

WYDZIAŁ
ELEKTROTECHNIKI
I INFORMATYKI
POLITECHNIKI RZESZOWSKIEJ

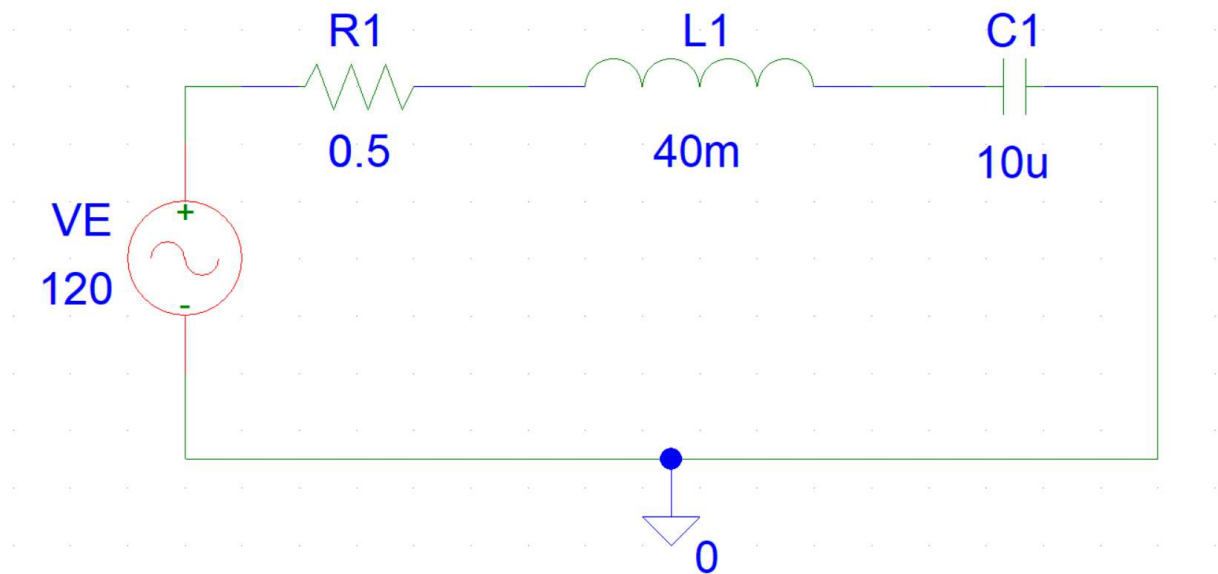
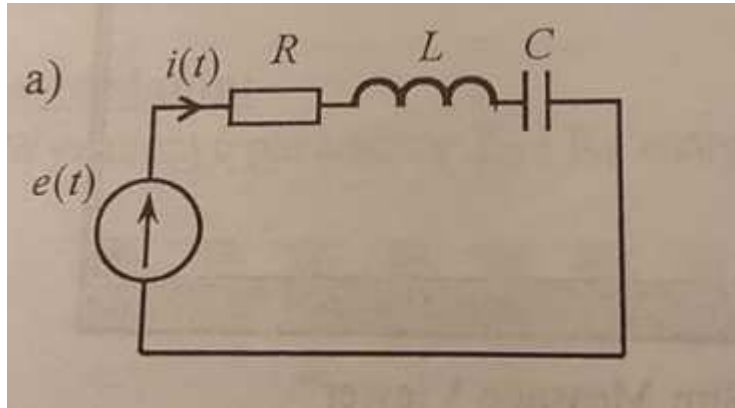
Katedra Elektrotechniki i Podstaw Informatyki

LABORATORIUM OBWODÓW I SYGNAŁÓW SPRAWOZDANIE

Ćw. nr	Temat		
3	Obwody prądu sinusoidalnie zmiennego.		
Opracowali		Rok / gr. lab.	Data wyk. ćw.
		1ET-DI / L2	27.01.2019

A) Analiza szeregowego obwodu RLC

Dane: $R=20\Omega$, $L=40\text{mH}$, $C=10\mu\text{F}$ $e(t)=120\sin(1000t)\text{V}$



Wyniki analizy komputerowej:

**** 01/27/19 13:20:24 **** Evaluation PSpice (Nov 1999)

* C:\Users\Norbert\Desktop\3 ois\lab_3_1.sch

**** CIRCUIT DESCRIPTION

* Schematics Version 9.1 - Web Update 1
* Sun Jan 27 13:19:40 2019

** Analysis setup **

.OPTIONS NOBIAS

.OPTIONS NOPAGE

.OP

.AC LIN 1 159.1549431 159.1549431

.PRINT AC VM(R_R1) VP(R_R1) VR(R_R1) VI(R_R1)

+VM(L_L1) VP(L_L1) VR(L_L1) VI(L_L1)

+VM(C_C1) VP(C_C1) VR(C_C1) VI(C_C1)

+IM(R_R1) IP(R_R1) IR(R_R1) II(R_R1)

* From [PSPICE NETLIST] section of pspiceev.ini:

.lib "nom.lib"

.INC "lab_3_1.net"

**** INCLUDING lab_3_1.net ****

* Schematics Netlist *

```
L_L1      $N_0001 $N_0002 40m
C_C1      $N_0002 0 10u
V_VE      $N_0003 0 AC 120 0
R_R1      $N_0003 $N_0001 20
```

```
**** RESUMING lab_3_1.cir ****
.INC "lab_3_1.als"
```

```
**** INCLUDING lab_3_1.als ****
* Schematics Aliases *
```

```
.ALIASES
L_L1      L1(1=$N_0001 2=$N_0002 )
C_C1      C1(1=$N_0002 2=0 )
V_VE      VE(+=$N_0003 -=0 )
R_R1      R1(1=$N_0003 2=$N_0001 )
.ENDALIASES
```

```
**** RESUMING lab_3_1.cir ****
.probe
```

```
.END
```

```
****   OPERATING POINT INFORMATION   TEMPERATURE =
27.000 DEG C
```

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ VM(R_R1) VP(R_R1) VR(R_R1) VI(R_R1)
VM(L_L1)

1.592E+02 3.795E+01 7.157E+01 1.200E+01 3.600E+01
7.589E+01

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ VP(L_L1) VR(L_L1) VI(L_L1) VM(C_C1)
VP(C_C1)

1.592E+02 1.616E+02 -7.200E+01 2.400E+01 1.897E+02
-1.844E+01

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ VR(C_C1) VI(C_C1) IM(R_R1) IP(R_R1) IR(R_R1)

1.592E+02 1.800E+02 -6.000E+01 1.897E+00 7.157E+01 6.000E-
01

**** AC ANALYSIS

TEMPERATURE = 27.000 DEG C

FREQ II(R_R1)

1.592E+02 1.800E+00

JOB CONCLUDED

TOTAL JOB TIME .02

Obliczenia ręczne:

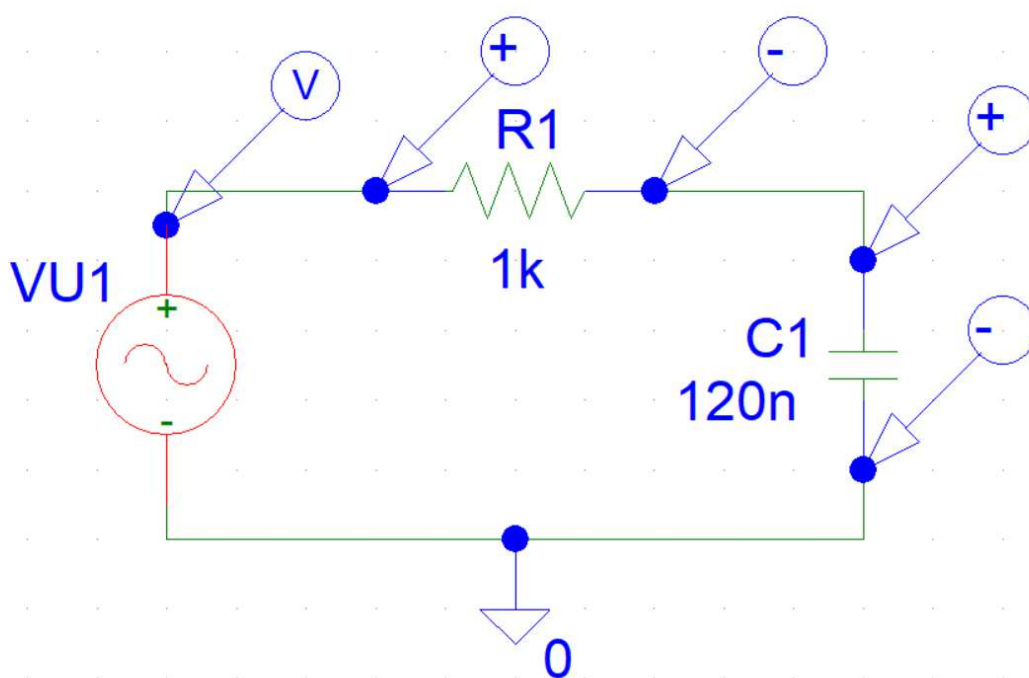
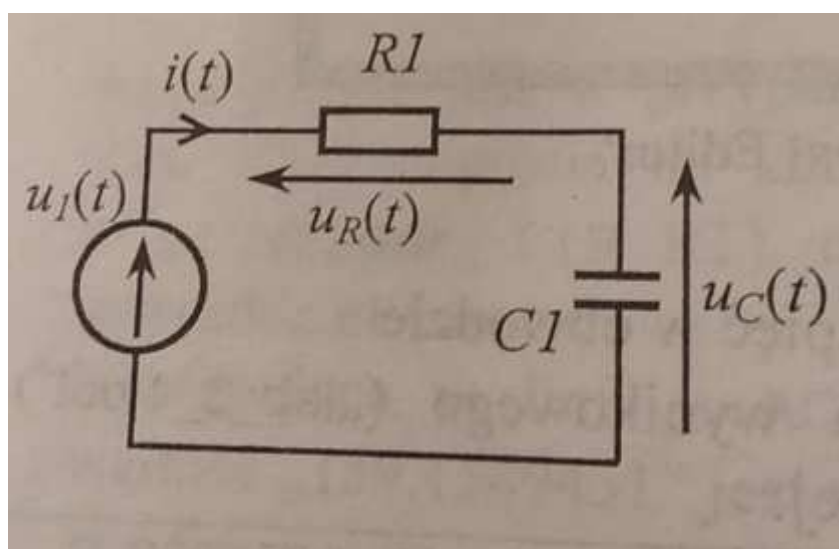
$R=20 \Omega$ $L=40 \text{ mH}$ $C=10 \mu\text{F}$
 $e(t)=110\sqrt{2}\sin(1000t) \text{ V}$
 $U=110 \text{ V}$ $\omega=1000 \frac{\text{rad}}{\text{s}}$ $U=110 \text{ V}$

$X_L = j\omega L = j1000 \cdot 40 \cdot 10^{-3} = j40 \Omega$
 $X_C = \frac{1}{j\omega C} = \frac{1}{j1000 \cdot 10 \cdot 10^{-6}} = -j100 \Omega$
 $Z = R + j(X_L - X_C) = 20 + j(40 - 100) = 20 - j60 = 63.24 \angle -71.56^\circ \Omega$
 $|Z| = \sqrt{20^2 + 60^2} = 63.24 \Omega$
 $\varphi = \arctg \frac{X_L - X_C}{R} = -71.56^\circ$
 $I = \frac{U}{|Z|} = \frac{110}{63.24} = 1.89 \angle 71.56^\circ \text{ A}$
 $U_R = R \cdot I = 37.8 \angle 71.56^\circ \text{ V}$
 $U_L = jX_L \cdot I = j40 \cdot 1.89 \angle 71.56^\circ = 75.6 \angle 161.56^\circ \text{ V}$
 $U_C = -jX_C \cdot I = -j100 \cdot 1.89 \angle 71.56^\circ = 189 \angle -18.44^\circ \text{ V}$
 $i(t) = 1.89\sqrt{2} \sin(1000t + 71.56^\circ) \text{ A}$
 $U_R(t) = 37.8\sqrt{2} \sin(1000t + 71.56^\circ) \text{ V}$
 $U_L(t) = 75.6\sqrt{2} \sin(1000t + 161.56^\circ) \text{ V}$ $\psi_{U_L} = \varphi_i + 90^\circ = 161.56^\circ$
 $U_C(t) = 189\sqrt{2} \sin(1000t - 18.44^\circ) \text{ V}$ $\psi_{U_C} = \varphi_i - 90^\circ = -18.44^\circ$
 $P = R \cdot I^2 = 20 \cdot (1.89)^2 = 71.442 \text{ W}$
 $Q = X_L \cdot I^2 - X_C \cdot I^2 = 142.884 - 357.216 = -214.326 \text{ VAR}$

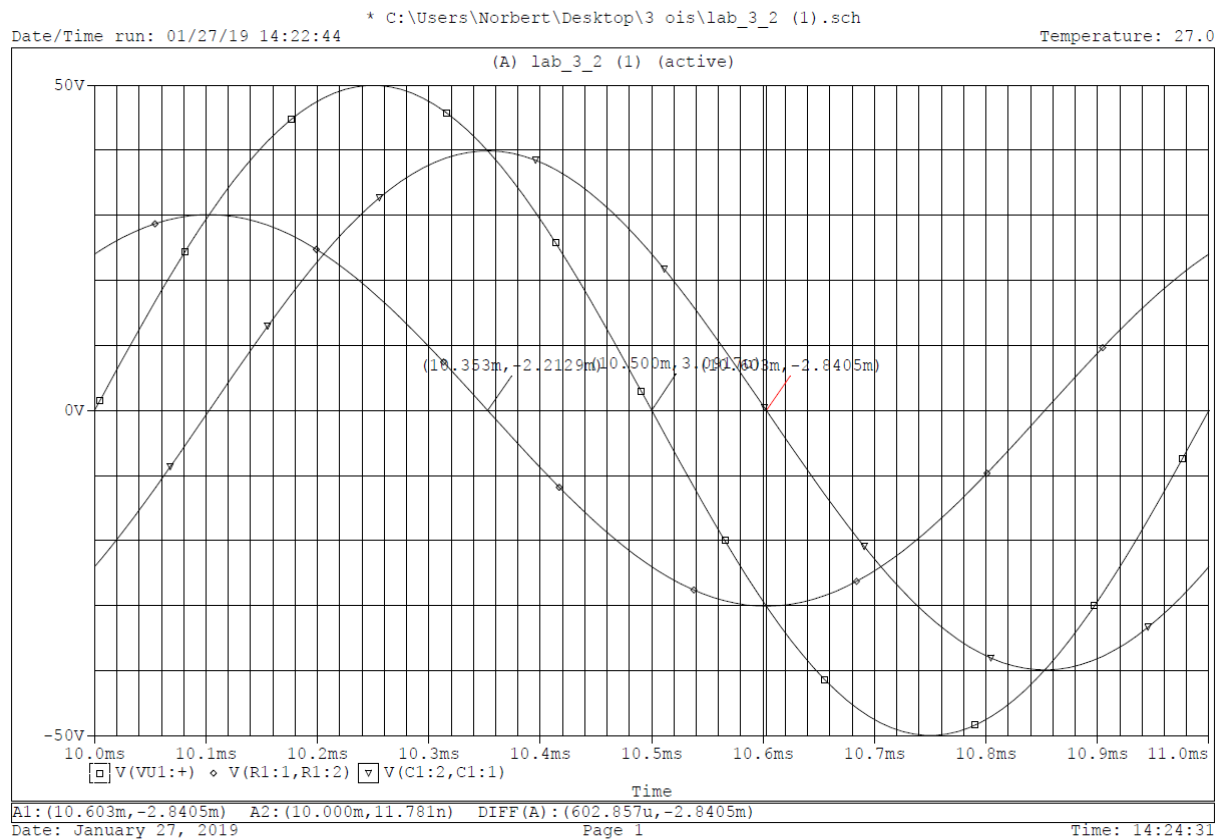
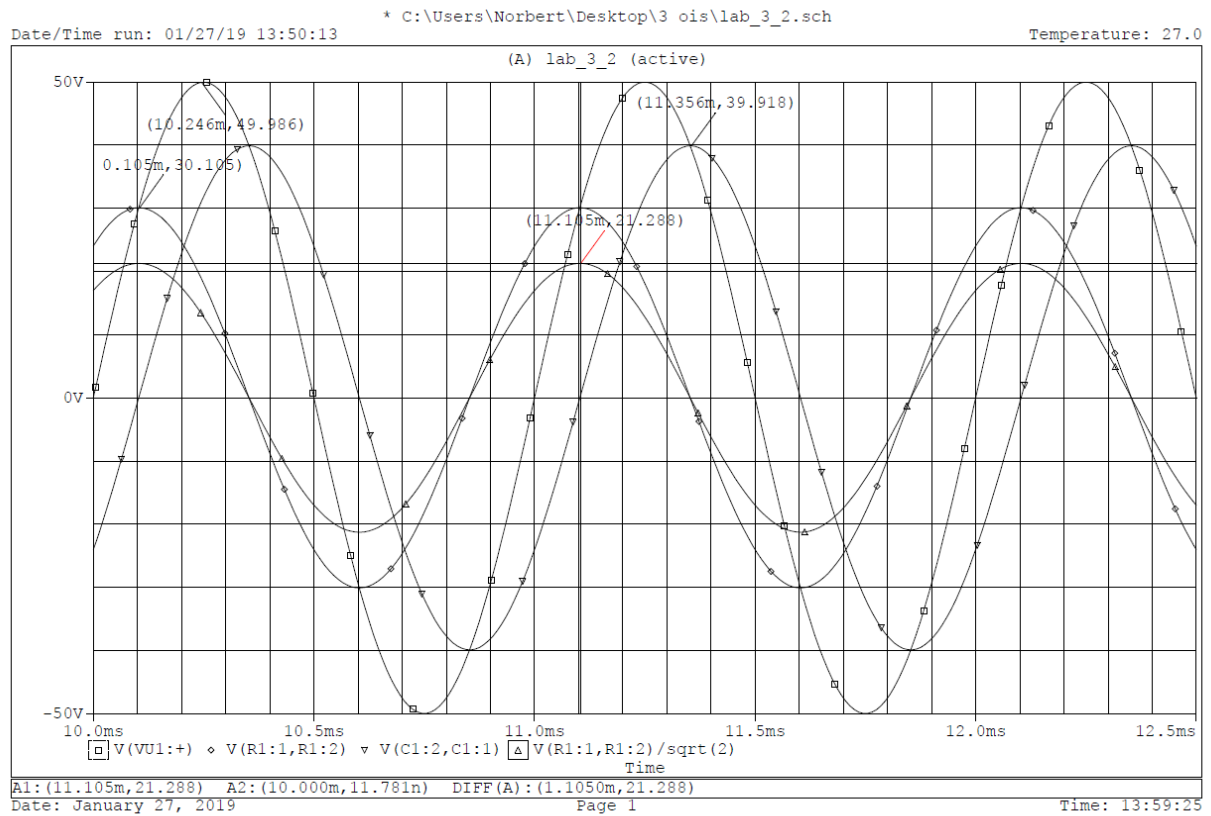
Wielkość	Wynik komputerowy	Wynik ręczny
$I[A]$	$1,897e^{j71,56}$	$1,89e^{j71,56}$
$\underline{U}_R[V]$	$37,95e^{j71,56}$	$37,8e^{j71,56}$
$\underline{U}_L[V]$	$75,89e^{j161,56}$	$75,6e^{j161,56}$
$\underline{U}_C[V]$	$189,7e^{-j18,44}$	$189e^{-j18,44}$

b) Analiza szeregowego obwodu RC

Dane: $R1=1k$, $C1=120nF$



Obliczenia komputerowe:



**** 01/27/19 14:22:44 **** Evaluation PSpice (Nov 1999)

* C:\Users\Norbert\Desktop\3 ois\lab_3_2 (1).sch

**** CIRCUIT DESCRIPTION

* Schematics Version 9.1 - Web Update 1
* Sun Jan 27 14:22:40 2019

** Analysis setup **
.tran 10u 12.5m 10m 10u
.OPTIONS NOBIAS
.OPTIONS NOPAGE
.OP

* From [PSPICE NETLIST] section of pspiceev.ini:
.lib "nom.lib"

.INC "lab_3_2 (1).net"

**** INCLUDING "lab_3_2 (1).net" ****
* Schematics Netlist *

R_R1 \$N_0002 \$N_0001 1k

```
C_C1      0 $N_0001 120n
V_VU1     $N_0002 0
+SIN 0 50 1k 0 0 0
```

```
**** RESUMING "lab_3_2 (1).cir" ****
.INC "lab_3_2 (1).als"
```

```
**** INCLUDING "lab_3_2 (1).als" ****
* Schematics Aliases *
```

```
.ALIASES
R_R1      R1(1=$N_0002 2=$N_0001 )
C_C1      C1(1=0 2=$N_0001 )
V_VU1     VU1(+= $N_0002 -=0 )
.ENDALIASES
```

```
**** RESUMING "lab_3_2 (1).cir" ****
.probe
```

```
.END
```

```
****   OPERATING POINT INFORMATION   TEMPERATURE =
27.000 DEG C
```

JOB CONCLUDED

TOTAL JOB TIME .02

Obliczenia ręczne:

$R = 1k\Omega$
 $C = 100nF$
 $f = 1kHz$
 $U_m = 50V$

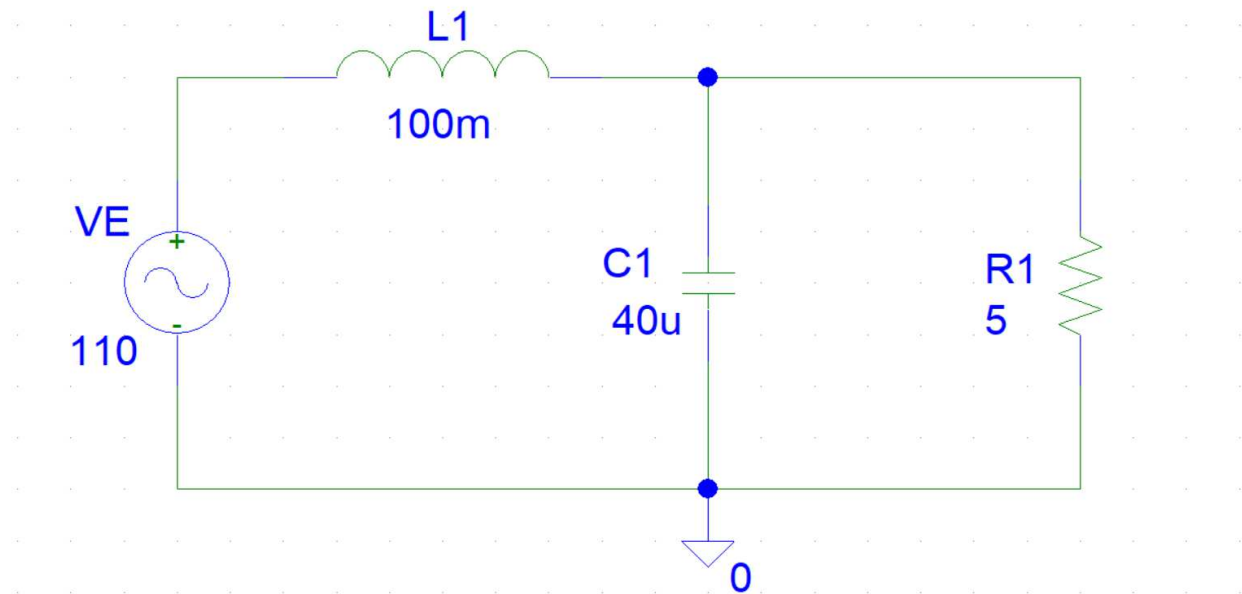
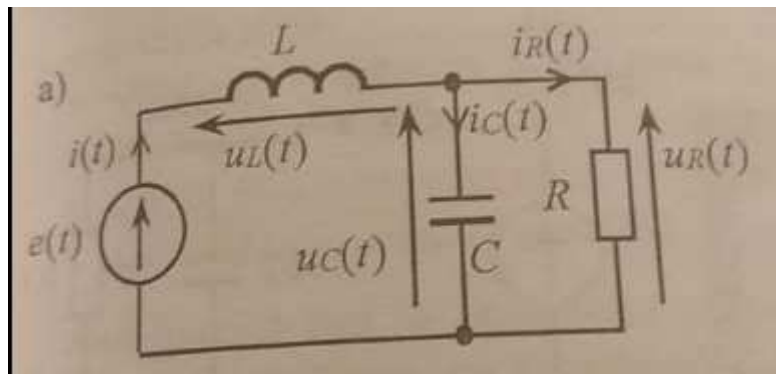
$\varphi_C = \frac{\omega C}{1} \cdot 360^\circ = \frac{10^3 \cdot 10^{-7}}{1} \cdot 360^\circ = -36^\circ$
 $\varphi_R = \frac{\omega R}{1} \cdot 360^\circ = \frac{10^3 \cdot 10^{-3}}{1} \cdot 360^\circ = 54^\circ$
 $U = \frac{U_m}{\sqrt{2}} = 35,355$
 $\omega = 2\pi f = 6283,185 \frac{rad}{s}$
 $u(t) = 35,355\sqrt{2} \sin(6283,185t - 36^\circ) = 50 \sin(6283,185t - 36^\circ) V$
 $X_C = \frac{1}{\omega C} = \frac{1}{6283,185 \cdot 10^{-7}} = 1326,291 \Omega$
 $Z = R - jX_C = 100 - j1326,291 = 1361,088 e^{-j52,984^\circ}$
 $I = \frac{U}{Z} = \frac{35,355}{1361,088} e^{j52,984^\circ} = 0,021 e^{j52,984^\circ}$
 $U_R = R \cdot I = 100 \cdot 0,021 = 2,1 e^{j52,984^\circ} V$
 $U_C = X_C \cdot I = 1326,291 \cdot 0,021 = 27,852 V$
 $u_R(t) = 29,698 \sin(6283,185t + 52,98^\circ) V$
 $u_C(t) = 39,915 \sin(6283,185t - 37,02^\circ) V$

Phasor diagram showing vectors U_R and U_C with angles 54° and -36° respectively from the reference axis.

Wielkość	Wyniki komputerowe	Wyniki ręczne
$u(t)[V]$	$49,996\sin(6283,185t)$	$50\sin(6283,185t)$
$u_R(t)[V]$	$30,105\sin(6283,185t+52,98)$	$29,698\sin(6283,185t+52,98)$
$u_C(t)[V]$	$39,918\sin(6283,185-37,02)$	$39,915\sin(6283,185-37,02)$

c) Wyznaczanie wartości prądów i napięć w obwodzie

Dane: $L=19,1\text{mH}$, $C=40\mu\text{F}$, $R=5\Omega$



Obliczenia komputerowe:

**** 01/27/19 17:16:08 ***** Evaluation PSpice (Nov 1999)

* C:\Users\Norbert\Desktop\3 ois\lab_3_3.sch

**** CIRCUIT DESCRIPTION

* Schematics Version 9.1 - Web Update 1
* Sun Jan 27 17:14:51 2019

** Analysis setup **

.OPTIONS NOBIAS

.OPTIONS NOPAGE

.OP

.AC LIN 1 50 50

.PRINT AC VM(R_R1) VP(R_R1) VR(R_R1) VI(R_R1)

+VM(L_L1) VP(L_L1) VR(L_L1) VI(L_L1)

+VM(C_C1) VP(C_C1) VR(C_C1) VI(C_C1)

+IM(R_R1) IP(R_R1) IR(R_R1) II(R_R1)

+IM(L_L1) IP(L_L1) IR(L_L1) II(L_L1)

+IM(C_C1) IP(C_C1) IR(C_C1) II(C_C1)

* From [PSPICE NETLIST] section of pspiceev.ini:

.lib "nom.lib"

.INC "lab_3_3.net"

**** INCLUDING lab_3_3.net ****

* Schematics Netlist *

R_R1 \$N_0001 0 5

C_C1 \$N_0001 0 318u

L_L1 \$N_0002 \$N_0001 19.1m

V_VE \$N_0002 0 AC 219.9102 -90

**** RESUMING lab_3_3.cir ****

.INC "lab_3_3.als"

**** INCLUDING lab_3_3.als ****

* Schematics Aliases *

.ALIASES

R_R1 R1(1=\$N_0001 2=0)

C_C1 C1(1=\$N_0001 2=0)

L_L1 L1(1=\$N_0002 2=\$N_0001)

V_VE VE(+= \$N_0002 -=0)

.ENDALIASES

**** RESUMING lab_3_3.cir ****

.probe

.END

**** OPERATING POINT INFORMATION TEMPERATURE =
27.000 DEG C

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ VM(R_R1) VP(R_R1) VR(R_R1) VI(R_R1)
VM(L_L1)

5.000E+01 1.738E+02 -1.615E+02 -1.649E+02 -5.503E+01

2.332E+02

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ VP(L_L1) VR(L_L1) VI(L_L1) VM(C_C1)
VP(C_C1)

5.000E+01 -4.500E+01 1.649E+02 -1.649E+02 1.738E+02
-1.615E+02

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ VR(C_C1) VI(C_C1) IM(R_R1) IP(R_R1) IR(R_R1)

5.000E+01 -1.649E+02 -5.503E+01 3.476E+01 -1.615E+02
-3.298E+01

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ II(R_R1) IM(L_L1) IP(L_L1) IR(L_L1) II(L_L1)

5.000E+01 -1.101E+01 3.886E+01 -1.350E+02 -2.748E+01
-2.748E+01

**** AC ANALYSIS

TEMPERATURE = 27.000 DEG C

FREQ	IM(C_C1)	IP(C_C1)	IR(C_C1)	II(C_C1)
------	----------	----------	----------	----------

5.000E+01	1.737E+01	-7.154E+01	5.498E+00	-1.647E+01
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JOB CONCLUDED

TOTAL JOB TIME .02

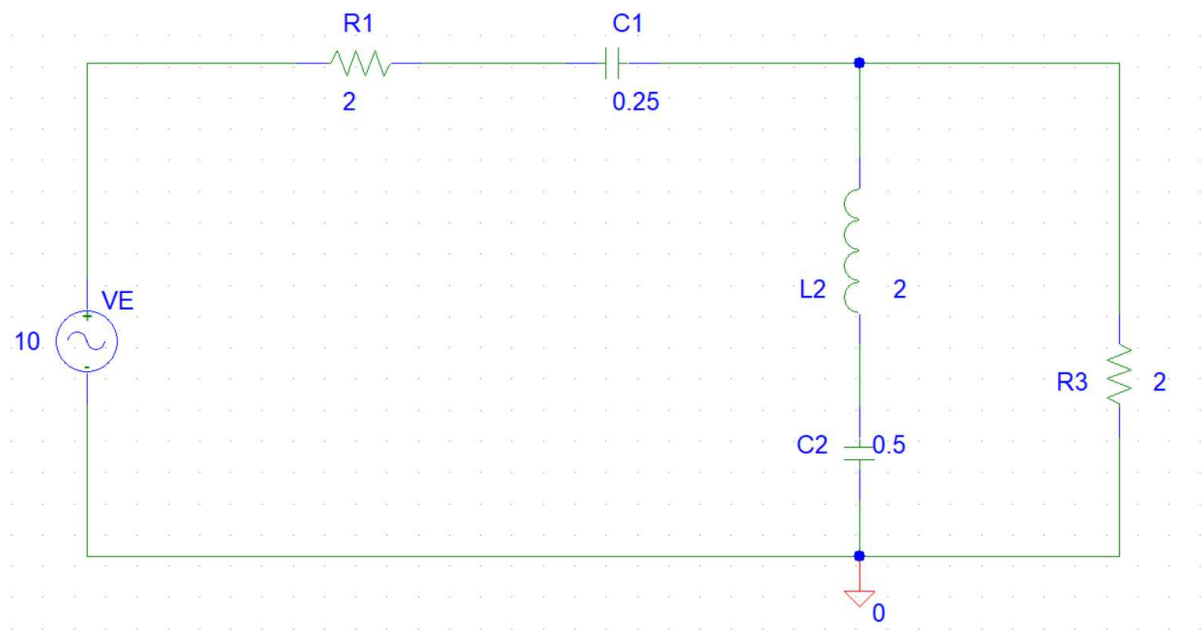
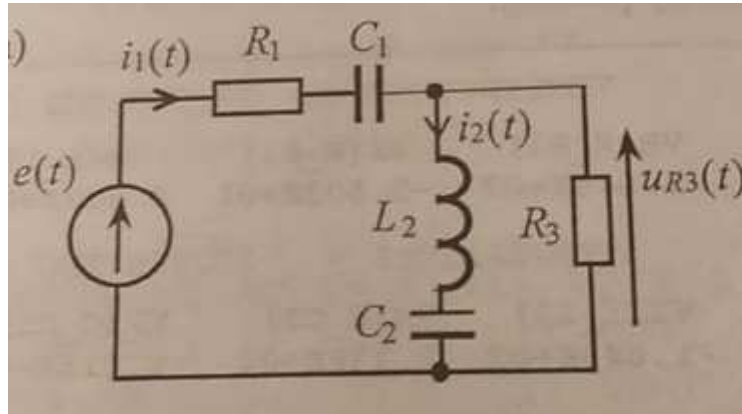
Obliczenia ręczne

$\omega = 2\pi f = 2.50 \cdot 10^3 \text{ rad/s}$
 $X_L = \omega L = 314.16 \cdot 10^{-3} = 0.314 \text{ } \Omega$
 $X_C = \frac{1}{\omega C} = \frac{1}{314.16 \cdot 10^{-6}} = 318.31 \text{ } \Omega$
 $\varphi_C = \arctg \frac{X_C}{R} = \arctg \frac{318.31}{5} = 89.05^\circ$
 $Z_{RC} = \frac{R \cdot X_C}{R + jX_C} = \frac{5 \cdot j318.31}{5 + j318.31} = \frac{j1591.55}{5 + j318.31} = 4.97 \angle -89.05^\circ \text{ } \Omega$
 $Z_{LC} = \frac{X_L \cdot X_C}{X_L + jX_C} = \frac{j314.16 \cdot j318.31}{j314.16 + j318.31} = \frac{-99999.86}{j6.15} = 16097.53 \angle -90^\circ \text{ } \Omega$
 $Z_{RL} = \frac{R \cdot X_L}{R + jX_L} = \frac{5 \cdot j0.314}{5 + j0.314} = 1.57 \angle 90^\circ \text{ } \Omega$
 $Z_{RLC} = Z_{RC} + Z_{LC} + Z_{RL} = 4.97 \angle -89.05^\circ + 16097.53 \angle -90^\circ + 1.57 \angle 90^\circ = 16104.07 \angle -90^\circ \text{ } \Omega$
 $I = \frac{U}{Z_{RLC}} = \frac{240 \angle 0^\circ}{16104.07 \angle -90^\circ} = 14.9 \angle 90^\circ \text{ A}$
 $U_R = I \cdot R = 14.9 \cdot 5 = 74.5 \angle 90^\circ \text{ V}$
 $U_L = I \cdot X_L = 14.9 \cdot 0.314 = 4.68 \angle 90^\circ \text{ V}$
 $U_C = I \cdot X_C = 14.9 \cdot 318.31 = 4742.82 \angle -90^\circ \text{ V}$
 $P = I^2 R = 14.9^2 \cdot 5 = 1105.05 \text{ W}$
 $Q = I^2 X_L = 14.9^2 \cdot 0.314 = 7.05 \text{ VAR}$
 $Q_C = I^2 X_C = 14.9^2 \cdot 318.31 = 7058.27 \text{ VAR}$
 $i(t) = 14.9 \sin(\omega t + 90^\circ) = 14.9 \cos(\omega t) \text{ A}$
 $i_R(t) = 14.9 \cos(\omega t) \text{ A}$
 $i_L(t) = 14.9 \cos(\omega t) \text{ A}$
 $i_C(t) = 14.9 \cos(\omega t) \text{ A}$

Wielkość	Wynik komputerowy	Wynik ręczny
\underline{I}	$38,86e^{-j135}$	$38,880e^{-j135,144}$
\underline{I}_{L1}	$38,86e^{-j135}$	$38,880e^{-j135,144}$
\underline{I}_{C1}	$17,37e^{-j71,54}$	$17,387e^{-j71,709}$
\underline{I}_{R1}	$34,76e^{-j161,5}$	$34,774e^{-j161,705}$
\underline{U}_{L1}	$233,2e^{-j45}$	$233,28e^{-j45,144}$
\underline{U}_{C1}	$173,8e^{-j161,5}$	$173,871e^{-j161,709}$
\underline{U}_{R1}	$173,8e^{-j161,5}$	$173,871e^{-j161,709}$

d) Wyznaczanie wartości prądów i napięć w obwodzie

Dane: $R_1=2\Omega$, $C_1=0,25F$, $L_2=2H$, $C_2=0,5F$, $R_3=2\Omega$



Obliczenia komputerowe

**** 01/27/19 17:56:13 ***** Evaluation PSpice (Nov 1999)

* C:\Users\Norbert\Desktop\3 ois\Schematic2.sch

**** CIRCUIT DESCRIPTION

* Schematics Version 9.1 - Web Update 1
* Sun Jan 27 17:55:14 2019

** Analysis setup **
.OPTIONS NOBIAS
.OPTIONS NOPAGE
.OP
.AC LIN 1 0.159155 0.159155
.PRINT AC IM(R_R1) IP(R_R1) IR(R_R1) II(R_R1)
+IM(L_L2) IP(L_L2) IR(L_L2) II(L_L2)
+VM(R_R3) VP(R_R3) VR(R_R3) VI(R_R3)

* From [PSPICE NETLIST] section of pspiceev.ini:
.lib "nom.lib"

.INC "Schematic2.net"

**** INCLUDING Schematic2.net ****
* Schematics Netlist *

R_R1 \$N_0002 \$N_0001 2
C_C1 \$N_0001 \$N_0003 0.25
L_L2 \$N_0004 \$N_0003 2
R_R3 0 \$N_0003 2
C_C2 0 \$N_0004 0.5
V_VE \$N_0002 0 DC 0V AC 10 15

```
**** RESUMING Schematic2.cir ****
.INC "Schematic2.als"
```

```
**** INCLUDING Schematic2.als ****
* Schematics Aliases *
```

```
.ALIASES
R_R1      R1(1=$N_0002 2=$N_0001 )
C_C1      C1(1=$N_0001 2=$N_0003 )
L_L2      L2(1=$N_0004 2=$N_0003 )
R_R3      R3(1=0 2=$N_0003 )
C_C2      C2(1=0 2=$N_0004 )
V_VE      VE(+= $N_0002 -=0 )
.ENDALIASES
```

```
**** RESUMING Schematic2.cir ****
.probe
```

```
.END
```

```
****   OPERATING POINT INFORMATION   TEMPERATURE =
27.000 DEG C
```

```
****   AC ANALYSIS                     TEMPERATURE = 27.000 DEG C
```

FREQ IM(R_R1) IP(R_R1) IR(R_R1) II(R_R1) IM(L_L2)

1.592E-01 2.236E+00 7.843E+01 4.483E-01 2.191E+00
2.236E+00

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ IP(L_L2) IR(L_L2) II(L_L2) VM(R_R3) VP(R_R3)

1.592E-01 7.843E+01 4.483E-01 2.191E+00 3.198E-06 -1.157E+01

**** AC ANALYSIS TEMPERATURE = 27.000 DEG C

FREQ VR(R_R3) VI(R_R3)

1.592E-01 3.133E-06 -6.412E-07

JOB CONCLUDED

TOTAL JOB TIME .02

Obliczenia ręczne:

$E(t) = 10\sqrt{2} \sin(\omega t + 45^\circ)$
 $E = 10\sqrt{2} = 10V$
 $\varphi_E = 45^\circ$
 $\underline{E} = E e^{j\varphi} = E (\cos\varphi + j\sin\varphi)$
 $\underline{E} = 10 (0.707 + j0.707)$
 $\underline{E} = 7.07 + j7.07$
 $-jX_{C1} = -j$
 $-jX_{C2} = -j^2$
 $jX_{L2} = j^2$
 $C_1 = \frac{1}{\omega R_1} = \frac{1}{1 \cdot 1} = 1F$
 $C_2 = \frac{1}{\omega R_2} = 0.5F$
 $L_2 = \frac{X_{L2}}{\omega} = 2H$
 $\underline{Z}_1 = R_1 + jX_{L1} = 2 - j4\Omega$
 $\underline{Z}_2 = X_{L2} + X_{C2} = j^2 - j^2 = 0\Omega$
 $\underline{Z}_{23} = 0$
 $\underline{Z} = \underline{Z}_1 = 2 - j4\Omega$
 $\underline{I}_1 = \frac{\underline{E}}{\underline{Z}} = \frac{7.07 + j7.07}{2 - j4} = \frac{9.659 + j7.588}{2 - j4} \cdot \frac{2 + j4}{2 + j4} = 0.4483 + j2.1906A$
 $I_1 = |\underline{I}_1| = \sqrt{0.4483^2 + 2.1906^2} = 2.236A$
 $I_{1m} = I_1 \sqrt{2} = 2.236 \cdot \sqrt{2} = 3.16A$
 $\varphi_{I_1} = \tan^{-1}\left(\frac{I_{1m}}{I_{1r}}\right) = \tan^{-1}\left(\frac{2.1906}{0.4483}\right) = 78.43^\circ$
 $i_1(t) = 3.16 \sin(\omega t + 78.43^\circ)A$
 $\underline{I}_2 = \underline{I}_1 \frac{R_2}{R_2 + \underline{Z}_2} = 0.4483 + j2.1906 \cdot \frac{2}{2.0} = 0.4483 + j2.1906$
 $I_2 = |\underline{I}_2| = |\underline{I}_1| = 0.4483 + j2.1906 = 2.236A$
 $I_{2m} = I_2 \sqrt{2} = 2.236 \cdot \sqrt{2} = 3.16A$
 $\varphi_{I_2} = \varphi_{I_1} = 78.43^\circ$
 $i_2(t) = 3.16 \sin(\omega t + 78.43^\circ)$

$$I_3 = I_1 - I_2 = 0 \text{ A}$$

$$U_{R3} = I_3 R_3 = 0 \cdot 2 = 0 \text{ V}$$

$$U_{R3}(\text{A}) = 0 \text{ V}$$

$$f = \frac{1}{2\pi\tau} = 0,1591549 \text{ Hz}$$

Wielkość	Wynik komputerowy	Wynik ręczny
$I_1[\text{A}]$	$0,448+j2,191$	$0,4483+j2,1906$
$I_2[\text{A}]$	$0,448+j2,191$	$0,4483+j2,1906$
$U_{R3}[\text{V}]$	$3.133 \cdot 10^{-6}$ $-j6.412 \cdot 10^{-7} \text{ V}$	0
fr[Hz]	0,1591549	0,1591549
$i_1(t)[\text{A}]$	$2,236 \text{ pier}2(\text{wt}+78,43)$	$3,16 \sin(\text{wt}+78,43)$
$i_2(t)[\text{A}]$	$2,236 \text{ pier}2(\text{wt}+78,43)$	$3,13 \sin(\text{wt}+78,43)$

Wnioski:

W tym ćwiczeniu badaliśmy obwodu prądu sinusoidalnie zmiennego. Wyniki obliczeń ręcznych w większości pokrywają się z obliczeniami komputerowymi. Wszelkie niedokładności są spowodowane przybliżeniami zastosowanymi w obliczeniach. We wszystkich ćwiczeniach postępowaliśmy zgodnie z instrukcjami zawartymi w książce co pozwoliło na precyzyjne pomiary oraz brak pomyłek. Dzięki programowi i możliwości wykonywania w nim wykresów upewniliśmy się że obliczenia ręczne były wykonane dokładnie.