi},$$

$$Y = 1/Z = \sqrt{g^2 + (b_L - b_C)^2} \quad \varphi = \text{arctg}[(b_L - b_C)/g] -$$

$$g = 1/R, b_L = 1/X_L \quad b_C = 1/X_C - ,$$

(. 10.1,)

S (. 10.1,)

R X_L

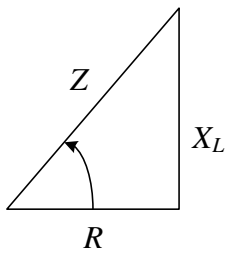
S :

$$\underline{Z}' = R' + jX'_L = g/Y^2 + j(b/Y^2),$$

$$R' = g/Y^2; X'_L = b/Y^2; Y = \sqrt{1/R^2 + 1/X_L^2}.$$

Z Y

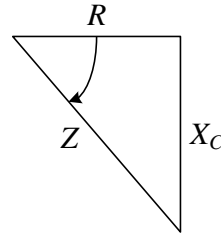
(. 10.2).



$$\underline{Z} = R + jX_L = Ze^{j\varphi}$$

$$Z = \sqrt{R^2 + X_L^2}$$

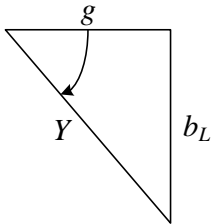
$$\varphi = \arctg \frac{X_L}{R}$$



$$\underline{Z} = R - jX_C = Ze^{j\varphi}$$

$$Z = \sqrt{R^2 + X_C^2}$$

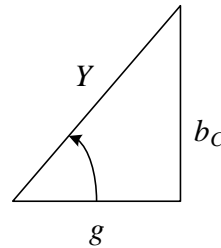
$$\varphi = \arctg \frac{-X_C}{R}$$



$$\underline{Y} = g - jb_L = Ye^{-j\varphi}$$

$$g = \frac{R}{Z^2} = \frac{R}{R^2 + X_L^2}$$

$$b_L = \frac{X_L}{Z^2} = \frac{X_L}{R^2 + X_L^2}$$



$$\underline{Y} = g + jb_C = Ye^{j\varphi}$$

$$g = \frac{R}{Z^2} = \frac{R}{R^2 + X^2}$$

$$b_L = \frac{X}{Z^2} = \frac{X}{R^2 + X^2}$$

10.2 –

R-L, R-C

$$\underline{I} = \underline{U}/\underline{Z},$$

$$\underline{I} = \underline{Y}\underline{U}, \quad \underline{U} = \underline{Z}\underline{I}$$

10.1.2.

(. 10.1,):

$$\underline{I}_1 = \underline{I}_2 + \underline{I}_3;$$

$$\underline{U} = \underline{U}_1 + \underline{U}_2,$$

$$\underline{I}_2 = \underline{Y}_2 \underline{U}_2; \underline{I}_3 = \underline{Y}_3 \underline{U}_2; \underline{I}_1 = (\underline{Y}_2 + \underline{Y}_3) \underline{U}_2,$$

$$\underline{I}_1 = \underline{U}/\underline{Z} = \underline{U}/[\underline{Z}_1 + (\underline{Z}_2 \underline{Z}_3)/(\underline{Z}_2 + \underline{Z}_3)]; \underline{Z}_2 = 1/\underline{Y}_2; \underline{Z}_3 = 1/\underline{Y}_3.$$

$$\underline{E} = e^{j30^\circ} \underline{U} = 10e^{j30^\circ};$$

$$\underline{Z}_1 = R - jX_C = 5 - j5 = 7,07e^{-j45^\circ};$$

$$\underline{Z}_2 = R + jX_L = 4 + j3 = 5e^{j37^\circ};$$

$$\underline{Z}_3 = -jX_C = 5e^{-j90^\circ}.$$

$$\underline{Y}_2 = 1/\underline{Z}_2 = 1/(5e^{j37^\circ}) = 0,2e^{-j37^\circ}; \underline{Y}_3 = 1/\underline{Z}_3 = 1/(5e^{-j90^\circ}) = 0,2e^{j90^\circ},$$

$$\underline{Y}_{23} = \underline{Y}_2 + \underline{Y}_3 = 0,2e^{-j37^\circ} + 0,2e^{j90^\circ} = 0,2\cos37^\circ - j0,2\sin37^\circ + j0,2 =$$

$$= 0,16 - j0,12 + j0,2 = 0,16 + j0,08 = 0,179e^{j26,5^\circ}.$$

$$\underline{Z} = \underline{Z}_1 + \underline{Z}_{23} = \underline{Z}_1 + 1/\underline{Y}_{23} = 7,07e^{-j45^\circ} + 5,59e^{-j26,5^\circ} = 5 - j5 + 5 - j2,5 =$$

$$= 10 - j7,5 = 12,5e^{-j37^\circ}$$

$$I_1 = \underline{U} / \underline{Z} = 10 e^{j30^\circ} / 12,5e^{-j37^\circ} = 0,8e^{j67^\circ}$$

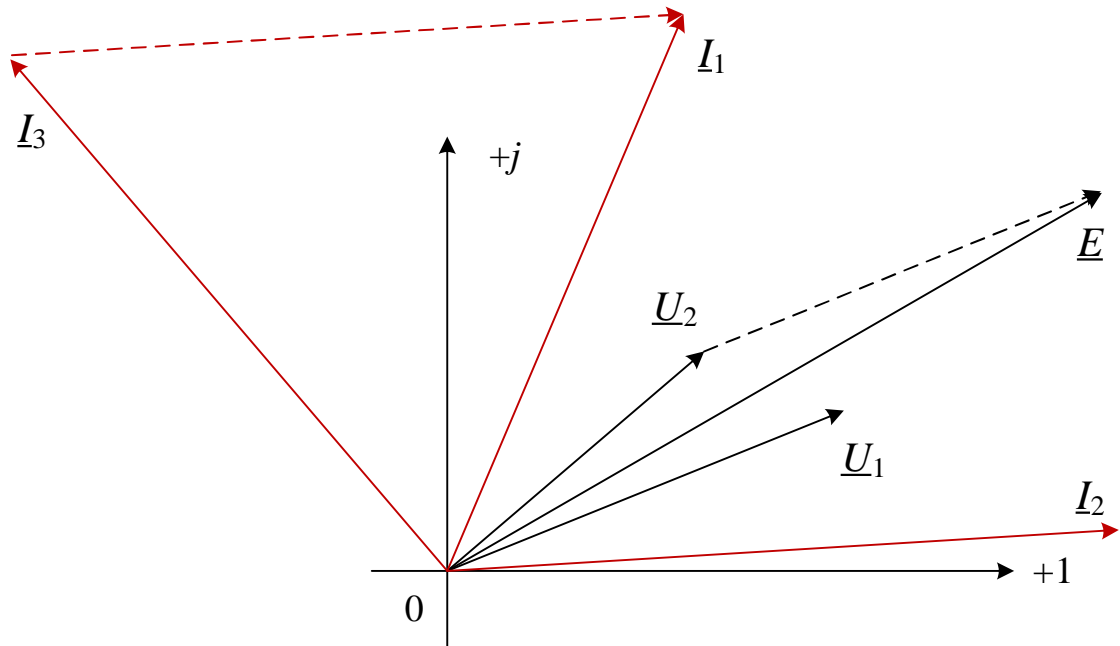
$$U_1 = Z_1 I_1 = 7,07e^{-j45^\circ} \cdot 0,8e^{j67^\circ} = 5,66e^{j22^\circ} \text{ B};$$

$$U_2 = Z_{23} I_1 = 5,59e^{-j26,5^\circ} \cdot 0,8e^{j67^\circ} = 4,47e^{j40,5^\circ} \text{ B};$$

$$I_2 = U_2 / Z_2 = 4,47e^{j40,5^\circ} / 5e^{j37^\circ} = 0,89e^{j3,5^\circ};$$

$$I_3 = U_2 / Z_3 = 4,47e^{j40,5^\circ} / 5e^{-j90^\circ} = 0,89e^{j130,5^\circ}$$

. 10.3.



10.3 –

10.2.

10.2.1.

(. . 10.1) . 10.1. . 10.2. , -

φ_k φ (?) .

10.1

	,	f,	S1			2			3		
			R ₁ ,	L ₁ ,	C ₁ ,	R ₂ ,	L ₂ ,	C ₂ ,	R ₃ ,	L ₃ ,	C ₃ ,
			1...10	2 + N	1000	–	0,6	5	6	0,2	–
11...20	1 + N	2000	4	0,4	–	4	–	8	8	0,4	–
N –											

10.2.2. Multisim

S1, P2, P3,

$$e = \sqrt{2}E \sin(2\pi ft),$$

$$R = 1$$

1, 2 3

$$R_V = 10$$

V, V1 V2,

0,05...0,1 /

f = 1...2 ,

(2...3)

$$u_R = iR ,$$

$$R = 1$$

$$A$$

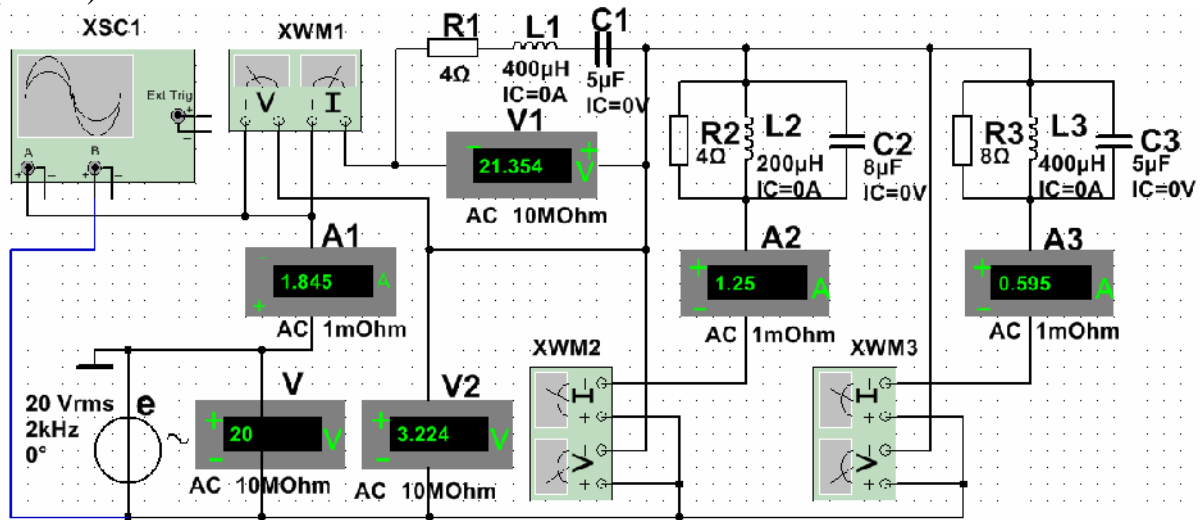
i,

1,

0,1 ... 0,5 / (mV/div),

, - 5...20 /

B,
(V/div).



10.4 -

Multisim

S

10.2

	f,	E,	φ,	U ₁ ,	I ₁ ,	φ ₁ ,	U ₂ ,	I ₂ ,	φ ₂ ,	U ₃ ,	I ₃ ,	φ ₃ ,
					A			A			A	
-	f											
	f											
	2f											
-				Z ₁ = U ₁ /I ₁ ,			Z ₂ = U ₂ /I ₂ ,			Z ₃ = U ₃ /I ₃ ,		
-	f											
-	2f											

Multisim (

«Run»).

$$\varphi_k = \psi_{uk} - \psi_{ik}, \quad k -$$

. 10.2.

$$\varphi = \psi - \psi_{il} = -\psi_{il}$$

$\varphi_1, \varphi_2, \varphi_3$,
 $| \varphi_k | = \arccos(P_k / U_k I_k)$, $P_k -$ $k-$;
 $U_k -$ $k-$; $I_k -$ $k-$; $k = 1, 2, 3$.

$$\varphi = 360^\circ \Delta t / T,$$

$\Delta t -$

u i_1 ;

$T = 1/f -$

$f -$

5 %

Multisim,

(. . 10.1).

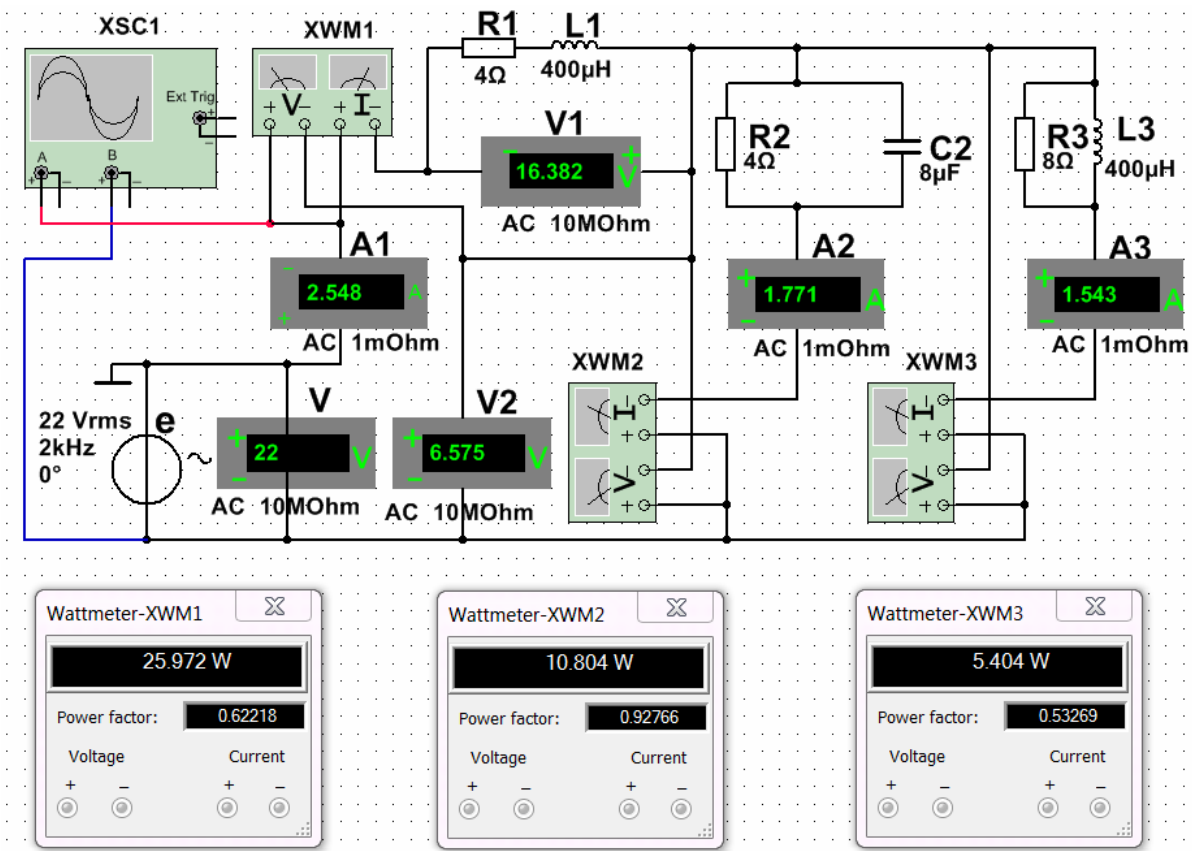
. 10.5

. 10.6 -

u i_1

21 (. . 10.1): $= 22$, $f = 2$, $R_1 = 4$,

$L_1 = 0,4$, $R_2 = 4$, $C_2 = 8$, $R_3 = 8$, $L_3 = 0,4$.



10.5 -

Multisim

21

$$\varphi_1 = \arccos(0,622) = 51,52^\circ; \varphi_2 = -\arccos(0,9276) = -21,93^\circ;$$

$$\varphi_3 = \arccos(0,53269) = 57,81^\circ; \varphi = 360 \cdot t/T = 360 \cdot 59,677/500 = 42,97^\circ.$$

$$\underline{Z}_1 = Z_1 e^{j\varphi_1} = (U_1 / I_1) e^{j\varphi_1} = (16,382/2,548) e^{j51,52^\circ} = 6,429 e^{j51,52^\circ} ;$$

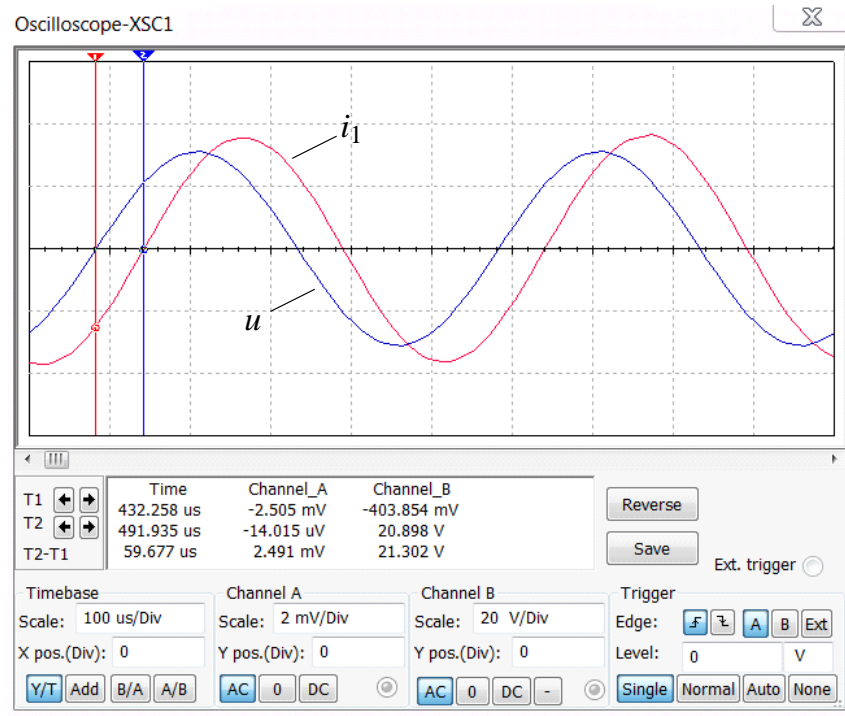
$$\underline{Z}_2 = Z_2 e^{-j\varphi_2} = (6,575/1,771) e^{-j21,93^\circ} = 3,713 e^{-j21,93^\circ} ;$$

$$\underline{Z}_3 = Z_3 e^{j\varphi_3} = (6,575/1,543) e^{j57,8125^\circ} = 4,26 e^{j57,81^\circ} .$$

$$\underline{Z} = Z e^{j\varphi} = (U / I_1) e^{j\varphi} = (22/2,548) e^{j42,97^\circ} = 8,63 e^{j42,97^\circ} .$$

$$= UI_1 \cos\varphi = 22 \cdot 2,548 \cdot \cos 42,97^\circ \approx 41,02 ,$$

$$= I_1 + I_2 + I_3 = 25,97 + 10,8 + 5,4 = 42,17 .$$



10.6 – u i_1

Multisim

10.2.3.

10.2.1,

f -

. 10.2.

. 10.2.

()

$$u(t) = e(t)$$

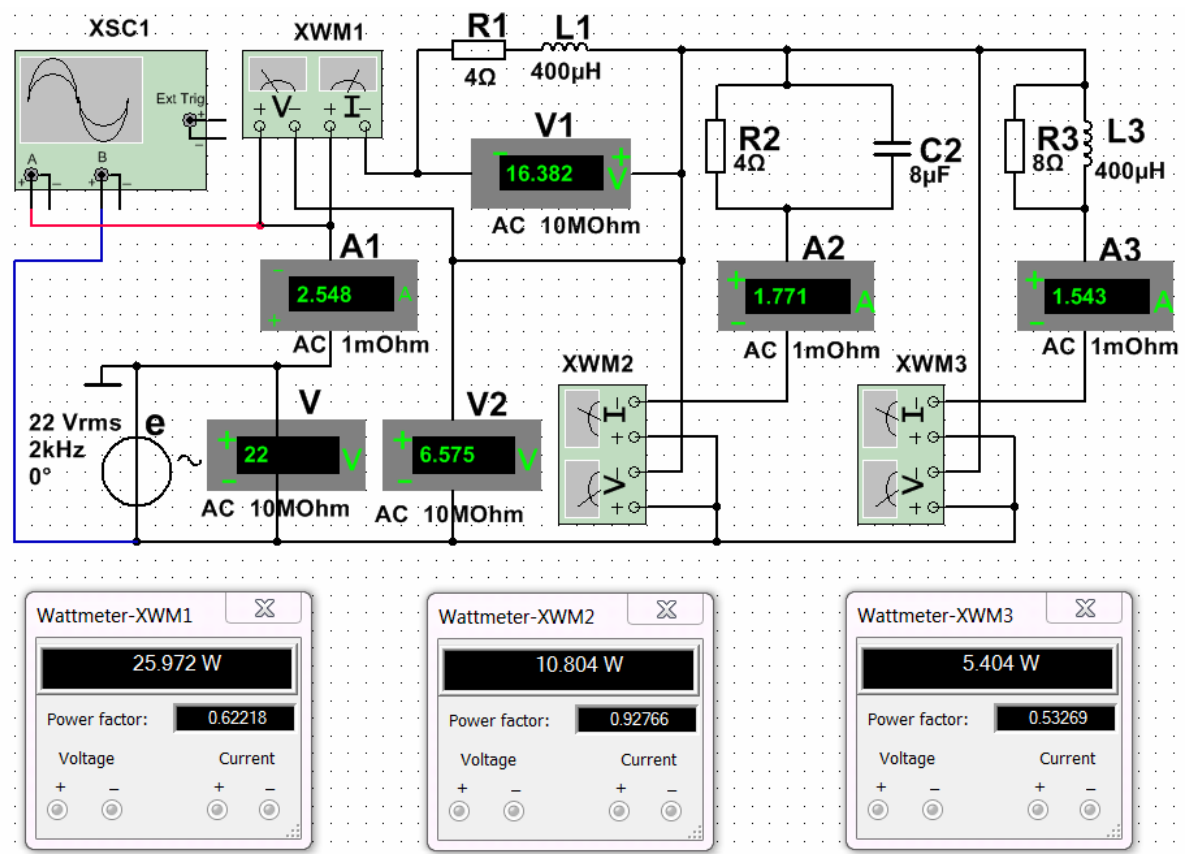
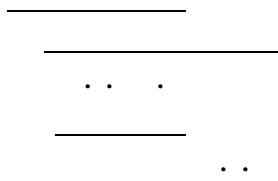
$i_1(t)$

f

- 1.
- 2.
- 3.
- 4.
- 5.

Multisim.

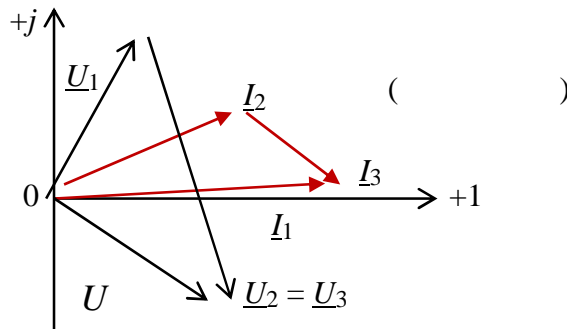
1. ?
 2. , -
 3. , ?
 4. .
 5. . -
 6. ? -
- ?
- ;
- ;



()

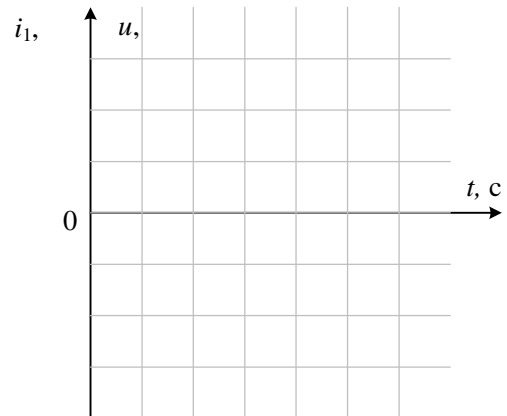
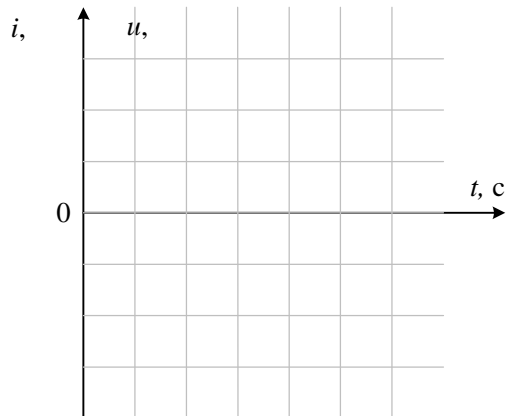
10.1

	,	$f,$	S1			2			3		
			$R_{1,}$	$L_{1,}$	$C_{1,}$	$R_{2,}$	$L_{2,}$	$C_{2,}$	$R_{3,}$	$L_{3,}$	$C_{3,}$
			1...10	$2 + N$	1000	-	0,6	5	6	0,2	-
11...20	$1 + N$	2000	4	0,4	-	4	-	8	8	0,4	-
$N -$											



10.2

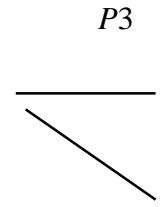
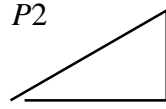
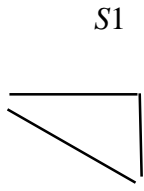
	$f,$	$E,$	$\varphi,$	$U_1,$	$I_1,$ A	$\varphi_1,$	$U_2,$	$I_2,$ A	$\varphi_2,$	$U_3,$	$I_3,$ A	$\varphi_3,$	
-	f												
	f												
	$2f$												
-													
-		$Z_1 = U_1/I_1,$				$Z_2 = U_2/I_2,$				$Z_3 = U_3/I_3,$			
-	f												
	$2f$												



Z_k

$R_k, L_k (X_{Ck})$

... $f = \dots$



$2f = \dots$

