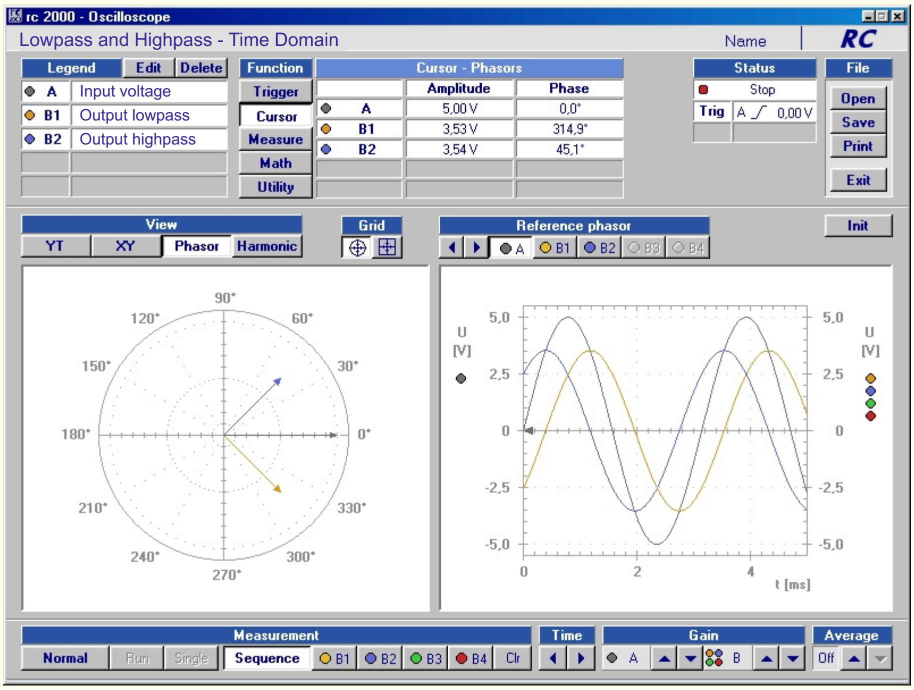
RC DIDACTIC SYSTEMS

Teaching System rc2000 - µLAB

Cookbook



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

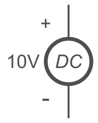
Content

Content

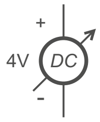
Content

0.1 Symbols used in exercises

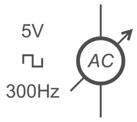
Symbols



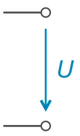
Component board with built-in precise reference power source 10V.



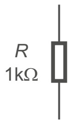
Programmable DC supply with the set value.



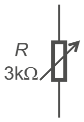
Function generator with the set amplitude, frequency and waveform.



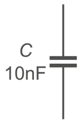
Voltmeter DC & AC RMS on clamps.



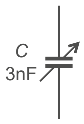
Exact 2-pin resistor of the specified value



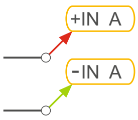
Resistor decade 1 or 2 of the set value.



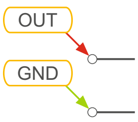
Exact 2-pin capacitor of the specified value.



Capacitor decade of the specified value.



Connectors of probes in input of measuring unit ADDU - Channel A (+IN A -IN A) or B (+IN B -IN B).



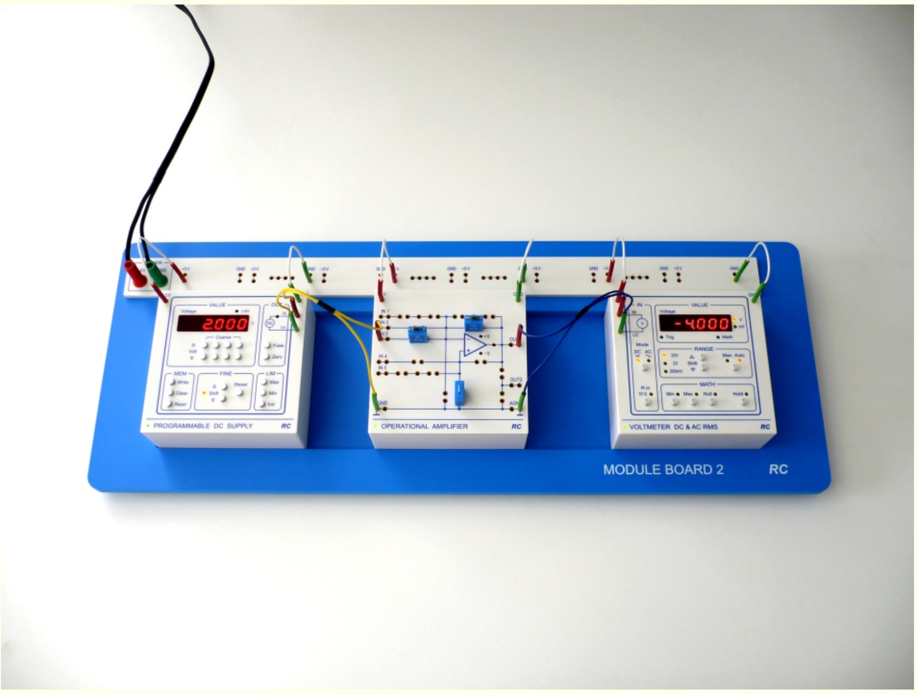
Connectors of probes in output of measuring unit ADDU.

Comments

Outputs of the modules are designed to have the minimum output resistance ($R_{OUT} < 0{,}1\Omega$). They can therefore be regarded as ideal.

Teaching System rc2000 - µLAB

DC Circuits



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

Content

1.1 Unloaded and Loaded Voltage Divider

Exercise

Verify the validity of the equation for unloaded and loaded voltage divider by comparing the measured and calculated values.

Schema

1) Unloaded voltage divider

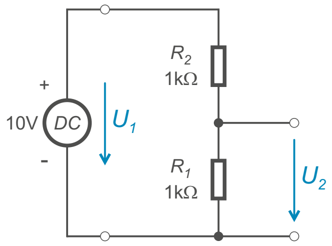


Fig. 1 - Unloaded divider

$U_1 = 10V$

$R_1 = 1k\Omega$

$R_2 = 1k\Omega$

$$U_2 = \frac{R_1}{R_1+R_2} U_1$$

$U_2 = 5V$

2) Loaded voltage divider

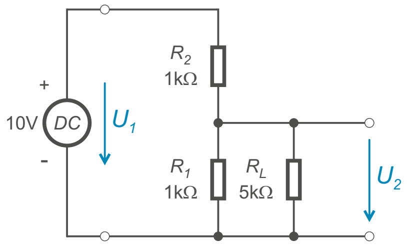


Fig. 2 - Loaded divider

$U_1 = 10V$

$R_1 = 1k\Omega$

$R_2 = 1k\Omega$

$R_L = 5k\Omega$

$$U_2 = \frac{R_1.R_L}{R_2.R_L+R_1.R_2+R_1.R_L} U_1$$

$U_2 = 4,545V$

1.2 Voltage Source - Internal Resistance

Exercise

Measure the internal resistance R_i of the ideal (Fig. 1 and 2) and a real voltage source (Fig. 3 and 4).

Schema

1) Ideal voltage source

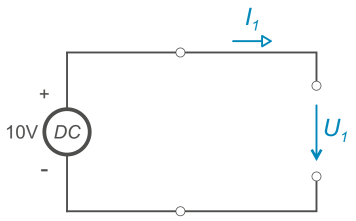


Fig. 1 - Unloaded

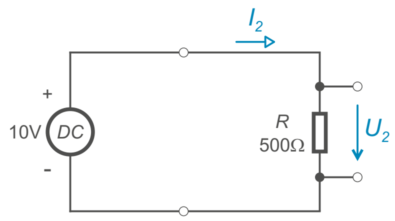


Fig. 2 - Loaded

$$R_i = \frac{U_1 - U_2}{I_2 - I_1}$$

$$I_2 = \frac{U_2}{R}$$

$R_i = 0\Omega$

2) Real voltage source

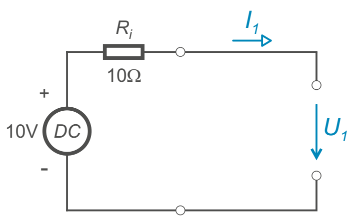


Fig. 3 - Unloaded

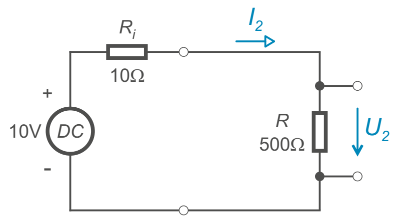


Fig. 4 - Loaded

$$R_i = \frac{U_1 - U_2}{I_2 - I_1}$$

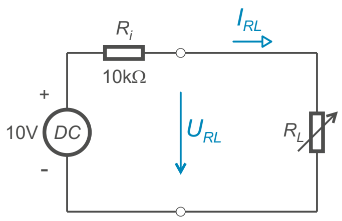
$$I_2 = \frac{U_2}{R}$$

$R_i = 10\Omega$

Exercise

Verify that in given circuit the maximum power is being transfered to the load resistor R_L on condition that $R_L = R_i$.

Schema



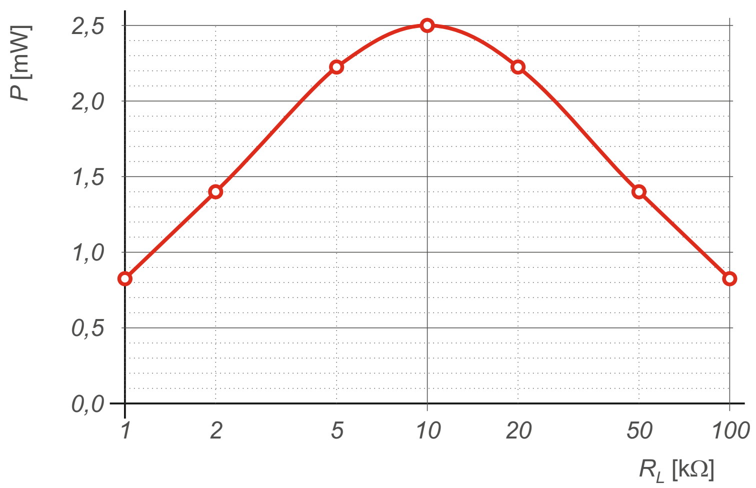
$U_1 = 10V$

$R_i = 10k\Omega$

$$I_{RL} = \frac{U_{RL}}{R_L}$$

$$P = \frac{U_{RL}^2}{R_L}$$

R_L [kΩ]	0,0	1,0	2,0	5,0	10,0	20,0	50,0	100,0
U_{RL} [V]	0,000	0,909	1,667	3,333	5,000	6,667	8,333	9,091
P [mW]	0,000	0,826	1,389	2,222	2,500	2,222	1,389	0,826



Exercise

Verify the validity of Kirchhoff's first law for the following two circuits.

Schema

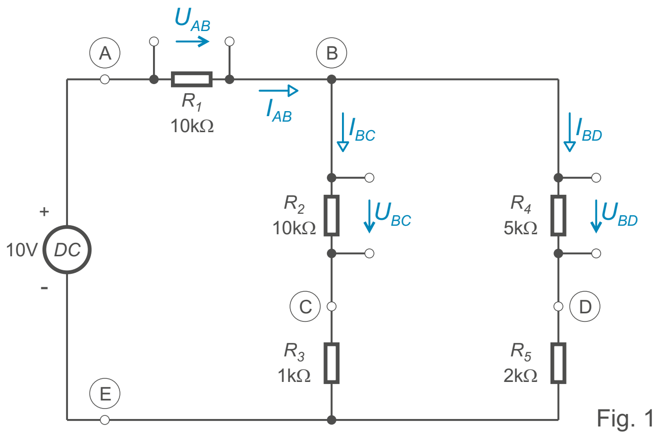


Fig. 1 - Circuit No. 1

$$I_{AB} = \frac{U_{AB}}{R_1}$$

$$I_{BC} = \frac{U_{BC}}{R_2}$$

$$I_{BD} = \frac{U_{BD}}{R_4}$$

$$I_{AB} = I_{BC} + I_{BD}$$

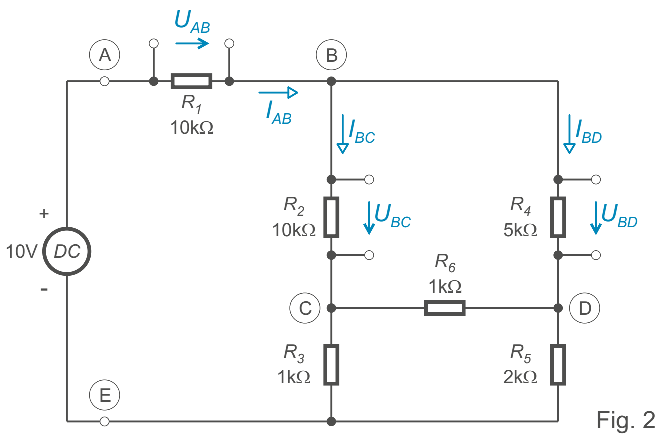


Fig. 2 - Circuit No. 2

$$I_{AB} = \frac{U_{AB}}{R_1}$$

$$I_{BC} = \frac{U_{BC}}{R_2}$$

$$I_{BD} = \frac{U_{BD}}{R_4}$$

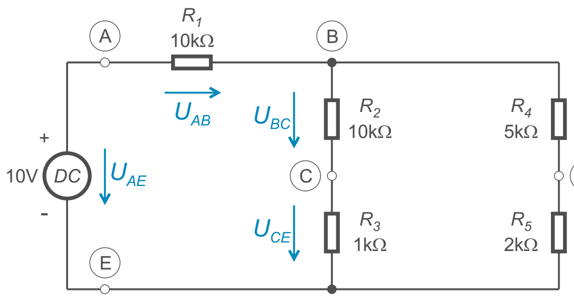
$$I_{AB} = I_{BC} + I_{BD}$$

Kirchhoff's Second Law

Exercise

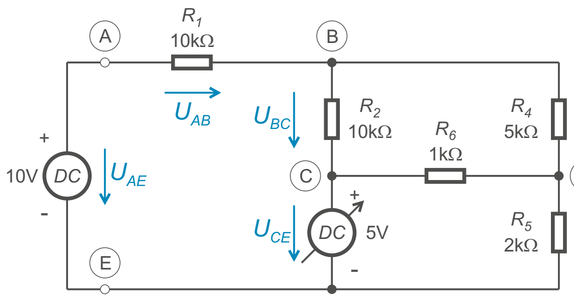
Verify the validity of Kirchhoff's second law for the following two circuits.

Schema



$$U_{AE} = U_{AB} + U_{BC} + U_{CE}$$

Fig. 1 - Circuit No. 1



$$U_{AE} = U_{AB} + U_{BC} + U_{CE}$$

Fig. 2 - Circuit No. 2

1.6 Thevenine Theorem

Exercise

Simplify circuit 1 using the Thevenine theorem.

Schema

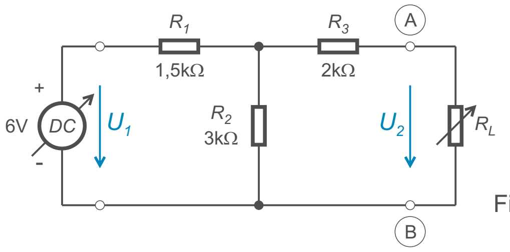


Fig. 1 - Given circuit

$U_1 = 6V$

$R_1 = 1,5k\Omega$

$R_2 = 3k\Omega$

$R_2 = 2k\Omega$

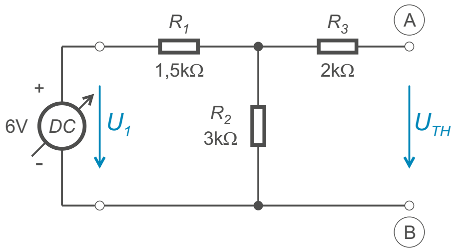


Fig. 2 - Replacement voltage U_{TH}

$$U_{TH} = \frac{R_2}{R_1+R_2}\; U_1$$

$U_{TH} = 4V$

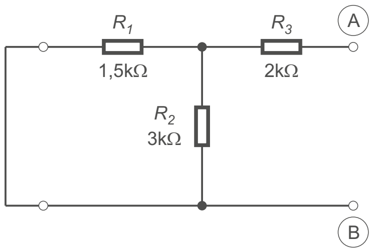


Fig. 3 - Replacement resistor R_{TH}

$$R_{TH} = R_3 + \frac{R_1.R_2}{R_1+R_2}$$

$R_{TH} = 3k\Omega$

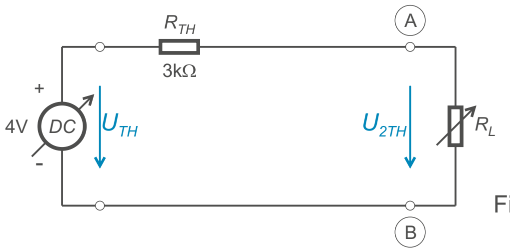


Fig. 4 - Simplified circuit

$U_{TH} = 4V$

$R_{TH} = 3k\Omega$

Exercise

Prove that the superposition principle applies only to linear networks.

Schema

1) Linear circuit

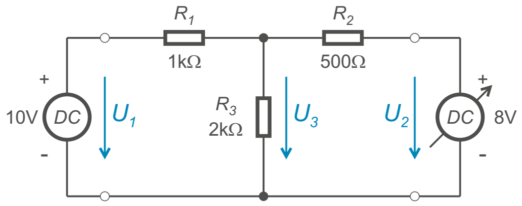


Fig. 1 - Examined linear circuit

$$U_3 = U_{31} + U_{32}$$

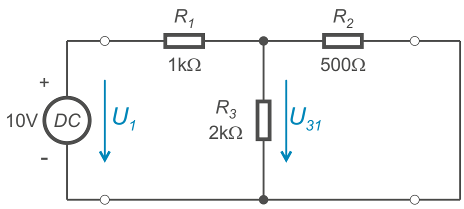


Fig. 2 - Contribution of first source

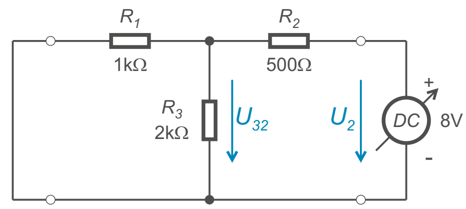


Fig. 3 - Contribution of second source

2) Nonlinear circuit

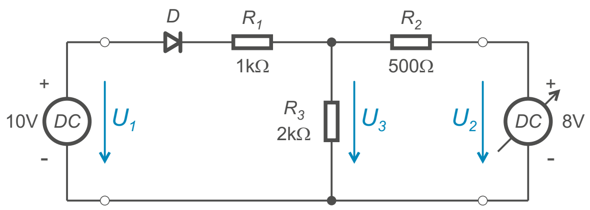


Fig. 4 - Examined nonlinear circuit

$$U_3 \neq U_{31} + U_{32}$$

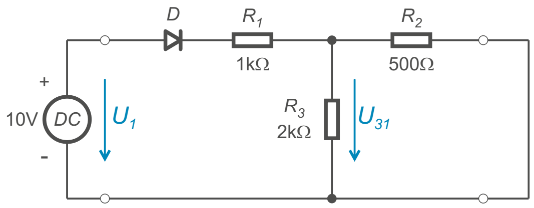


Fig. 5 - Circuit without second source

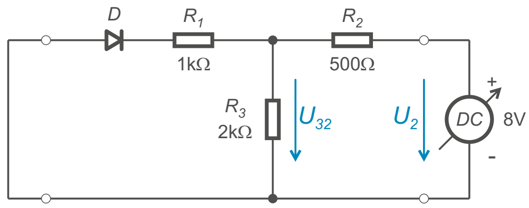


Fig. 6 - Circuit without first source

1.8 Transformation Delta - Star

Exercise

With the delta - star transformation determine the value U_2 in given circuit.

Schema

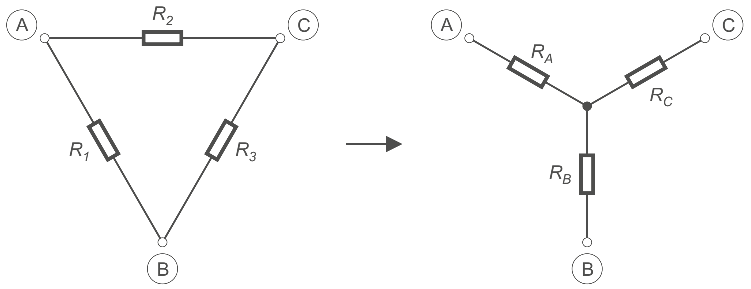


Fig. 1 - Transformation delta - star

$$R_A = \frac{R_1.R_2}{R_1+R_2+R_3}$$

$$R_B = \frac{R_1.R_3}{R_1+R_2+R_3}$$

$$R_C = \frac{R_3.R_2}{R_1+R_2+R_3}$$

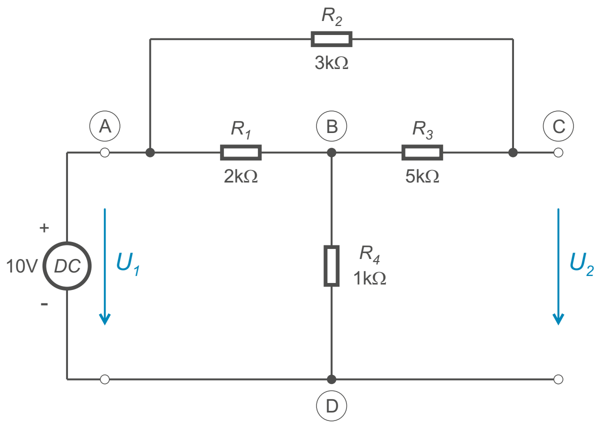


Fig. 2 - Given circuit - delta

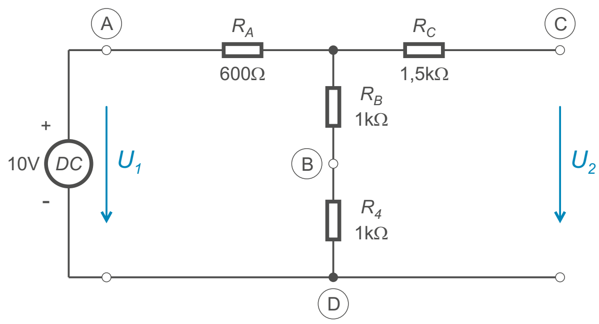
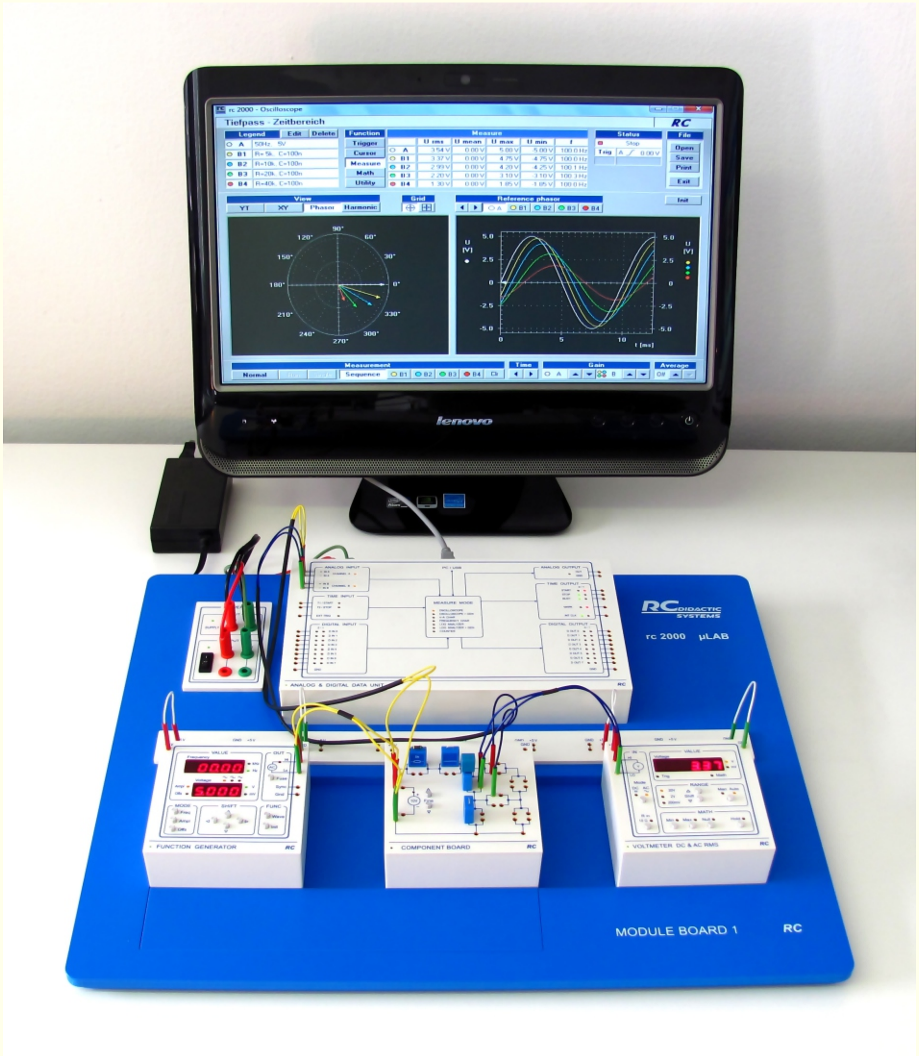


Fig. 3 - Circuit after transformation - star

Teaching System rc2000 - µLAB

AC Circuits



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

Content

2.1 RC Integrating Circuit and CR Differentiating Circuit

Exercise

Measure the response of the integrating and differentiating circuit to rectangular voltage. Make the measurement values for capacitor C = 4 nF, 40 nF, 240 nF.

Schema

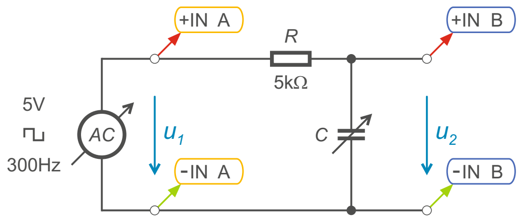


Fig. 1

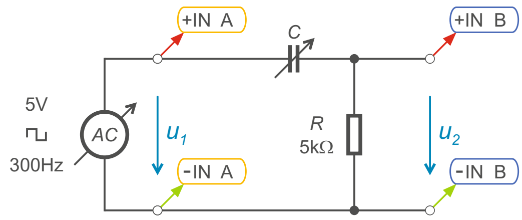
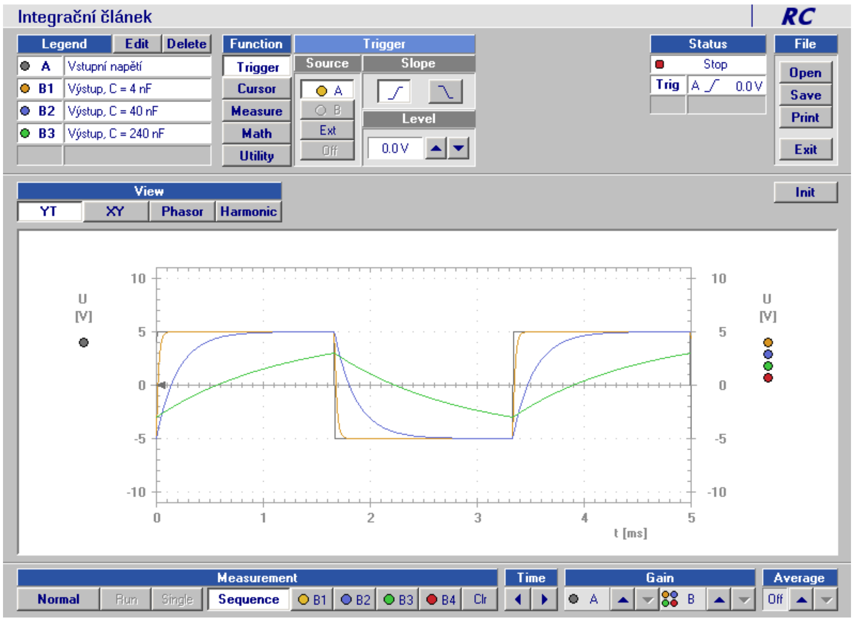


Fig. 2

Measurement

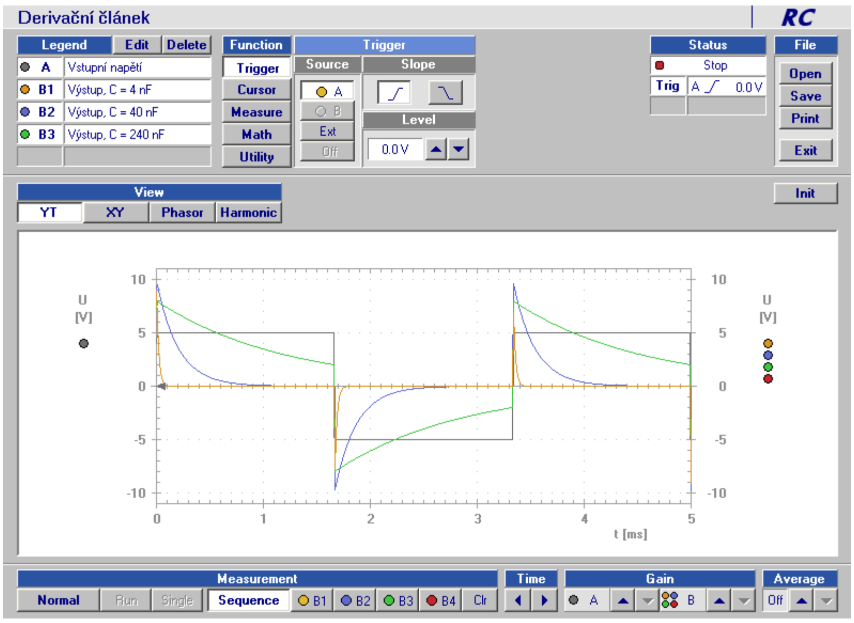


Integrating member

schema Fig. 1

measuring mode

oscilloscope



Differentiating member

schema Fig. 2

measuring mode

oscilloscope

Low Pass and High Pass - Time Domain

Exercise

Display time and phasor diagrams for the lower and upper pass filter (with the same cut-off frequency f_G).

Schema

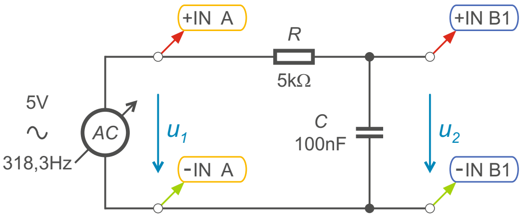


Fig. 1

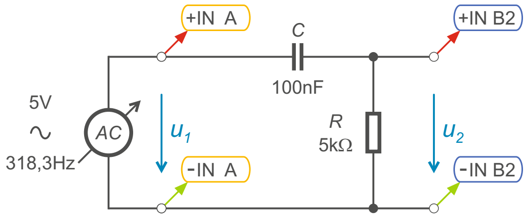
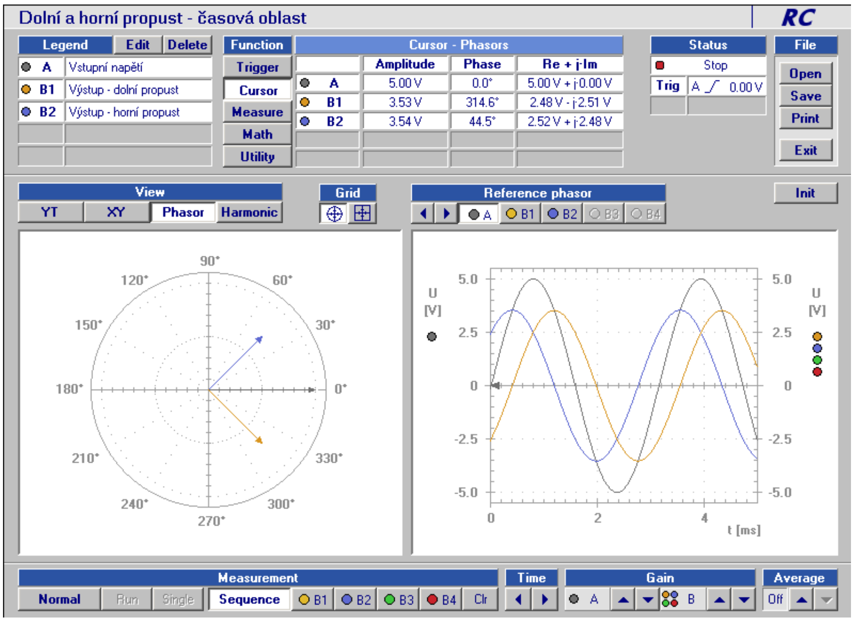


Fig. 2

Measurement



Phase diagrams

schema	Fig. 1, Fig. 2
measuring mode	oscilloscope

measured waveforms

●	$u_1(t)$	(V)
●	$u_2(t)$, Fig. 1	(V)
●	$u_2(t)$, Fig. 2	(V)

formula

$$f_G = \frac{1}{2 \pi R C} \qquad \text{(Hz)}$$

Exercise

Display amplitude and phase frequency characteristics for low pass and high pass (with the same cut off frequency f_G).

Schema

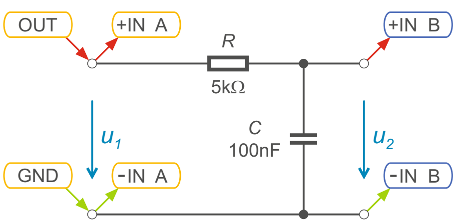


Fig. 1

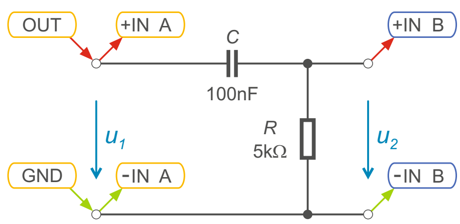
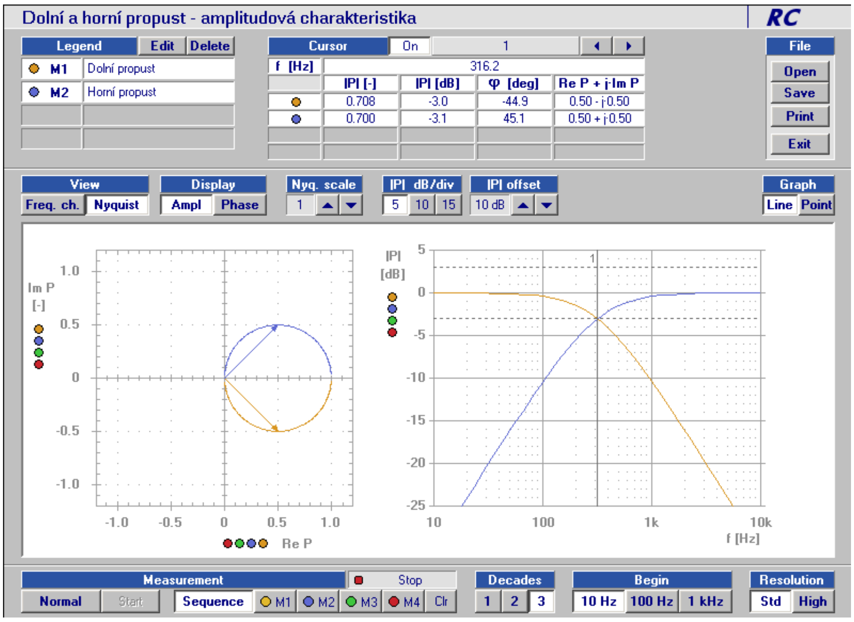


Fig. 2

Measurement



Amplitude characteristics

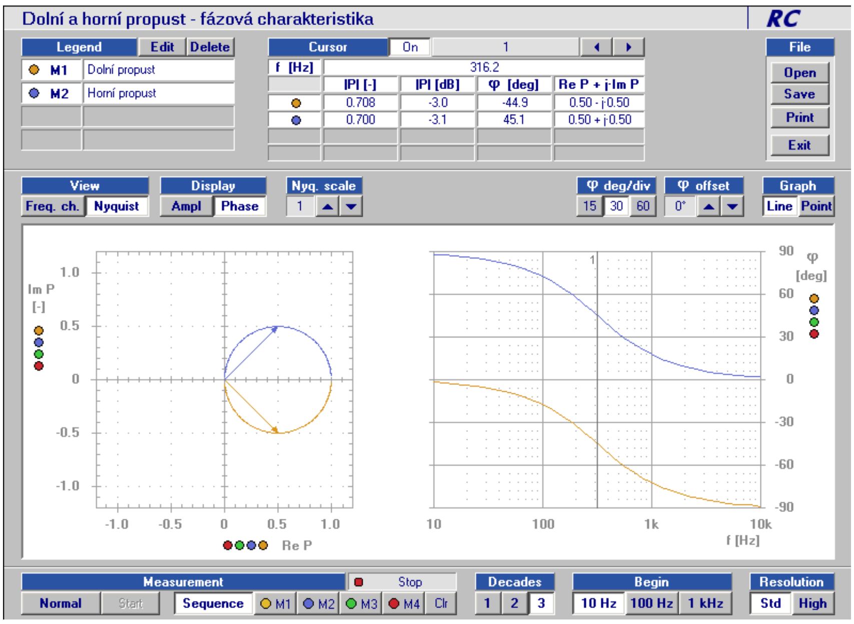
schema Fig. 1, Fig. 2

measuring mode

frequency characteristics

measured characteristics

- IPI(f) , Fig. 1 (dB)
- IPI(f) , Fig. 2 (dB)



Phase characteristics

schema Fig. 1, Fig. 2

measuring mode

frequency characteristics

measured characteristics

- φ(f) , Fig. 1 (°)
- φ(f) , Fig. 2 (°)

Exercise

Show time and phasor diagrams for series resonance circuit in connection with ideal capacitor and ideal coil (Fig. 1) and for circuit with ideal capacitor and with real coil (Fig. 2).

Schema

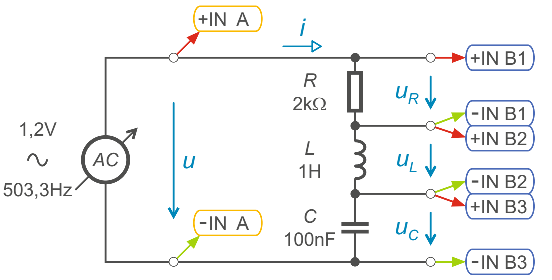


Fig. 1

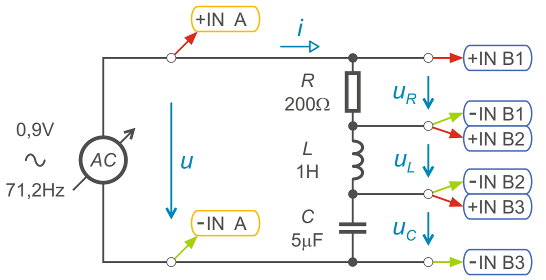
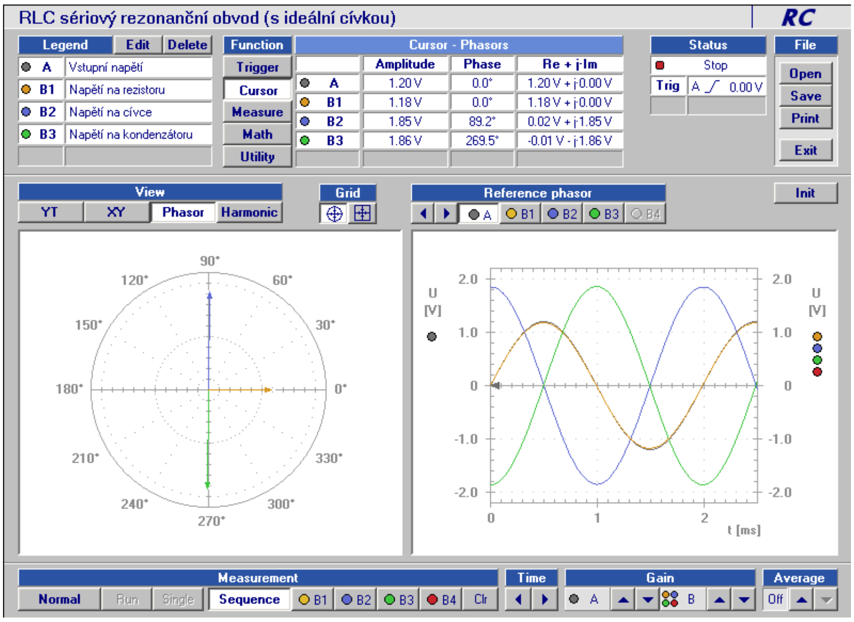


Fig. 2

Measurement



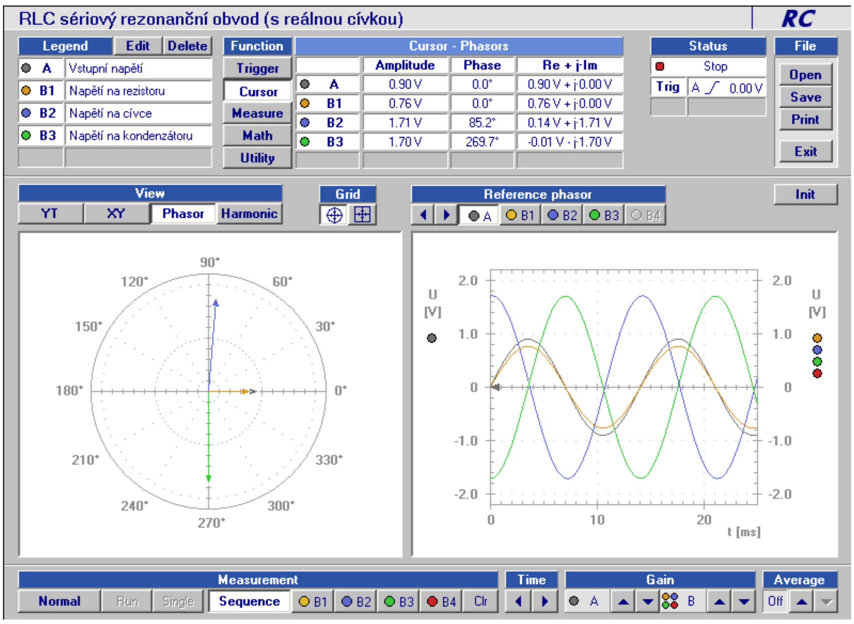
Circuit with ideal coil

schema Fig. 1

measuring mode
oscilloscope

measured time curves

- $u(t)$ (V)
- $u_R(t)$ (V)
- $u_L(t)$ (V)
- $u_C(t)$ (V)



Circuit with real coil

schema Fig. 2

measuring mode
oscilloscope

measured time curves

- $u(t)$ (V)
- $u_R(t)$ (V)
- $u_L(t)$ (V)
- $u_C(t)$ (V)

2.5 RLC Series Circuit - Bandpass

Exercise

Display amplitude and phase frequency characteristics for RLC bandpass (for different values of damping resistor *R*, for example *R* = 100 Ω, 200 Ω, 500 Ω).

Schema

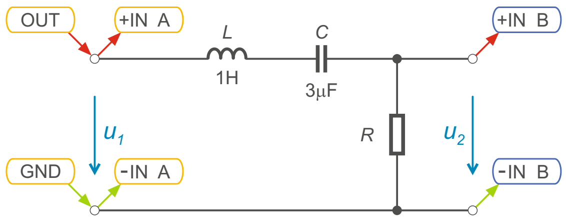
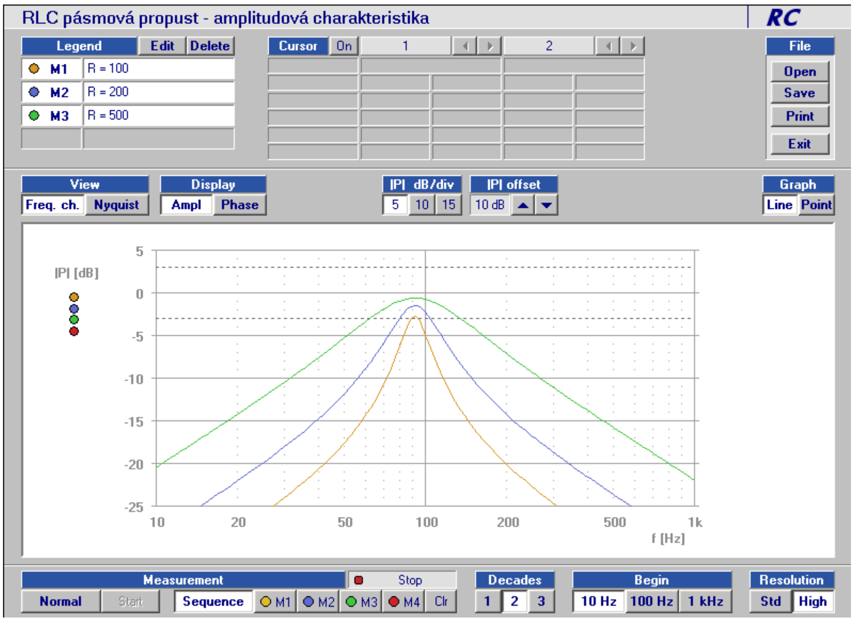


Fig. 1

Measurement



Amplitude characteristics

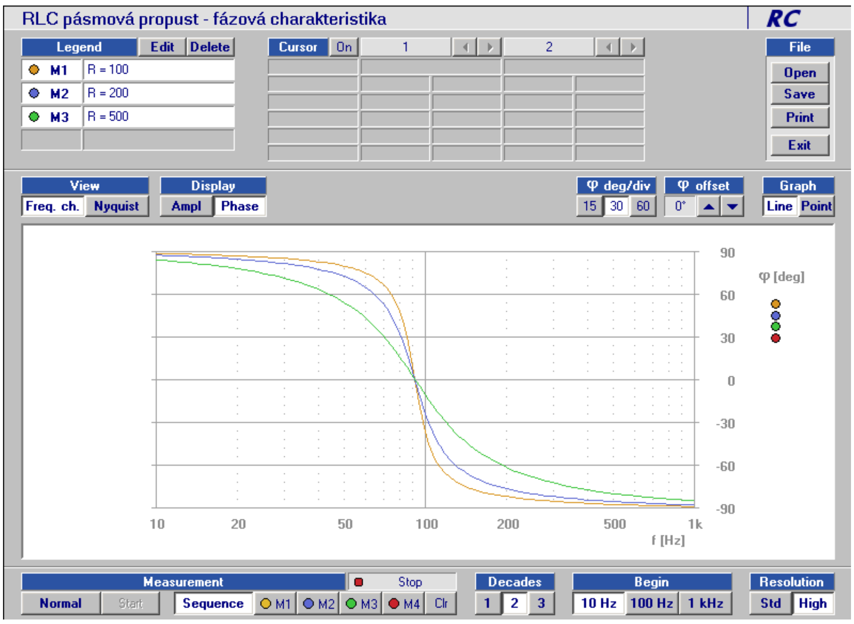
schema Fig. 1

measuring mode

frequency characteristics

measured characteristics

- IPI(f) , R = 100 Ω (dB)
- IPI(f) , R = 200 Ω (dB)
- IPI(f) , R = 500 Ω (dB)



Phase characteristics

schema Fig. 1

measuring mode

frequency characteristics

measured characteristics

- φ(f) , R = 100 Ω (°)
- φ(f) , R = 200 Ω (°)
- φ(f) , R = 500 Ω (°)

RLC Series Circuit - Band Stop

Exercise

Display amplitude and phase frequency characteristics for RLC band stop (for different values of dampening resistor *R*, for example *R* = 100 Ω, 200 Ω, 500 Ω).

Schema

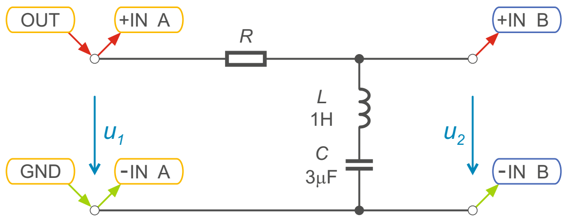
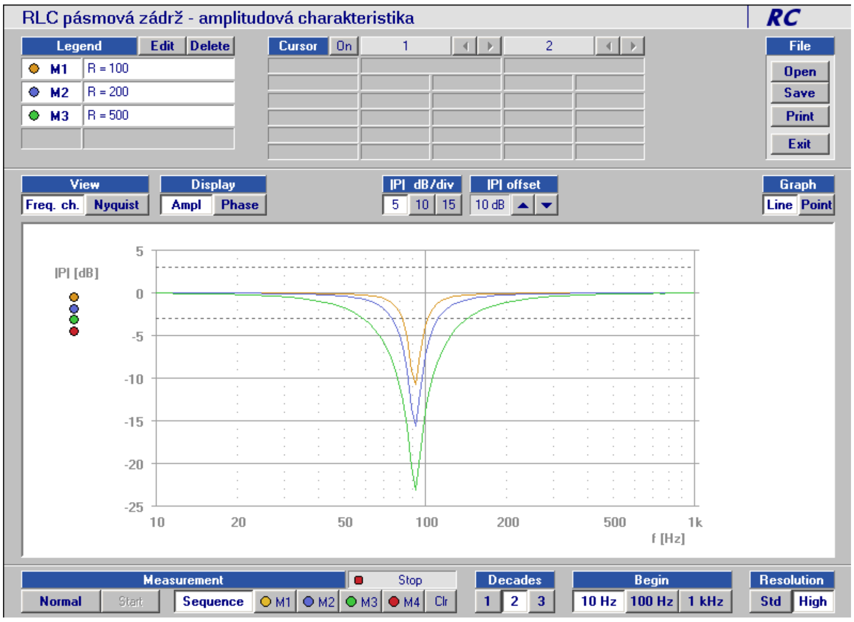


Fig. 1

Measurement



Amplitude characteristics

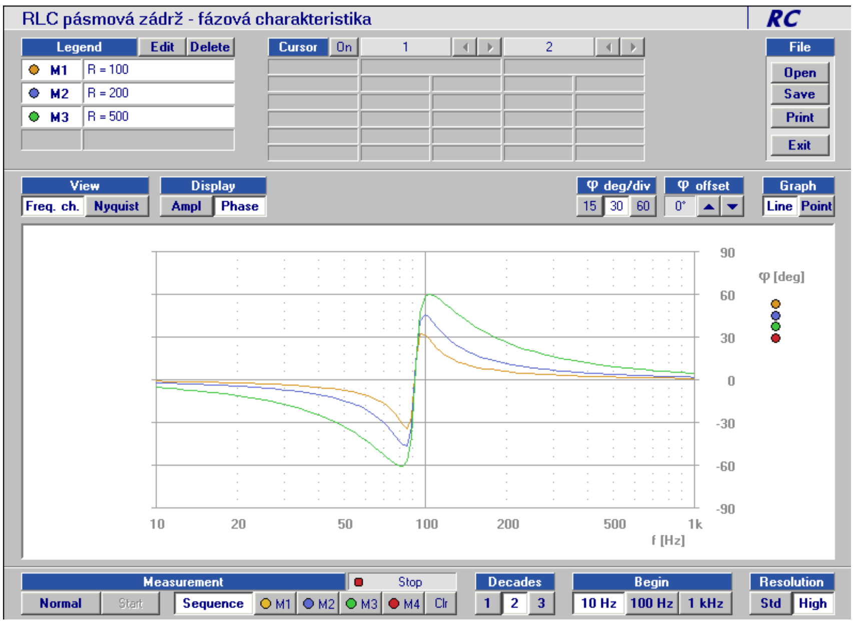
schema Fig. 1

measuring mode

frequency characteristics

measured characteristics

- IPI(f) , R = 100 Ω (dB)
- IPI(f) , R = 200 Ω (dB)
- IPI(f) , R = 500 Ω (dB)



Phase characteristics

schema Fig. 1

measuring mode

frequency characteristics

measured characteristics

- φ(f) , R = 100 Ω (°)
- φ(f) , R = 200 Ω (°)
- φ(f) , R = 500 Ω (°)

2.7 Resistor in AC Circuit

Exercise

Display waveforms and phasor diagrams for voltage and current in the circuit with a resistor.

Schema

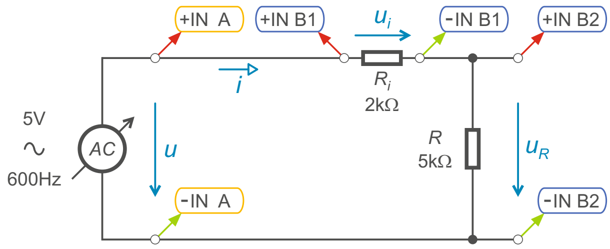
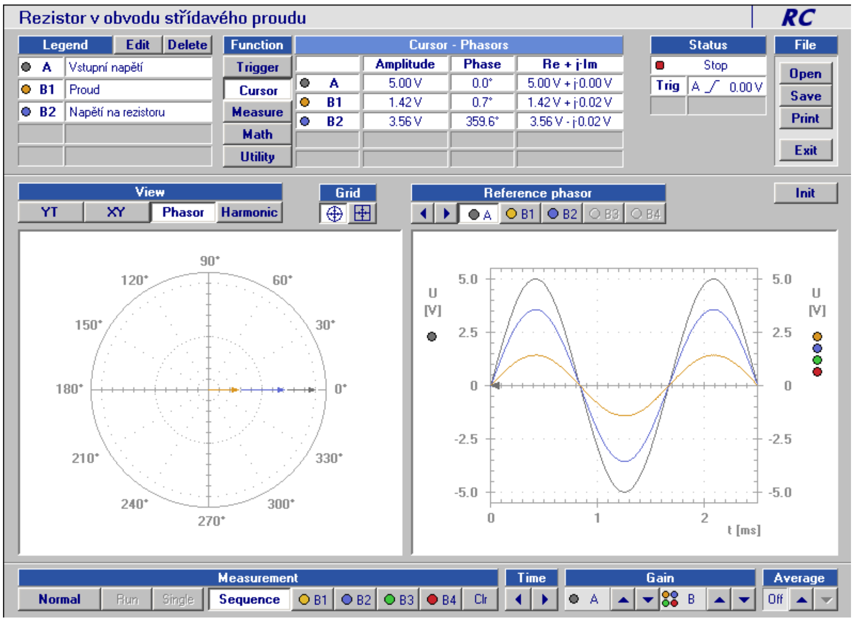


Fig. 1

Measurement



Waveforms on resistor

schema Fig. 1

measuring mode

oscilloscope

measured waveforms

- $u(t)$ (V)
- $i(t) = \frac{1}{R_i} u_i(t)$ (mA, kΩ, V)
- $u_R(t)$ (V)

Coil in AC Circuit

Exercise

Display waveforms and phasor diagrams for voltage and current in the circuit with a coil (ideal and real).

Schema

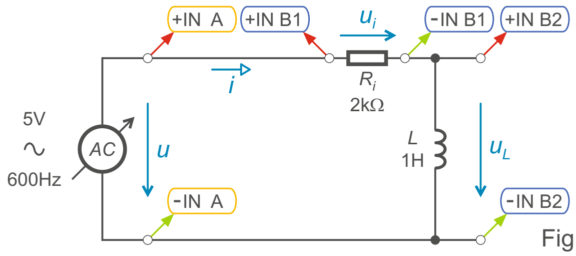


Fig. 1

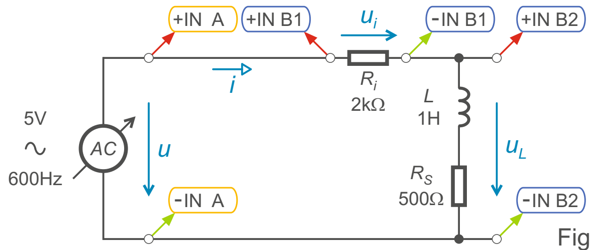
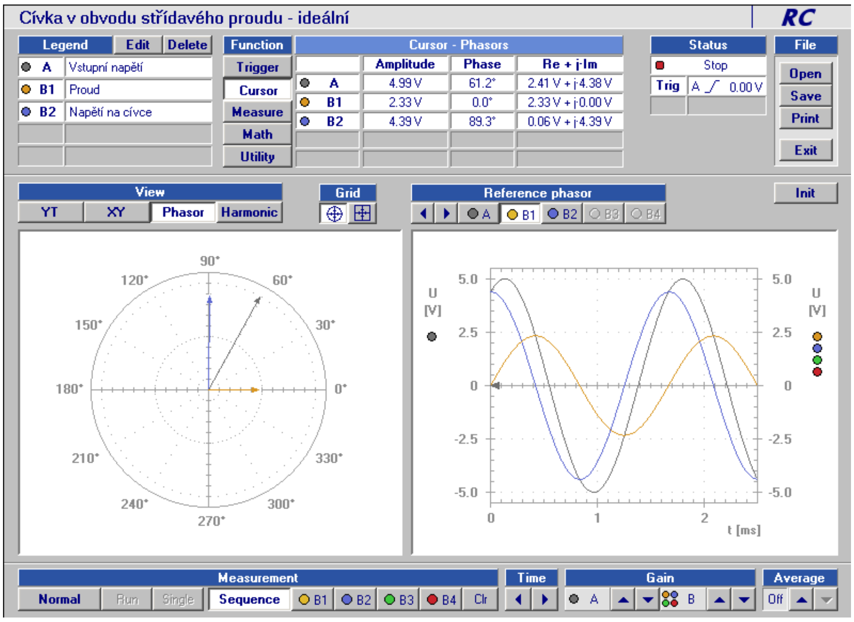
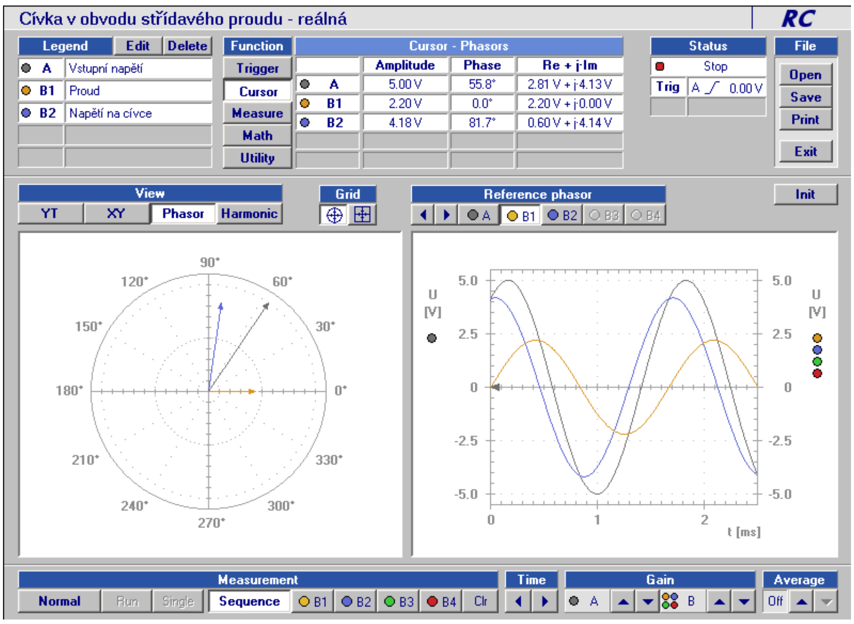


Fig. 2

Measurement



Ideal coil	
schema	Fig. 1
measuring mode	oscilloscope



Real coil	
schema	Fig. 2
measuring mode	oscilloscope

2.9 Capacitor in AC Circuit

Exercise

Display waveforms and phasor diagrams for voltage and current in the circuit with a capacitor (ideal and real).

Schema

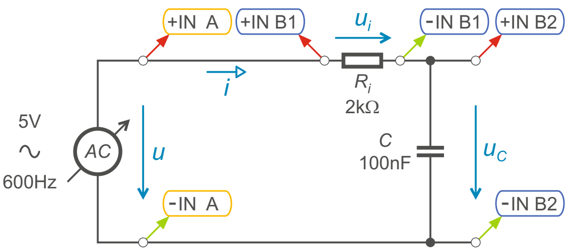


Fig. 1

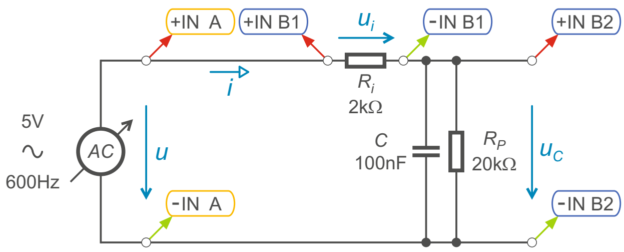
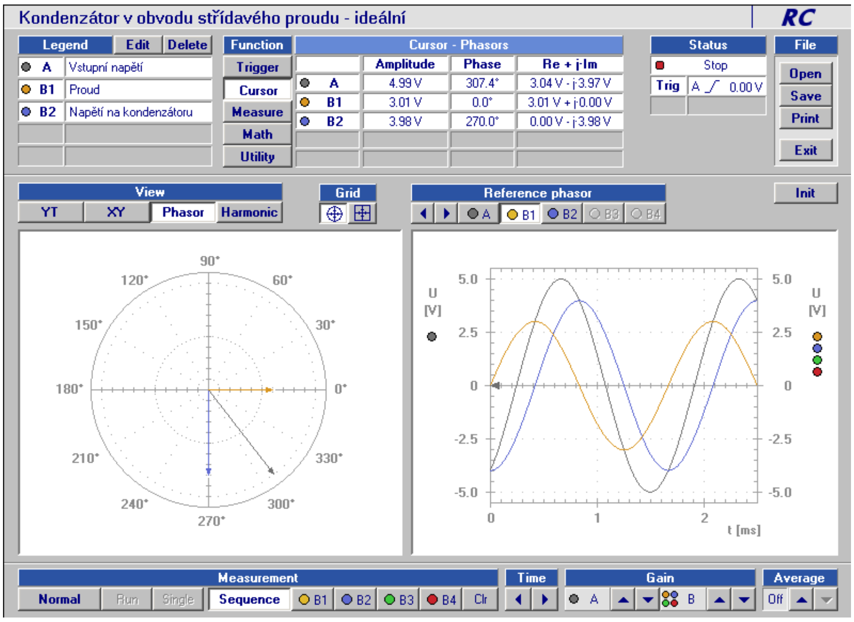


Fig. 2

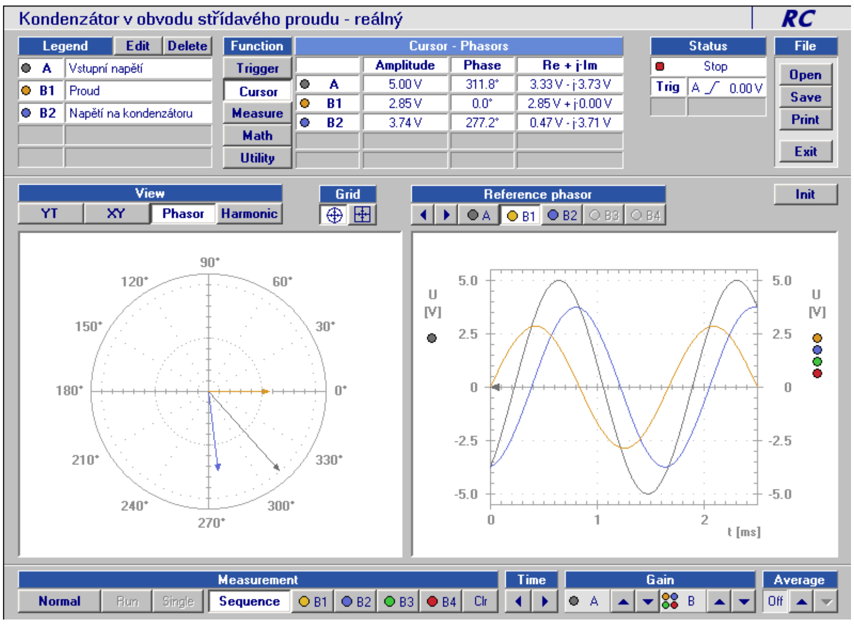
Measurement



Ideal capacitor

schema Fig. 1

measuring mode oscilloscope



Real capacitor

schema Fig. 2

measuring mode oscilloscope

Active Power - Resistor

Exercise

Display time course of power on resistor.

Schema

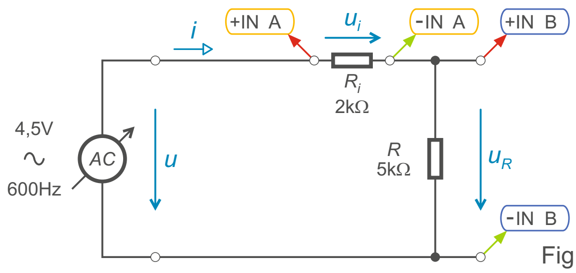
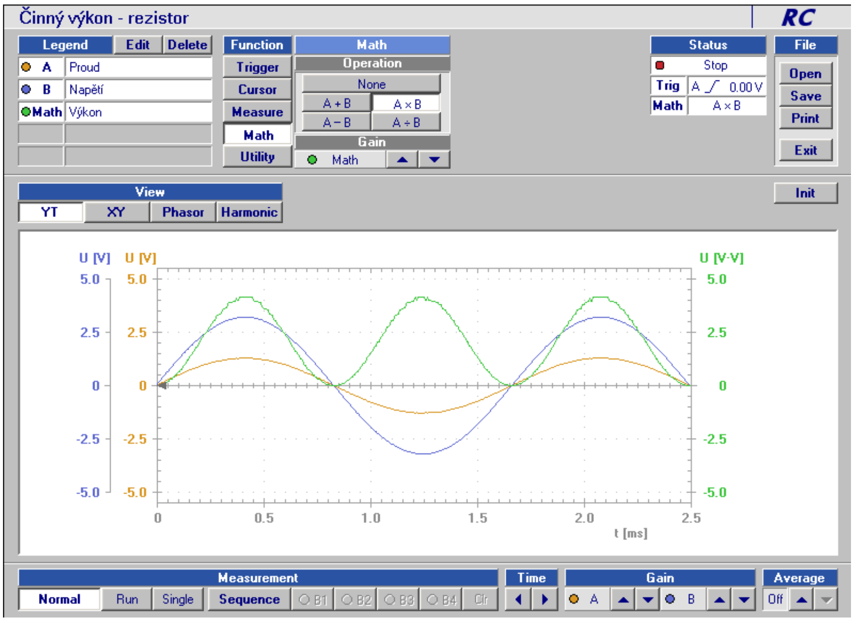


Fig. 1

Measurement



Power on resistor

schema Fig. 1

measuring mode

oscilloscope

Reactive Power - Coil

Exercise

Show time course of power on coil. Compare waveforms on the ideal and the real coil.

Schema

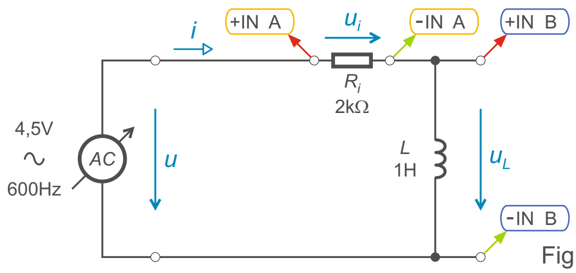


Fig. 1

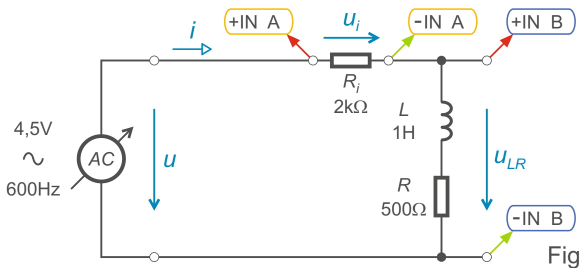
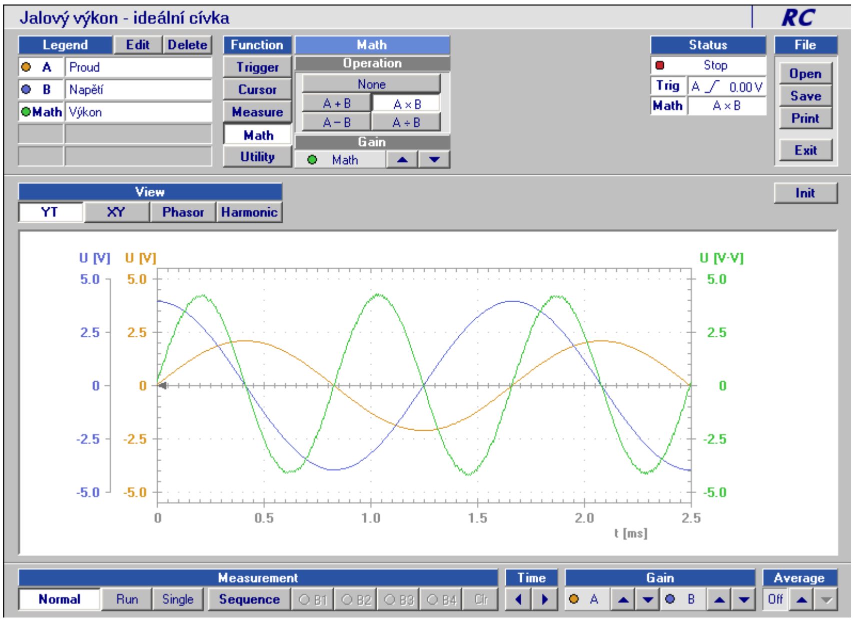
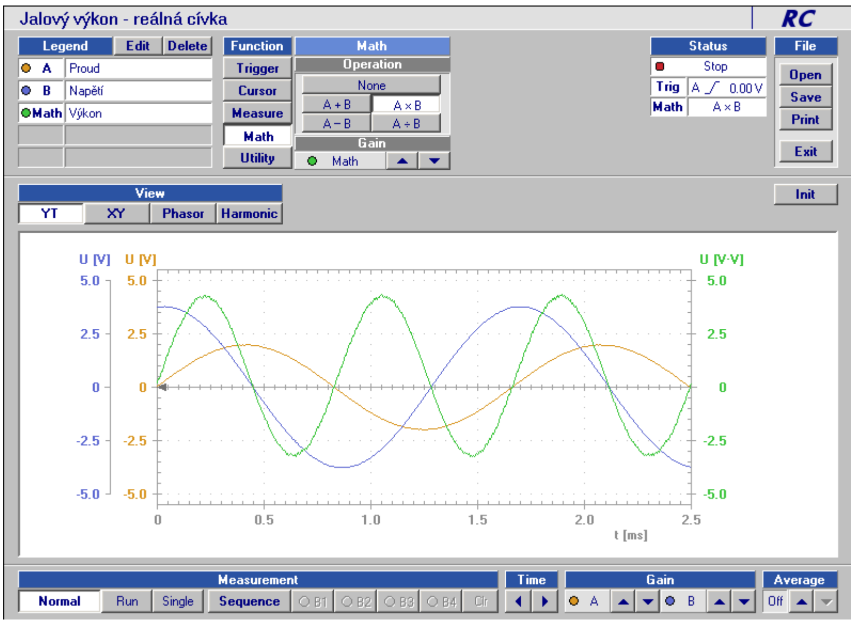


Fig. 2

Measurement



Ideal coil	
schema	Fig. 1
measuring mode	oscilloscope



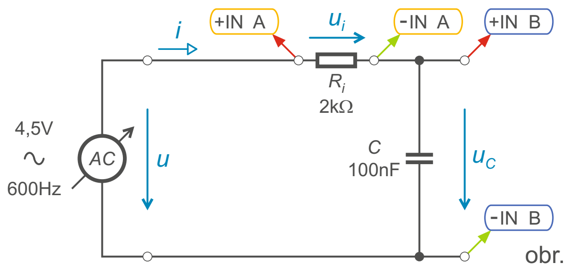
Real coil	
schema	Fig. 2
measuring mode	oscilloscope

Reactive Power - Capacitor

Exercise

Display time course of power on capacitor. Compare waveforms on ideal and real capacitor.

Schema



obr. 1

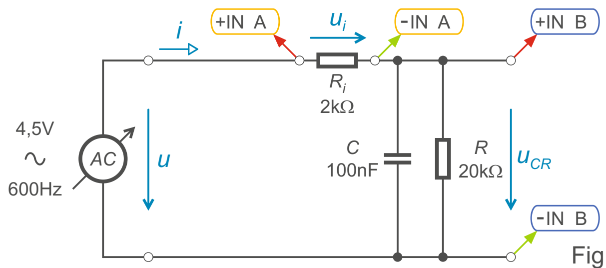
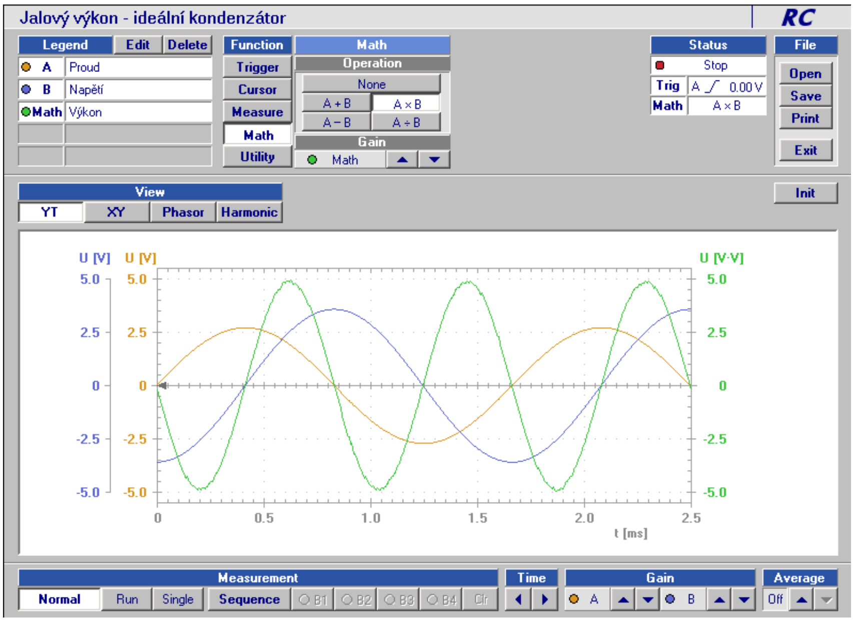


Fig. 2

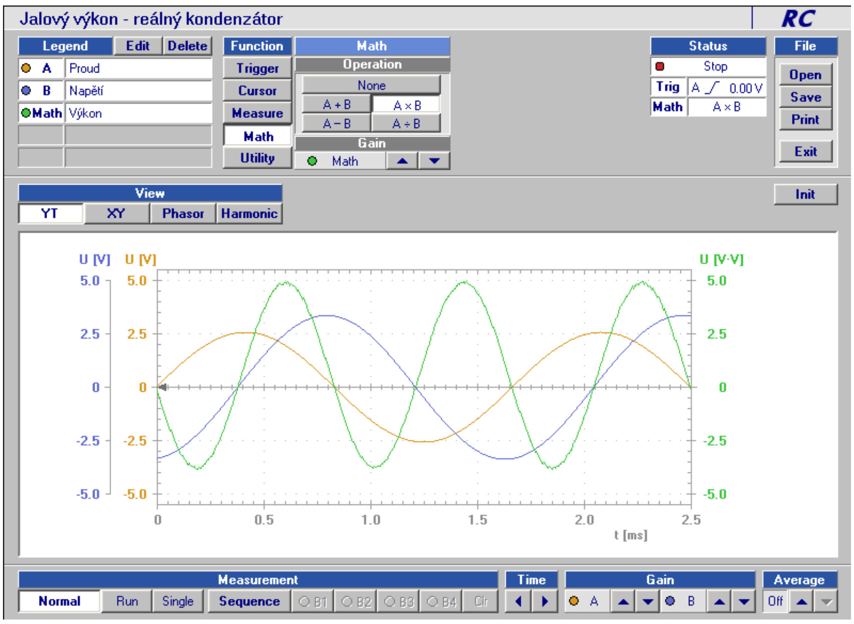
Measurement



Ideal capacitor

schema Fig. 1

measuring mode oscilloscope



Real capacitor

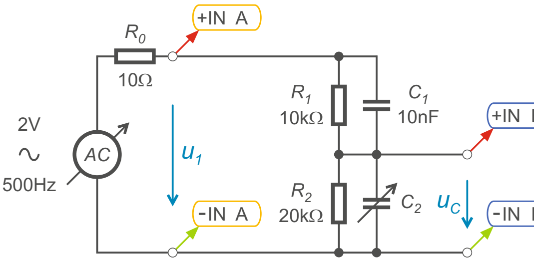
schema Fig. 2

measuring mode oscilloscope

Exercise

Measure voltage transfer of the impedance divider (for C_2 = 2 nF, 5 nF, 8 nF). To compensate the divider, following formula must be valid: $R_1C_1 = R_2C_2$.

Schema



obr. 1

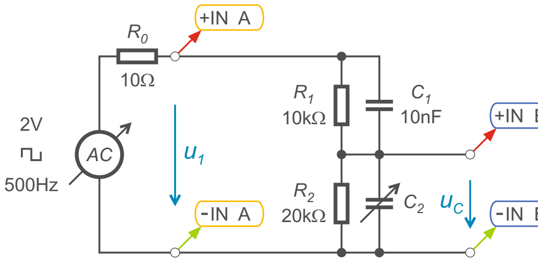
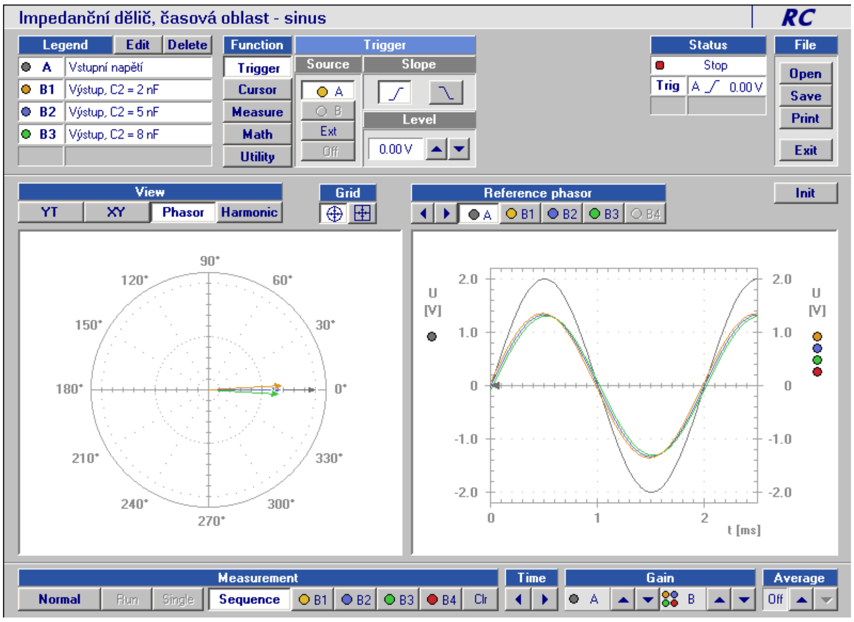


Fig. 2

Measurement

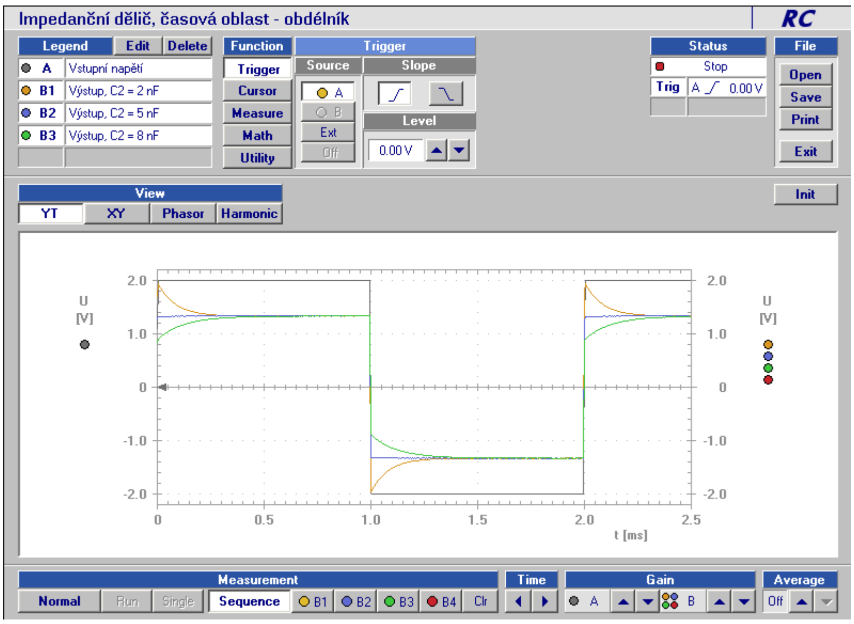


Harmonic course

schema Fig. 1

measuring mode

oscilloscope



Rectangular course

schema Fig. 2

measuring mode

oscilloscope

2.14 Impedance divider - Frequency Domain

Exercise

Measure transfer frequency characteristics of the divider (for C_2 = 2 nF, 5 nF, 8 nF). To compensate the divider, following formula must be valid: $R_1C_1 = R_2C_2$.

Schema

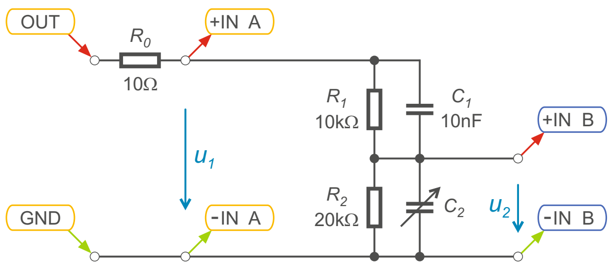
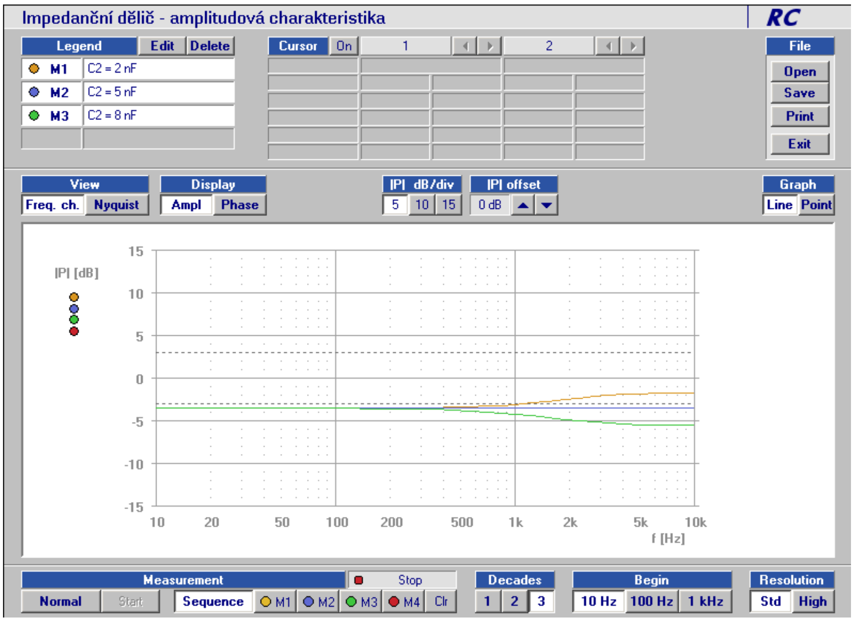


Fig. 1

Measurement

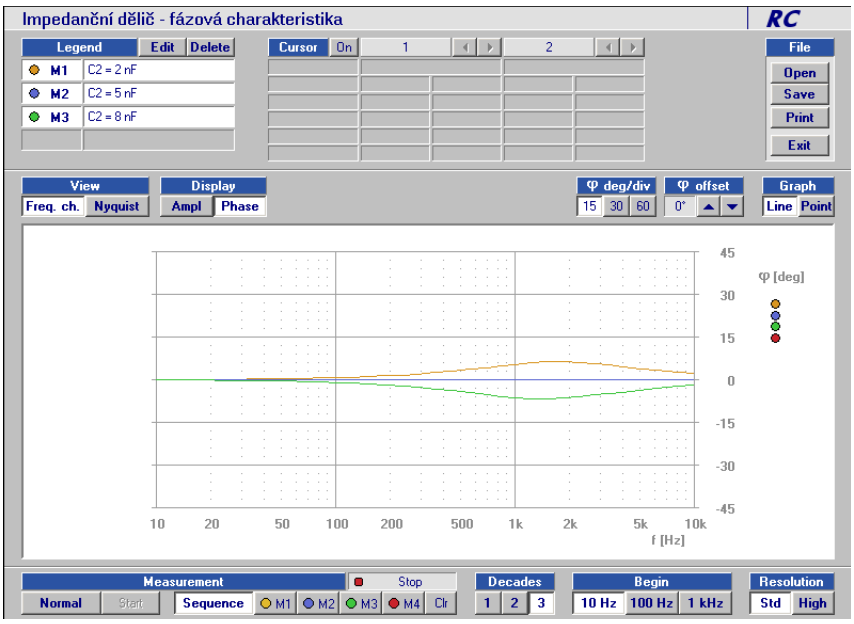


Amplitude characteristics

schema Fig. 1

measuring mode

frequency characteristics



Phase characteristics

schema Fig. 1

measuring mode

frequency characteristics

2.15 Equivalent Circuits (For a Single Frequency) - Time Domain

Exercise

Verify that the equivalent circuits have the same voltage transmission only for sinusoidal voltage of a single frequency.

Schema

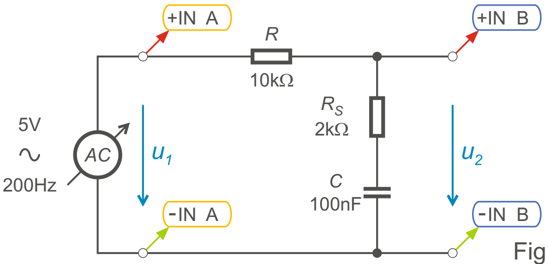


Fig. 1

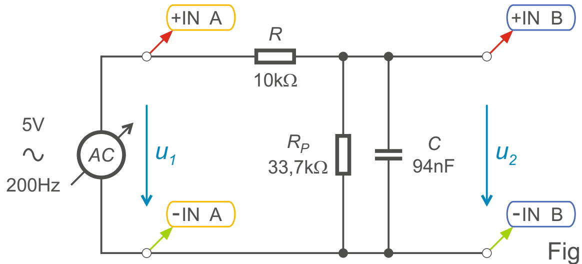
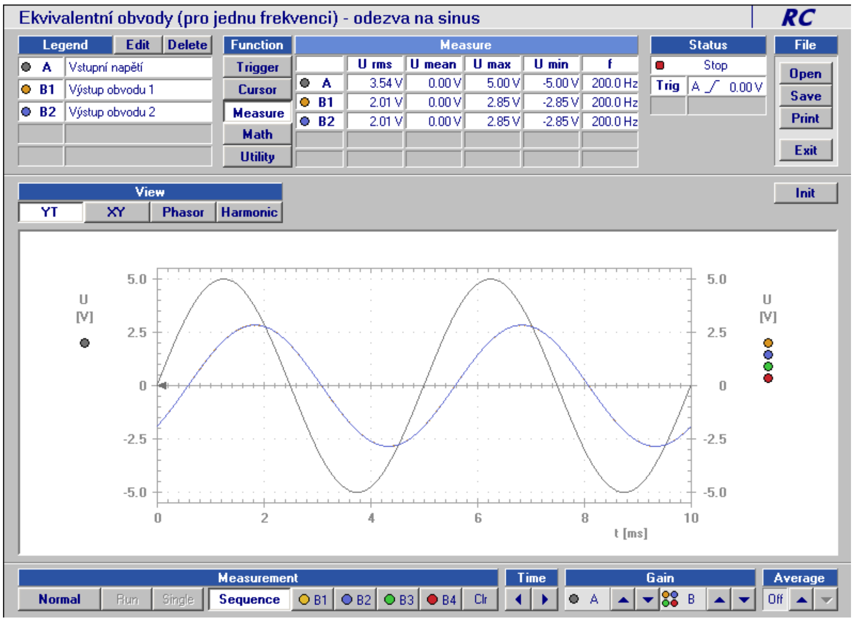


Fig. 2

Measurement

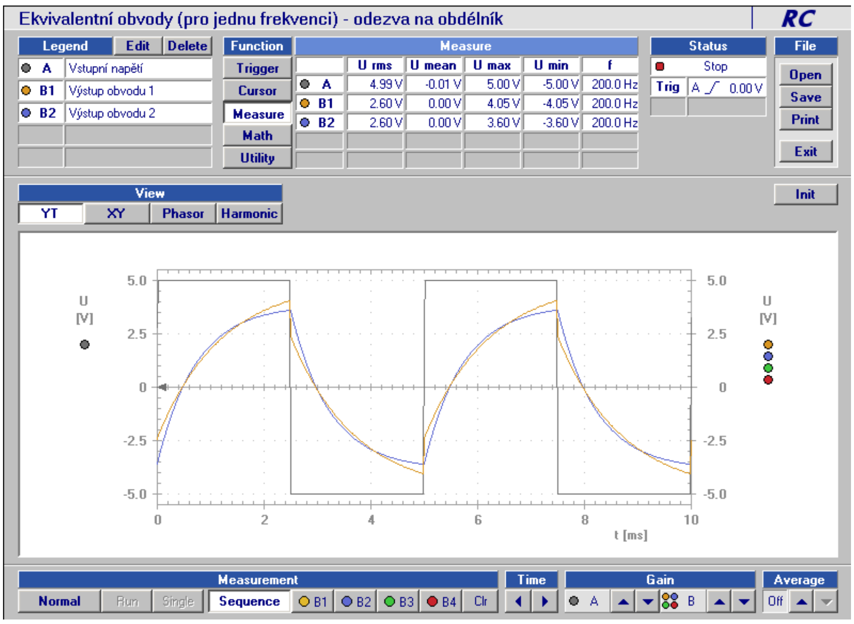


Harmonic course

schema Fig. 1, Fig. 2

measuring mode

oscilloscope



Rectangular waveform

schema Fig. 1, Fig. 2

measuring mode

oscilloscope

2.16 Equivalent Circuits (For a Single Frequency) - Frequency Domain

Exercise

Verify that the equivalent circuits have the same voltage transmission only for sinusoidal voltage of a single frequency.

Schema

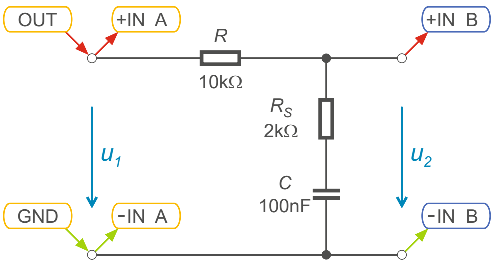


Fig. 1

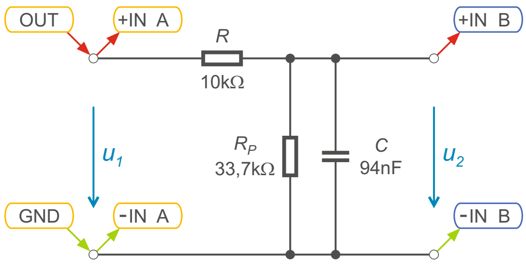
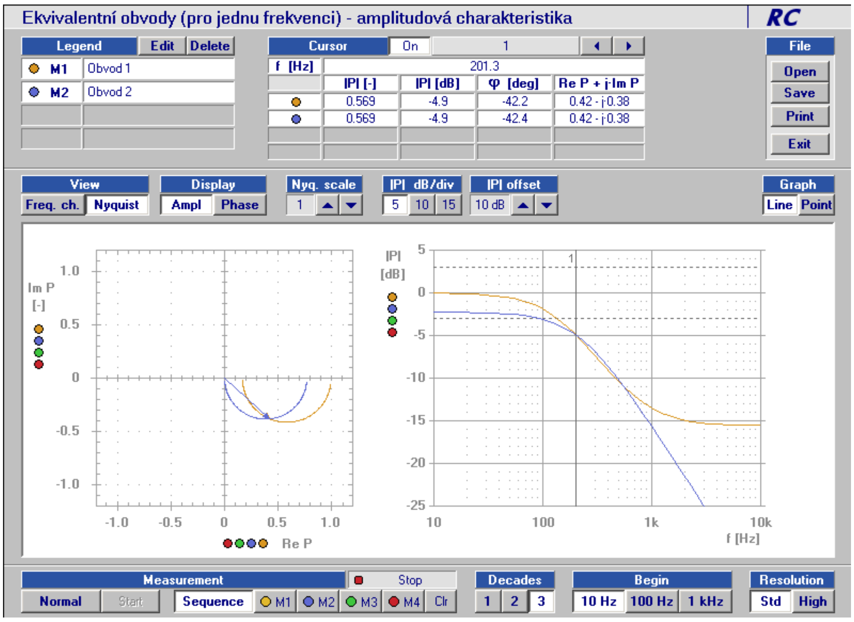


Fig. 2

Measurement

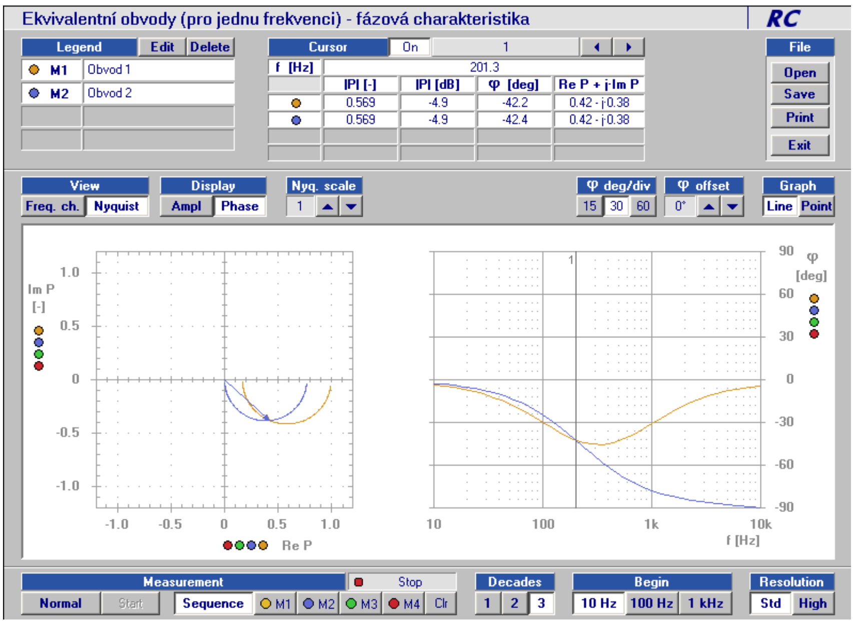


Amplitude characteristics

schema Fig. 1, Fig. 2

measuring mode

frequency characteristics



Phase characteristics

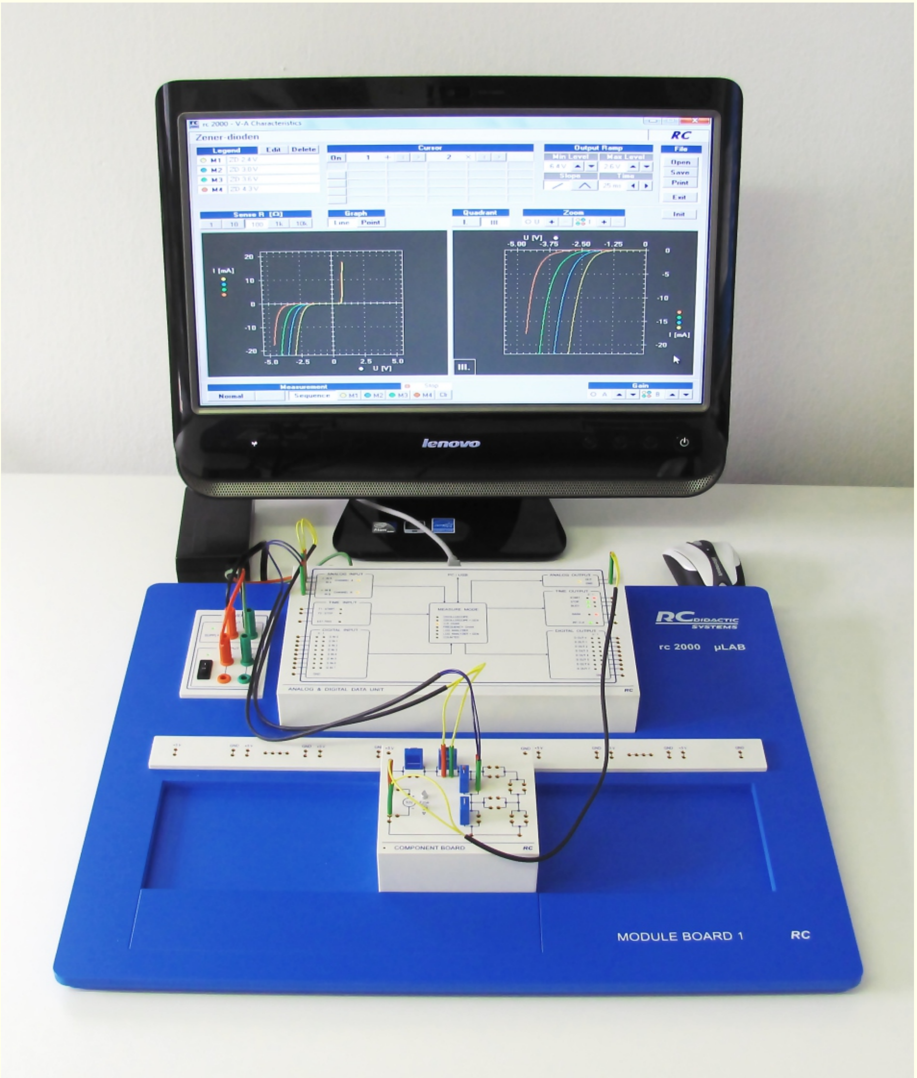
schema Fig. 1, Fig. 2

measuring mode

frequency characteristics

Teaching System rc2000 - µLAB

U-I Characteristics



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

Content

Exercise

Display characteristics of linear resistors. Use values 100 Ω, 200 Ω a 500 Ω.

Schema

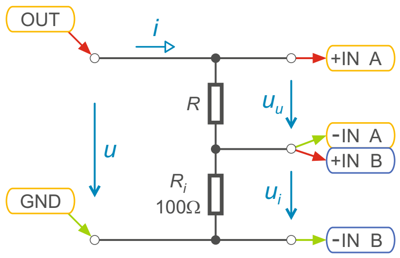
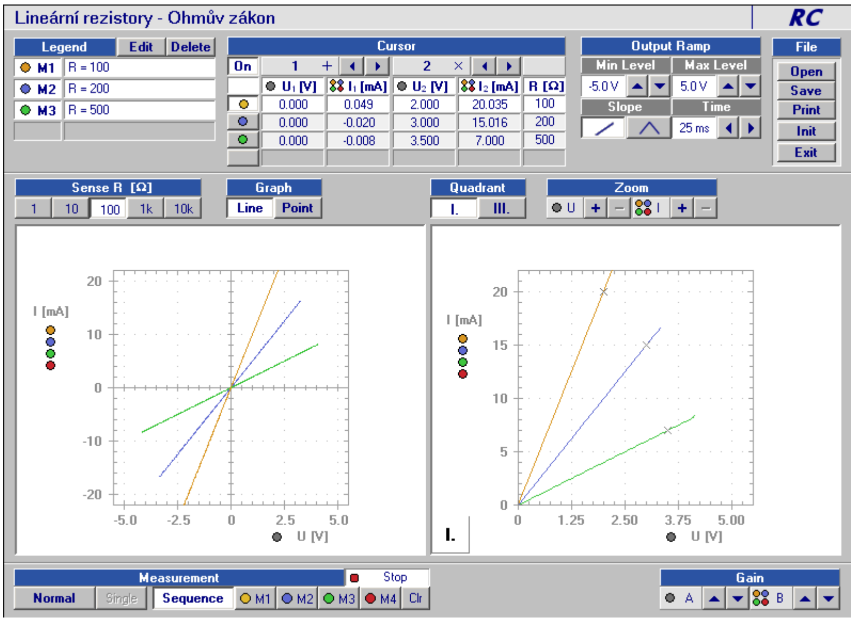


Fig. 1

$$u_u(t)=\frac{R_u}{R_i+R_u}\,u(t)$$

$$u_i(t)=\frac{R_i}{R_i+R_u}\,u(t)$$

Measurement



Linear resistors

schema Fig. 1

measuring mode

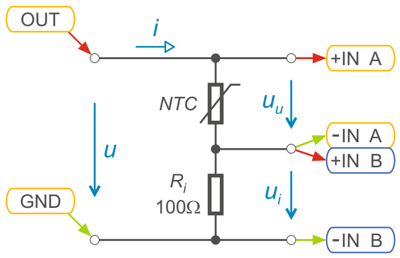
U-I characteristics

NTC Resistor - U-I Characteristic

Exercise

Display U-I characteristics of NTC resistor for two different temperatures.

Schema

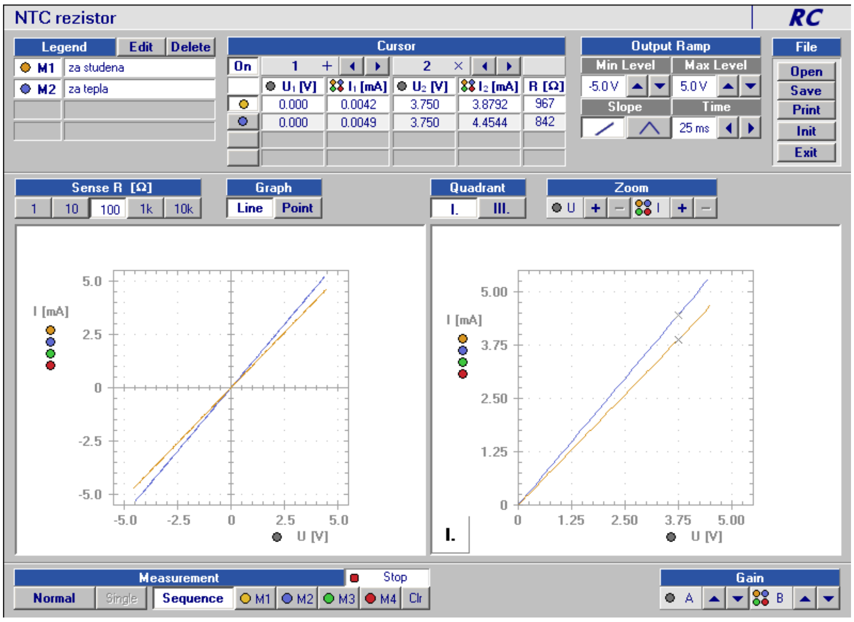


$u_u(t) = f(i(t))$

$u_i(t) = R_i \cdot i(t)$

Fig. 1

Measurement



NTC resistor

schema Fig. 1

measuring mode

U-I characteristics

3.3 PTC Resistor - U-I characteristic

Exercise

Display U-I characteristic of PTC resistor.

Schema

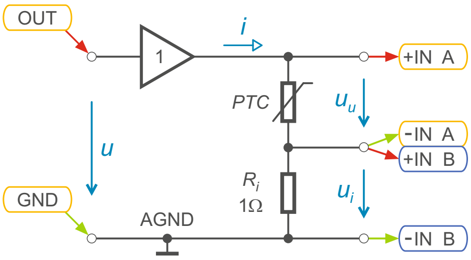
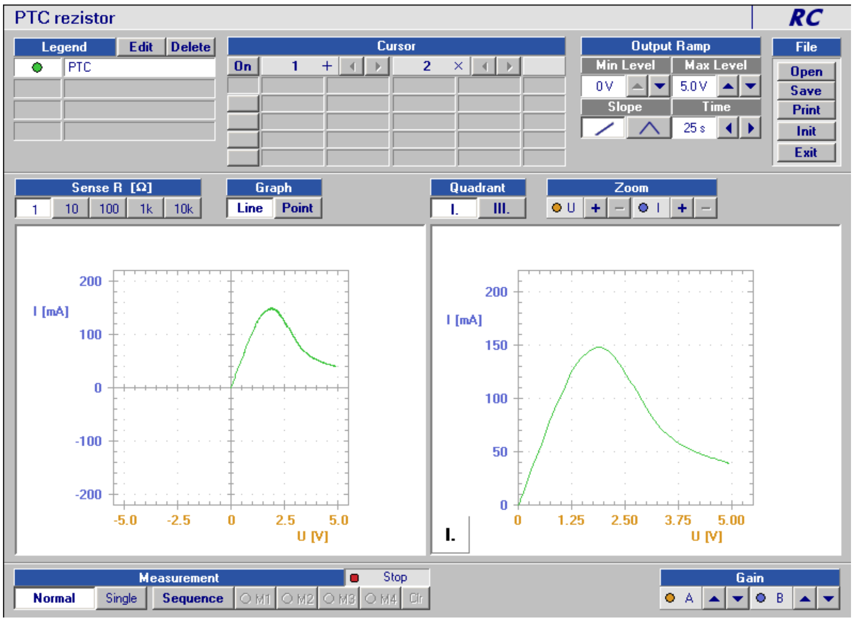


Fig. 1

$u_u\ (t) = \ f\ (\ i(t)\ )$

$u_i\ (t) = \ R_i\ .\ i(t)$

Measurement



PTC resistor

schema Fig. 1

measuring mode

U-I characteristics

Light Bulb - U-I Characteristic

Exercise

Display U-I characteristic of light bulb. Make the measurement both for increasing and decreasing voltage.

Schema

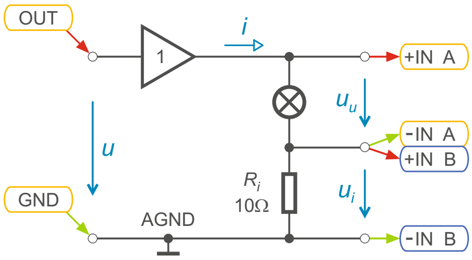
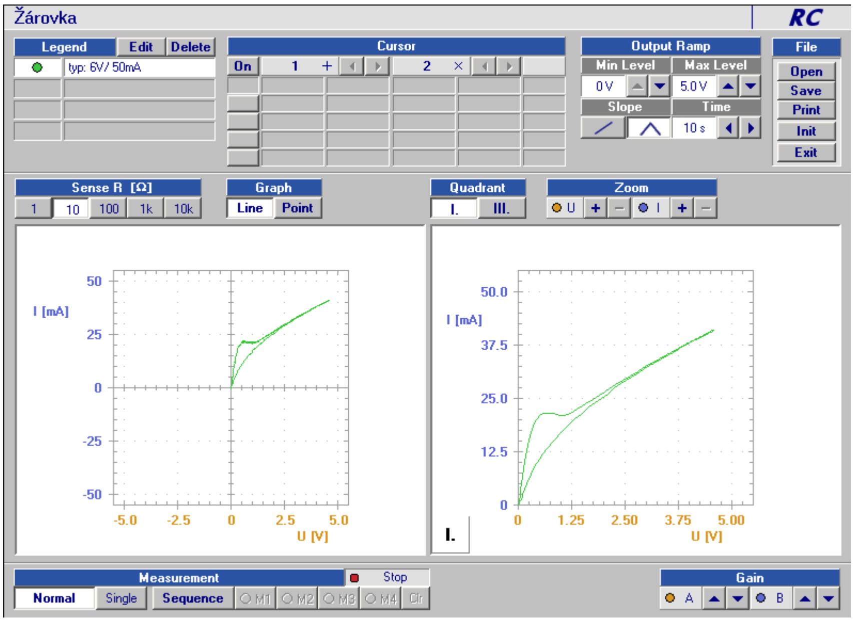


Fig. 1

$$u_u\,(t) = f\,(\,i(t)\,)$$

$$u_i\,(t) = R_i\,.\,i(t)$$

Measurement



Light bulb

schema Fig. 1

measuring mode

U-I characteristics

Exercise

Display U-I characteristics of rectifier diodes. Compare U-I characteristic of Schottky diode with U-I characteristic of PN junction diode.

Schema

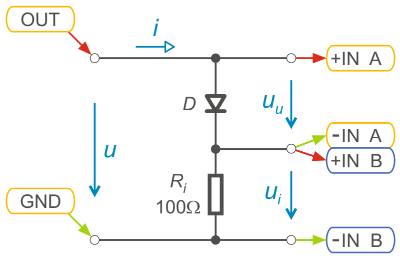
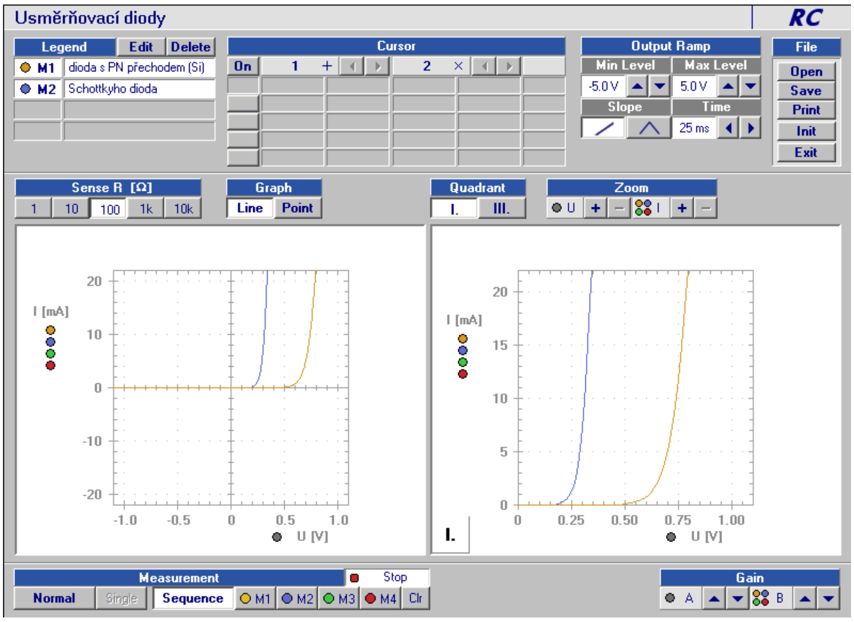


Fig. 1

$u_u(t) = f(i(t))$

$u_i(t) = R_i \cdot i(t)$

Measurement



Rectifier diode

schema	Fig. 1
measuring mode	U-I characteristics

Exercise

Display U-I characteristics of Zener diodes with different Zener voltage.

Schema

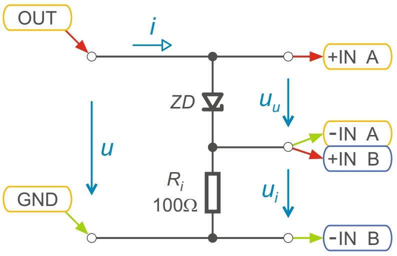
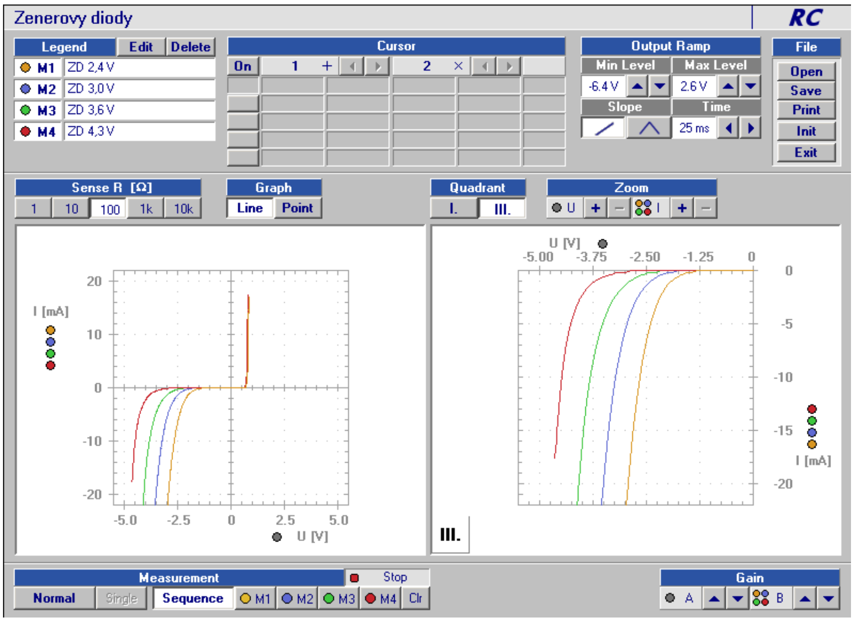


Fig. 1

$u_u(t) = f(i(t))$

$u_i(t) = R_i \cdot i(t)$

Measurement



Zener diodes

schema Fig. 1

measuring mode

U-I characteristics

Exercise

Display U-I characteristics of LEDs of different colors.

Schema

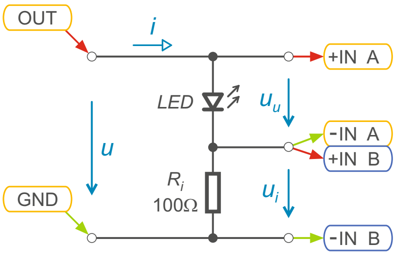
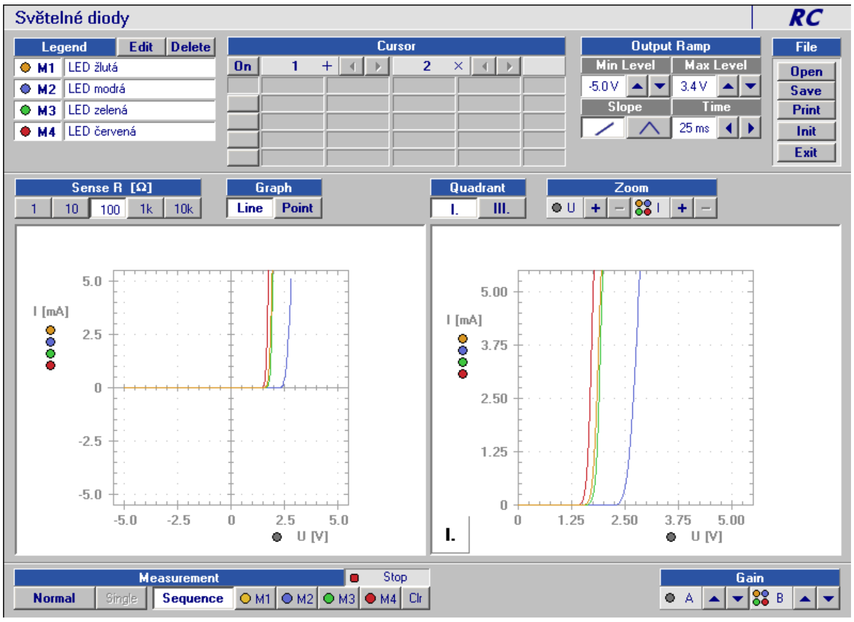


Fig. 1

$$u_u\,(t) = f\,(\,i(t)\,)$$

$$u_i\,(t) = R_i\,.\,i(t)$$

Measurement



LEDs

schema Fig. 1

measuring mode

U-I characteristics

Exercise

Display U-I characteristic of bipolar transil.

Schema

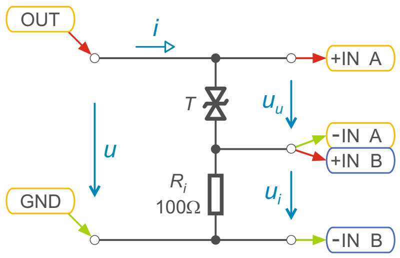
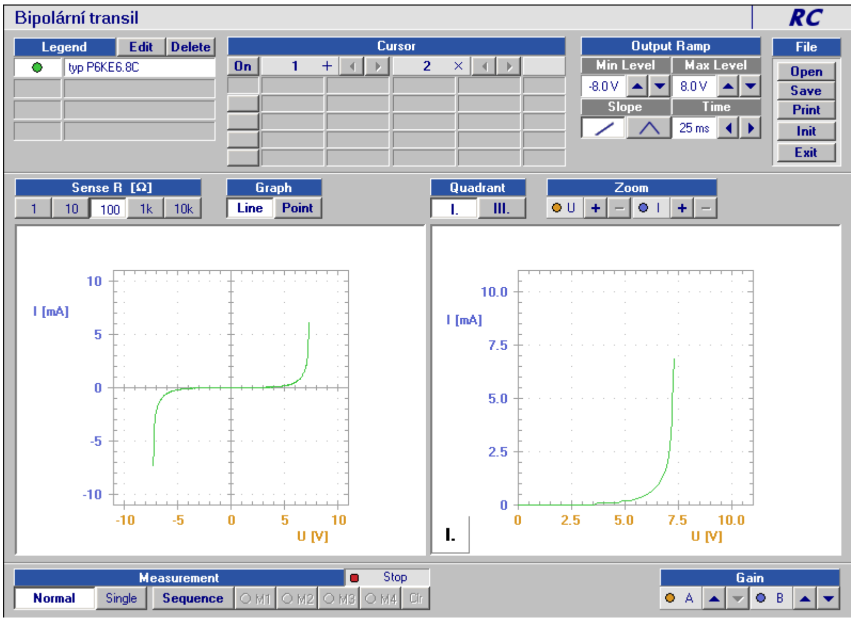


Fig. 1

$u_u(t) = f(i(t))$

$u_i(t) = R_i \cdot i(t)$

Measurement



Bipolar transil	
schema	Fig. 1
measuring mode	
U-I characteristics	

Exercise

Display U-I characteristics of two linear elements and their serial combination.

Schema

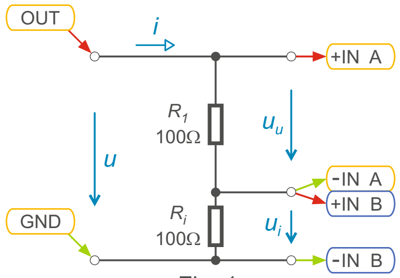


Fig. 1

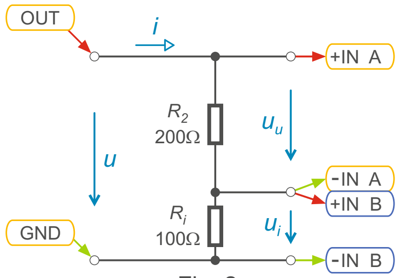


Fig. 2

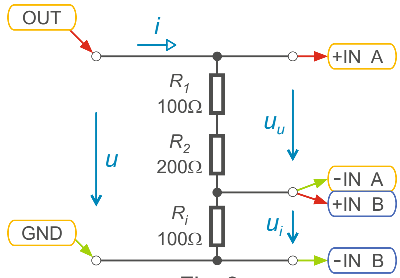
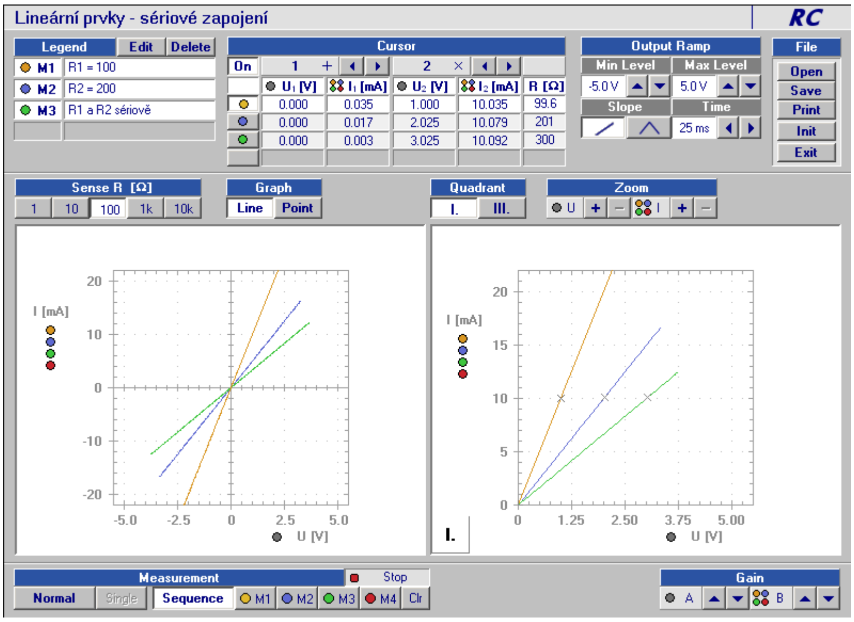


Fig. 3

Measurement



Linear elements (serial)

schema Fig. 1,2,3

measuring mode

U-I characteristics

$$u_u\,(t)=\frac{R_1}{R_i+R_1}\,u(t)$$

$$u_u\,(t)=\frac{R_2}{R_i+R_2}\,u(t)$$

$$u_u\,(t)=\frac{R_1+R_2}{R_i+R_1+R_2}\,u(t)$$

3.10 Linear Elements (Parallel Circuit) - U-I characteristics

Exercise

Display U-I characteristics of two linear elements and their parallel combination.

Schema

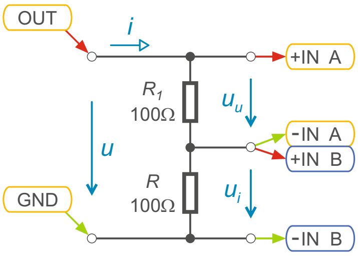


Fig. 1

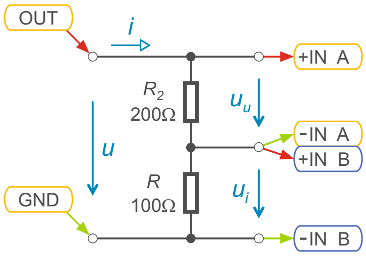


Fig. 2

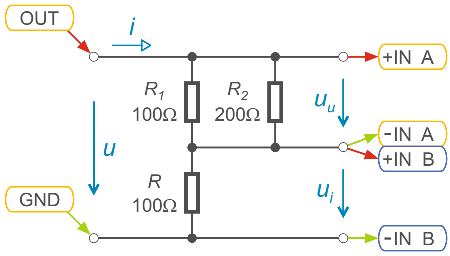
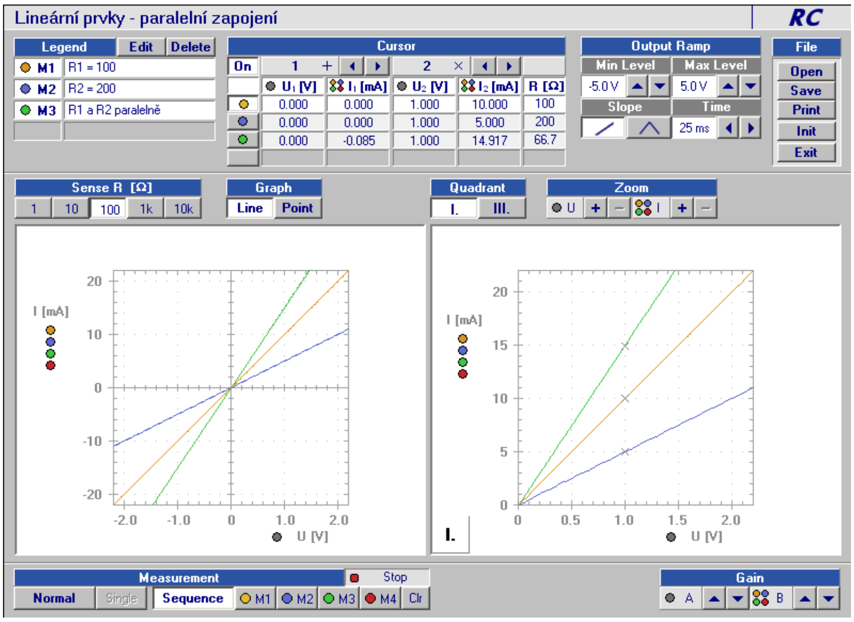


Fig. 3

Measurement



On	U₁ [V]	I₁ [mA]	U₂ [V]	I₂ [mA]	R [Ω]
M1	0.000	0.000	1.000	10.000	100
M2	0.000	0.000	1.000	5.000	200
M3	0.000	-0.085	1.000	14.917	66.7

Linear elements (parallel)

schema Fig. 1,2,3

measuring mode

U-I characteristics

● $u_u(t) = \dfrac{R_1}{R_i + R_1} u(t)$

● $u_u(t) = \dfrac{R_2}{R_i + R_2} u(t)$

● $u_u(t) = \dfrac{R_{1,2}}{R_i + R_{1,2}} u(t)$

$$R_{1,2} = \frac{R_1 \,.\, R_2}{R_1 + R_2}$$

3.11 Nonlinear Elements (Serial Circuit) - U-I characteristics

Exercise

Display U-I characteristics of two nelinear elements (diodes) and their serial combination.

Schema

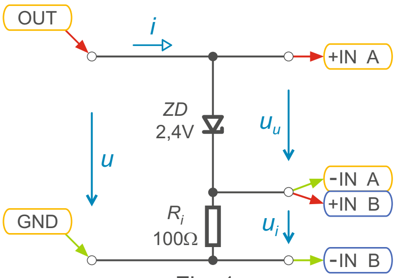


Fig. 1

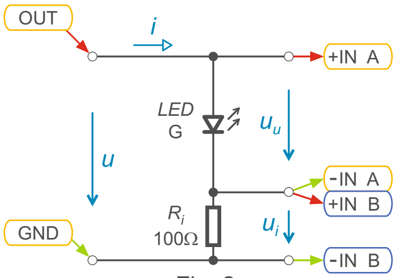


Fig. 2

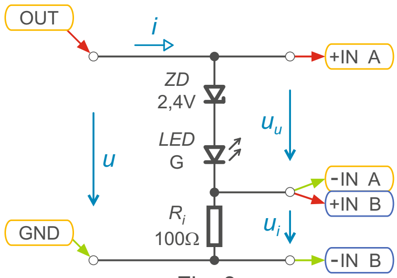
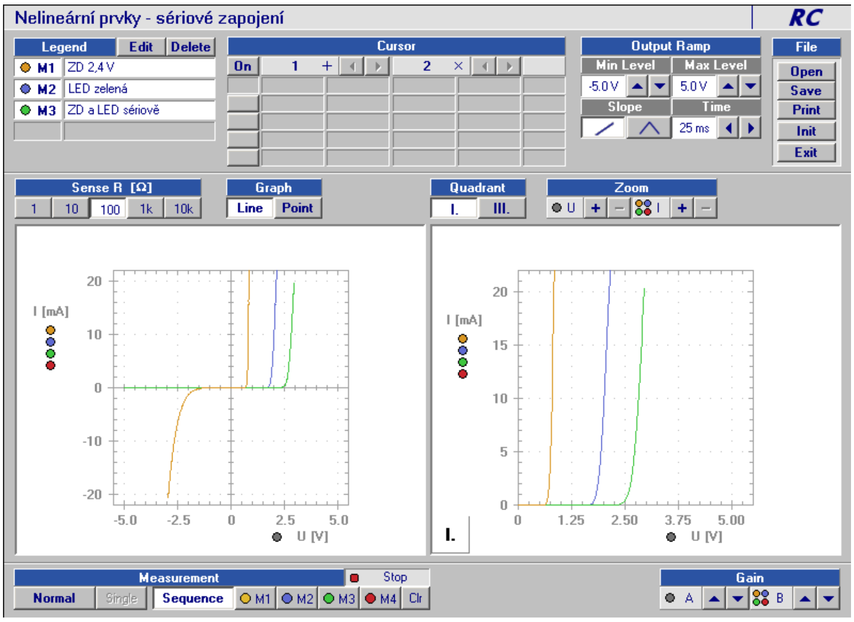


Fig. 3

Measurement



Nonlinear elements (serial)

schema	Fig. 1,2,3

measuring mode

U-I characteristics

Exercise

Display U-I characteristics of two nonlinear elements (diodes) and their parallel combination.

Schema

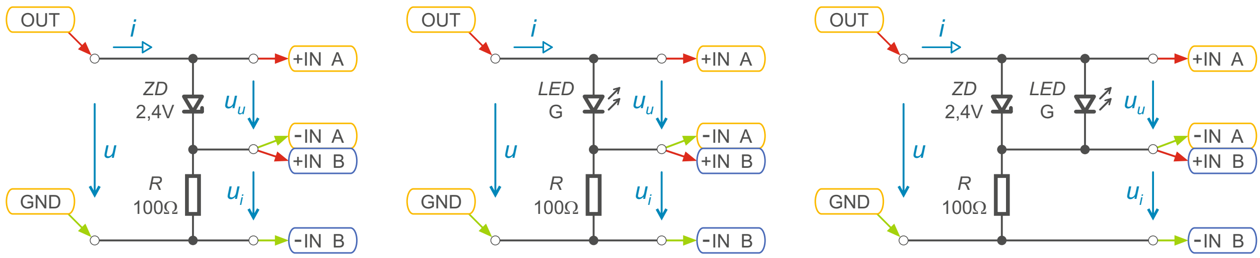
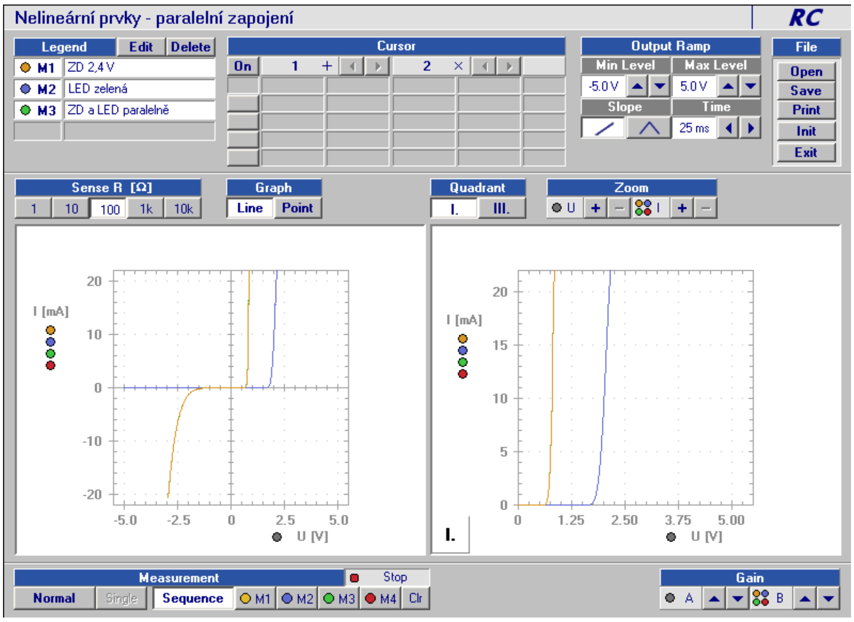


Fig. 1 Fig. 2 Fig. 3

Measurement



Nonlinear elements (parallel)

schema Fig. 1,2,3

measuring mode

U-I characteristics

3.13 Nonlinear and Linear Elements (Serial Circuit) - U-I Characteristics

Exercise

Display U-I characteristics of serial combination of linear and nonlinear element.

Schema

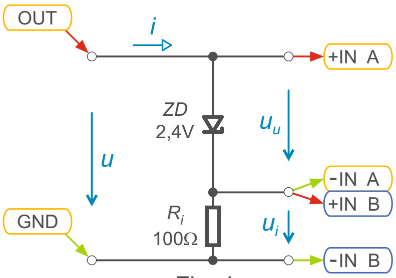


Fig. 1

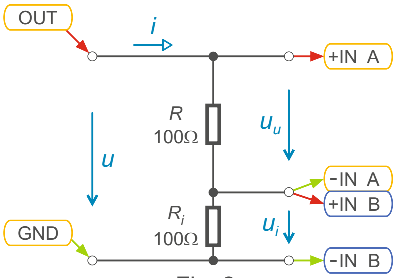


Fig. 2

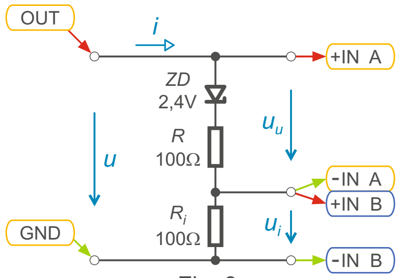
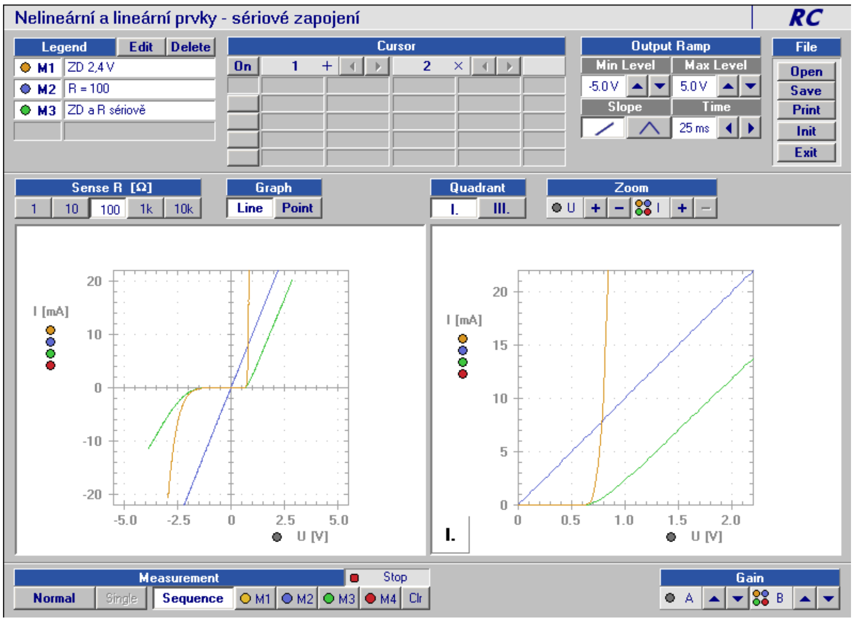


Fig. 3

Measurement



Nonlinear and linear elements

schema Fig. 1,2,3

measuring mode

U-I characteristics

3.14 **Nonlinear and Linear Elements (Parallel Circuit) - U-I Characteristics**

Exercise

Display U-I characteristics of parallel combination of linear and nonlinear element.

Schema

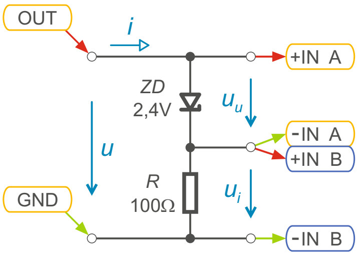


Fig. 1

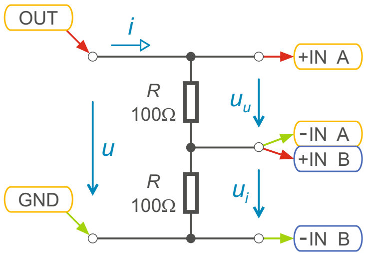


Fig. 2

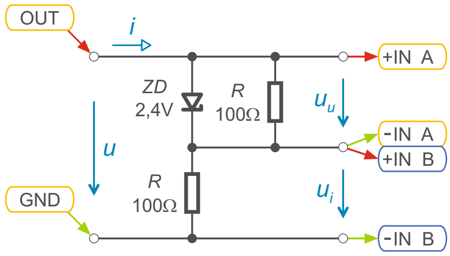
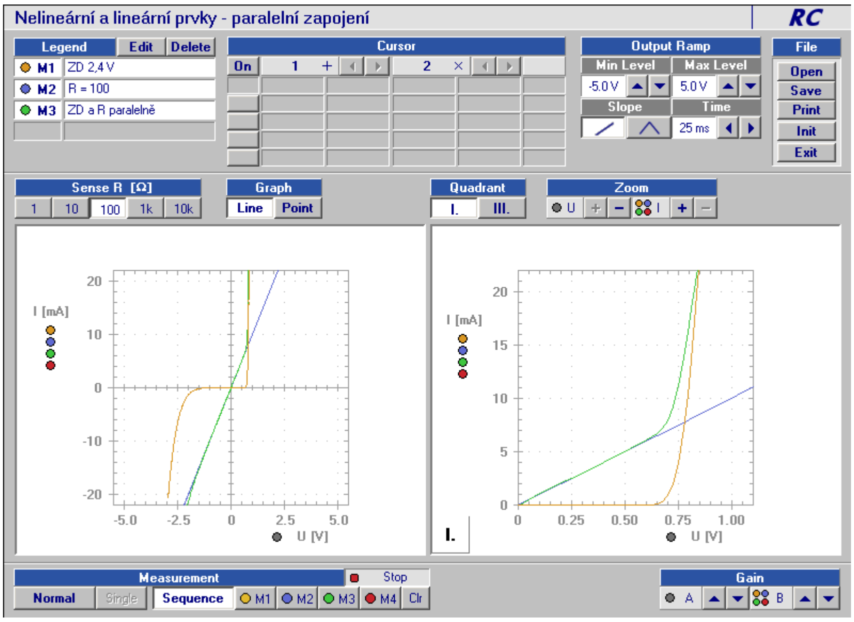


Fig. 3

Measurement



Nonlinear and linear elements	
schema	Fig. 1,2,3
measuring mode	
U-I characteristics	

3.15 Input Characteristics of Bipolar Transistor NPN

Exercise

Measure and display input characteristics of transistor BC546B.

Schema

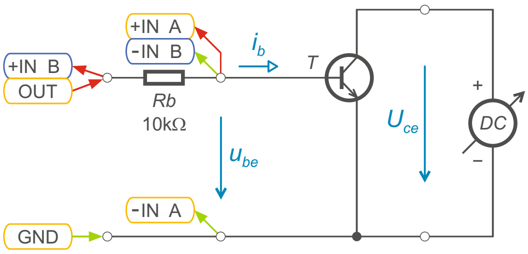


Fig. 1

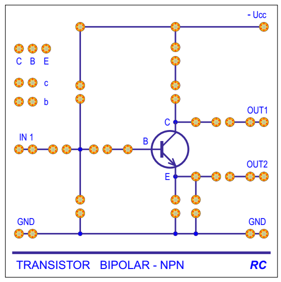
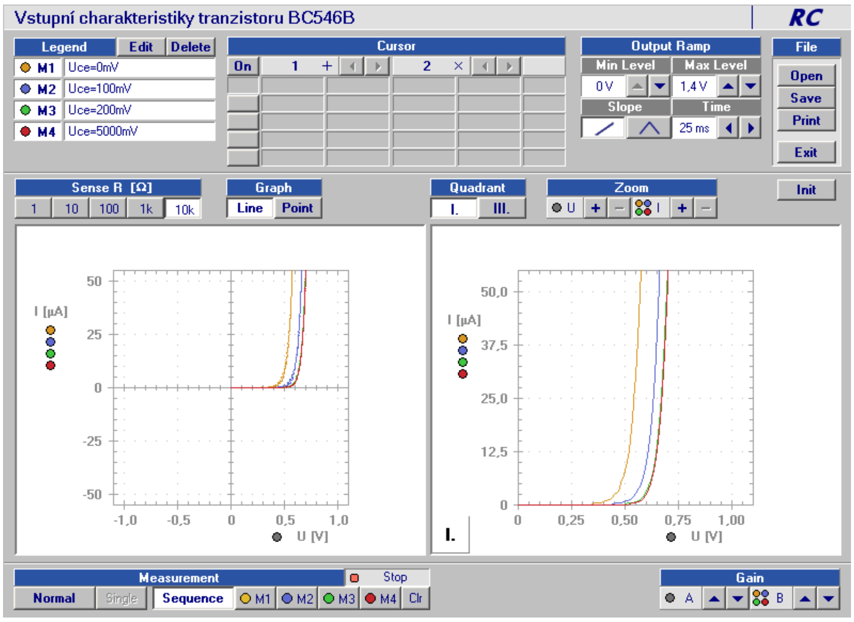


Fig. 2

Measurement



Input characteristics

schema Fig. 1

measuring mode

V-A characteristics

Notice

- plug 3-pin element ***BC546B*** into a ***module of bipolar transistor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safeties ***b*** and ***c*** with a couplings
- in a program (Block *Output Ramp*) we set output signal in a range *0V - 1,4V*

3.16 Output Characteristics of Bipolar Transistor NPN

Exercise

Measure and display output characteristics of NPN transistor BC546B.

Schema

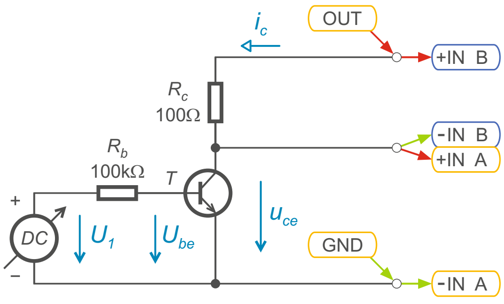


Fig. 1

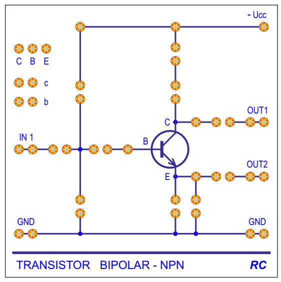
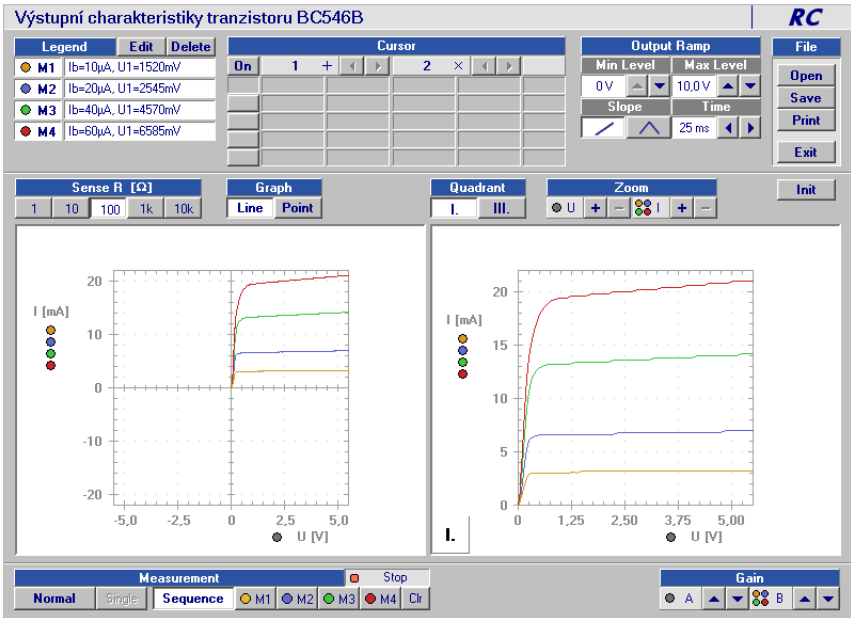


Fig. 2

Measurement



Output characteristics	
schema	Fig. 1
measuring mode	V-A characteristics

Notice

- plug 3-pin element ***BC546B*** into a ***module of bipolar transistor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safety ***c*** with a coupling
- in a program (Block*Output Ramp*) we set output signal in a range *0V - 10V*

3.17 Output Characteristic of a Bipolar Transistor PNP

Exercise

Measure and display the output characteristics of the BC556B PNP transistor.

Schema

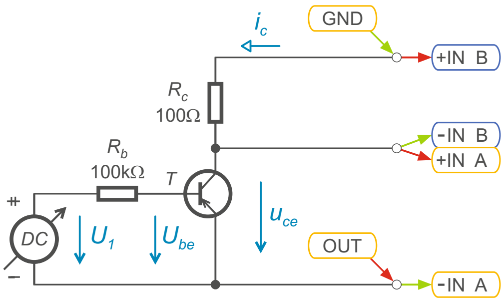


Fig. 1

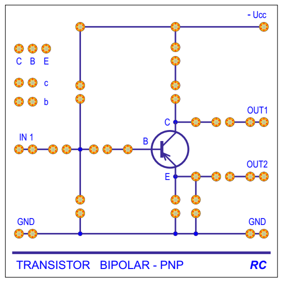
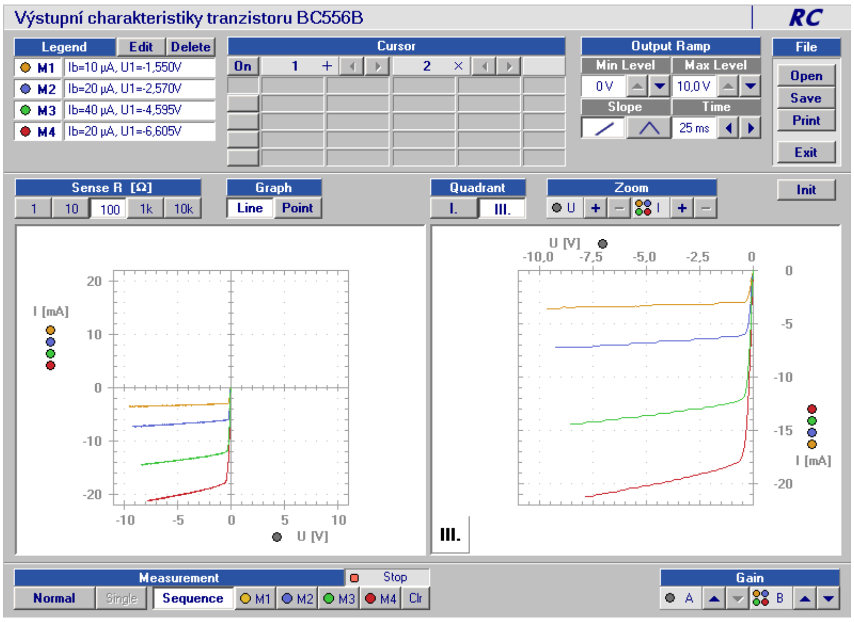


Fig. 2

Measurement



Output characteristics

schema Fig. 1

measuring mode

V-A characteristics

Notice

- plug 3-pin element ***BC556B*** into a ***Module of bipolar transistor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safety ***c*** with a coupling
- if the axis orientation of the diagram is maintained, the measured curves for the PNP transistor are "opposite" to the NPN transistor.
- in a program (Block *Output Ramp*) we set output signal in a range *0V - 10V*
- the output curve of the voltage from the output ramp can only increase - so the voltage to the circuit is reversed...

3.18 Output Characteristic of a Unipolar Transistor J-FET

Exercise

Measure and display the output characteristics of transistor BF245B.

Schema

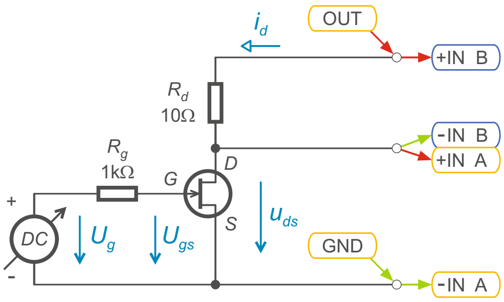


Fig. 1

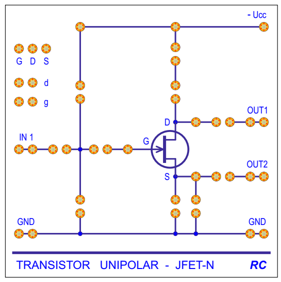
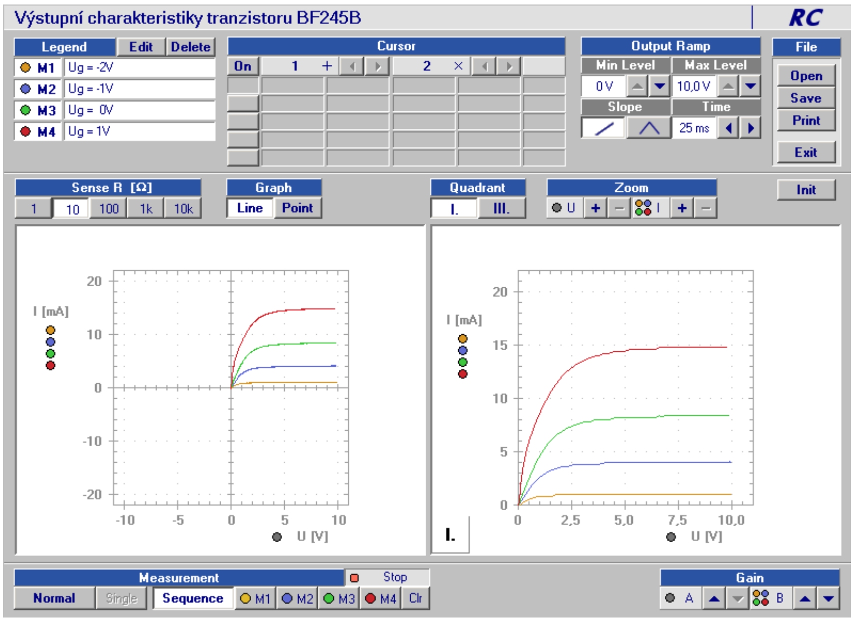


Fig. 2

Measurement



Output characteristics

schema Fig. 1

measuring mode

V-A characteristics

Notice

- plug 3-pin element ***BF245B***into a ***Module of unipolar transistor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safety ***d*** *with a coupling*
- in a program (Block*Output Ramp*) we set output signal in a range *0V - 10V*

U-I Characteristic of the Thyristor

Exercise

Display the U-I characteristics of the thyristor.

Schema

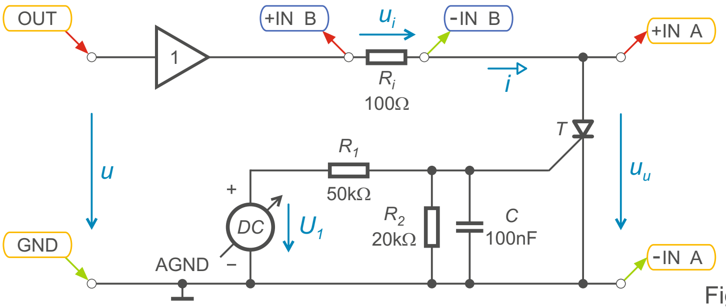


Fig. 1

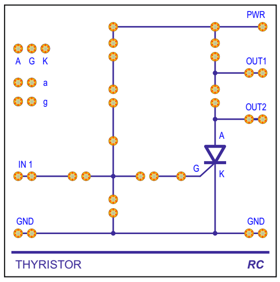
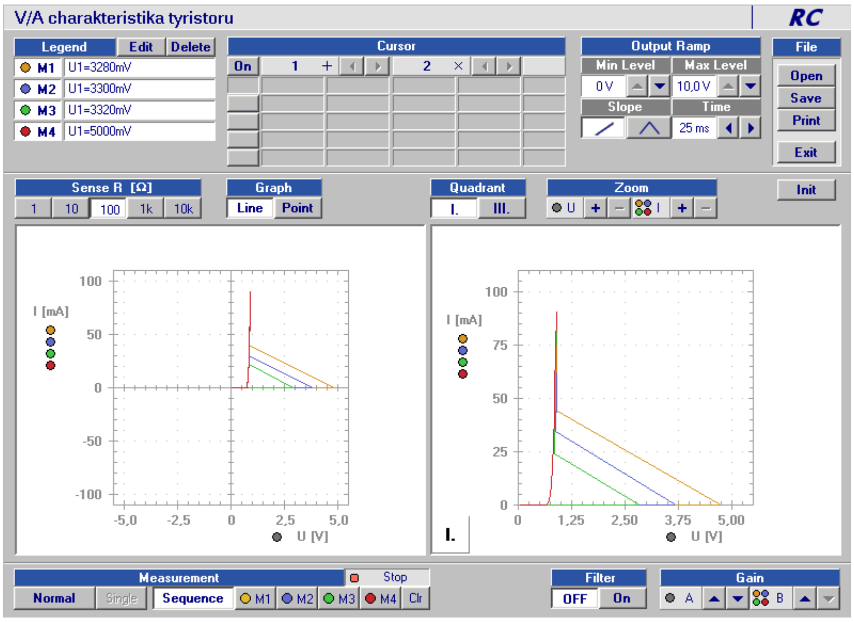


Fig. 2

Measurement



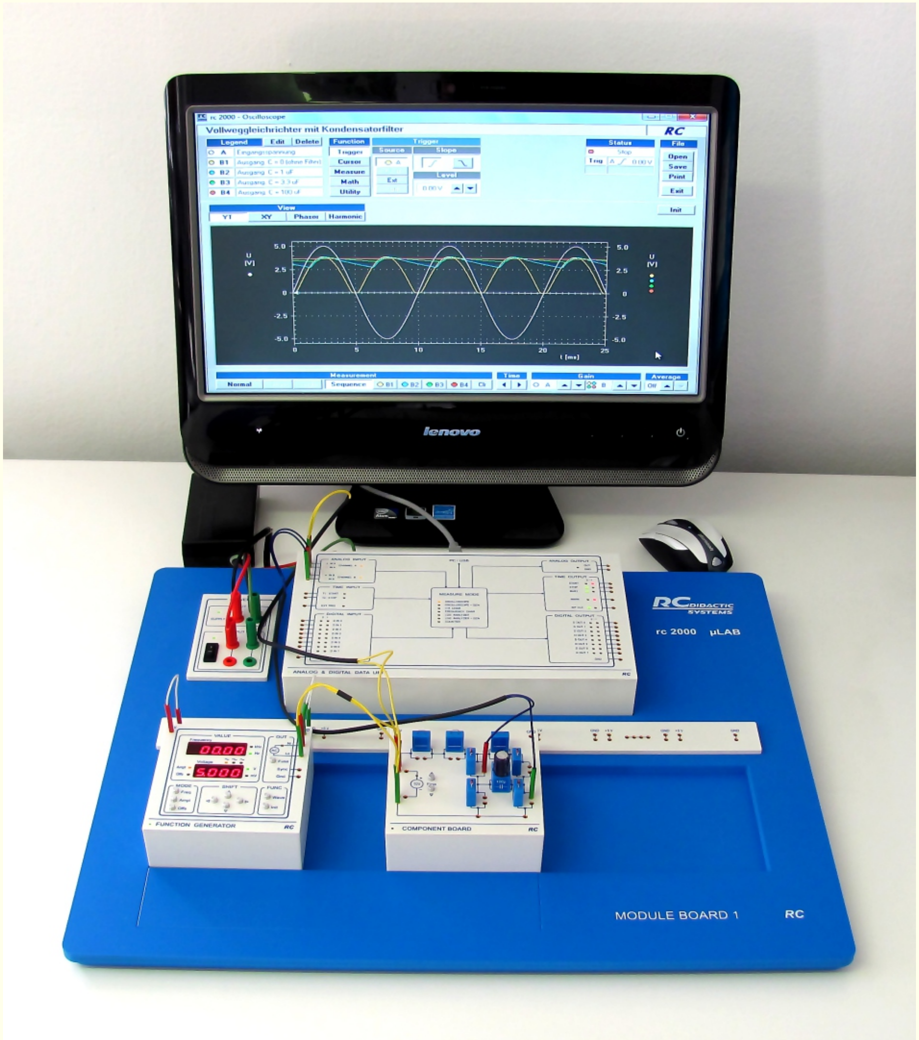
Output characteristics	
schema	Fig. 1
measuring mode	V-A characteristics

Notice

- plug 3-pin element ***2N5060*** into a ***module of thyristor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safeties ***a*** and ***k*** *with couplings*
- v programu ***V/A Charakteristiky*** vypneme hlazení průběhu tlačítkem ***Filter OFF***

Teaching System rc2000 - µLAB

Components



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

Content

Exercise

Display the input and output voltage of the half-wave rectifier without (Fig. 1) and with capacitor filter (Fig. 2). Use the values of filter capacitor $C = 1\ \mu F$ a $10\ \mu F$.

Schema

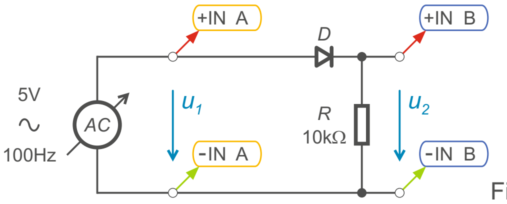


Fig. 1

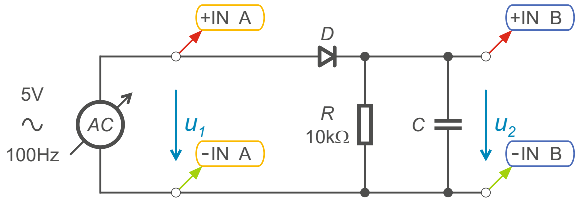
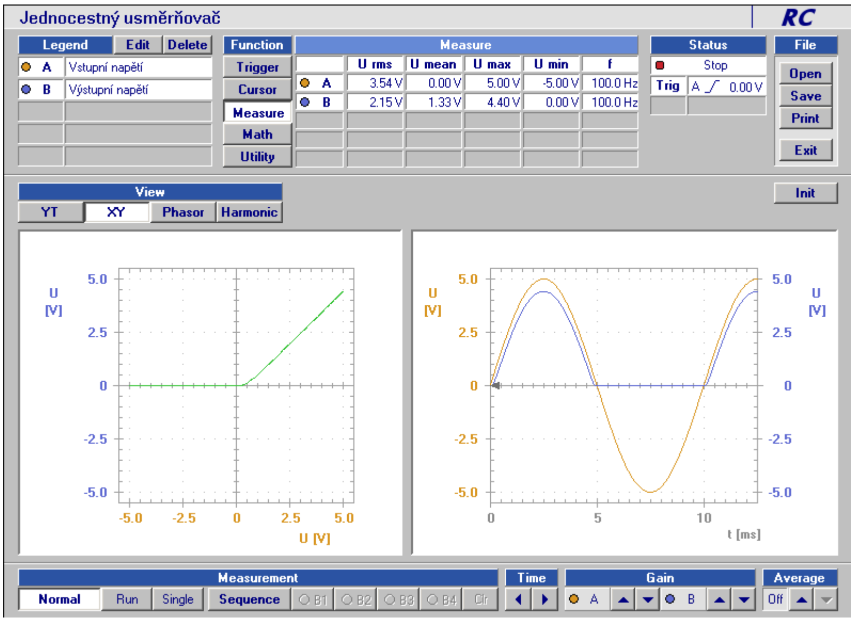
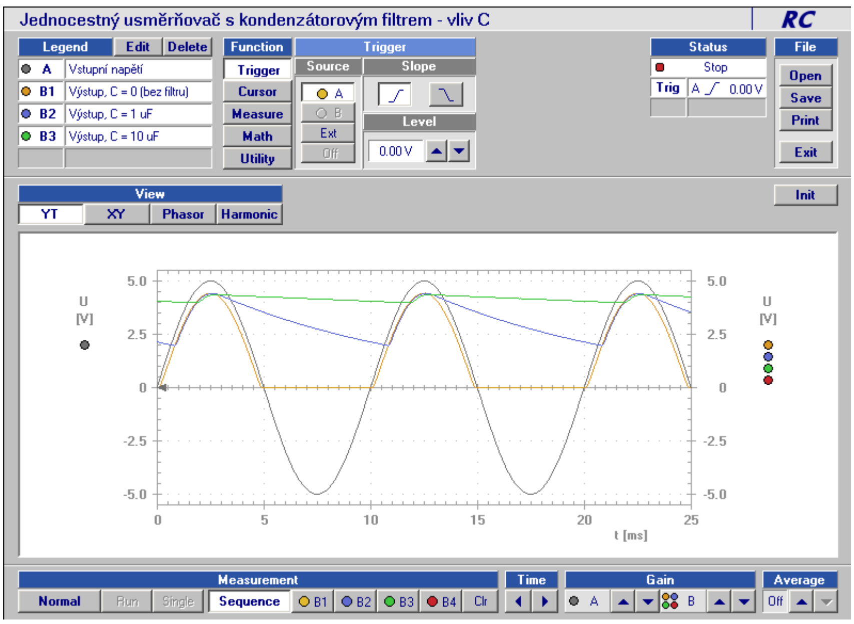


Fig. 2

Measurement





4.2 Half-Wave Rectifier - Diode Current

Exercise

Display diode current of half-wave rectifier without filter (Fig. 1) and with capacitor filter (Fig. 2).

Schema

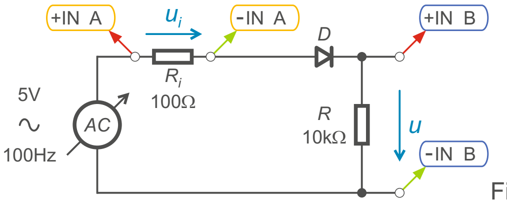


Fig. 1

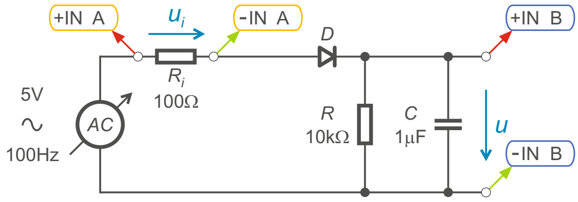
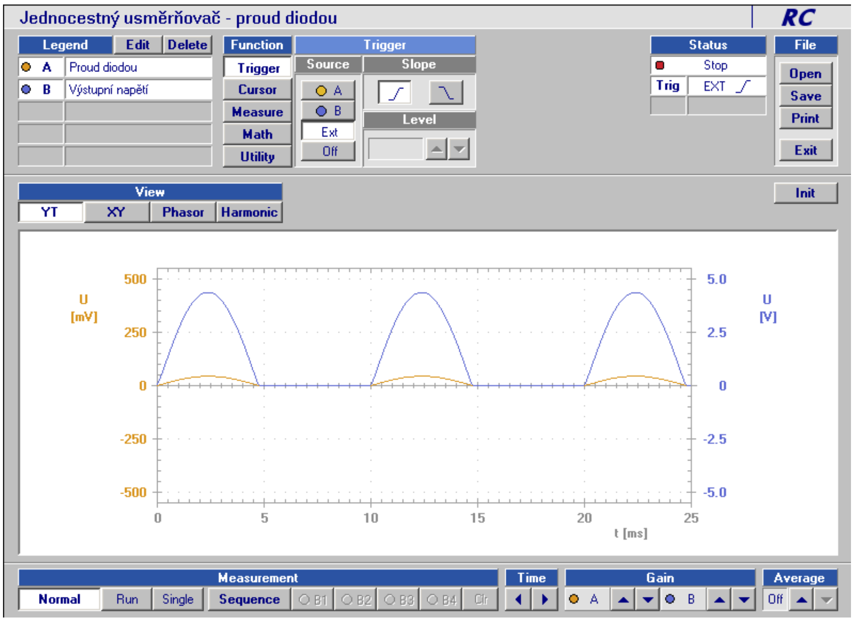


Fig. 2

Measurement



Rectifier without filter

schema Fig. 1

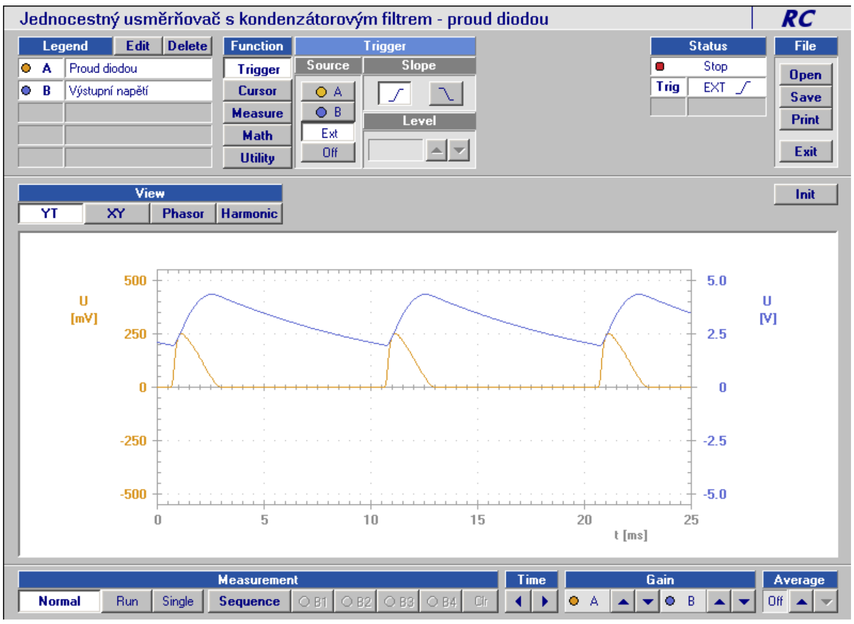
measuring mode

oscilloscope

connection of trigger

measured waveforms

- $i(t) = \frac{1}{R_i} u_i(t)$ (mA, kΩ, V)
- $u(t)$ (V)



Rectifier with filter

schema Fig. 2

measuring mode

oscilloscope

connection of trigger

measured waveforms

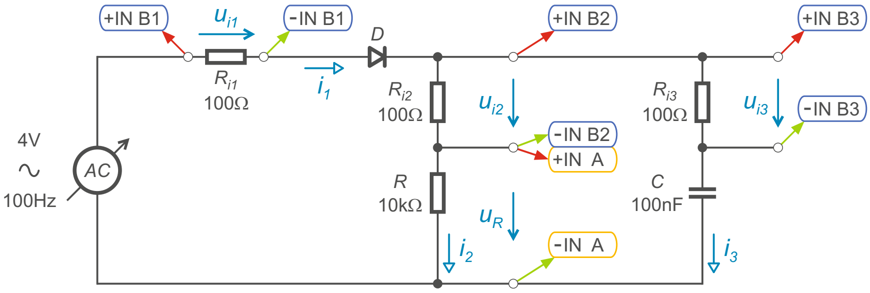
- $i(t) = \frac{1}{R_i} u_i(t)$ (mA, kΩ, V)
- $u(t)$ (V)

Half-Wave Rectifier with Capacitor Filter - Currents

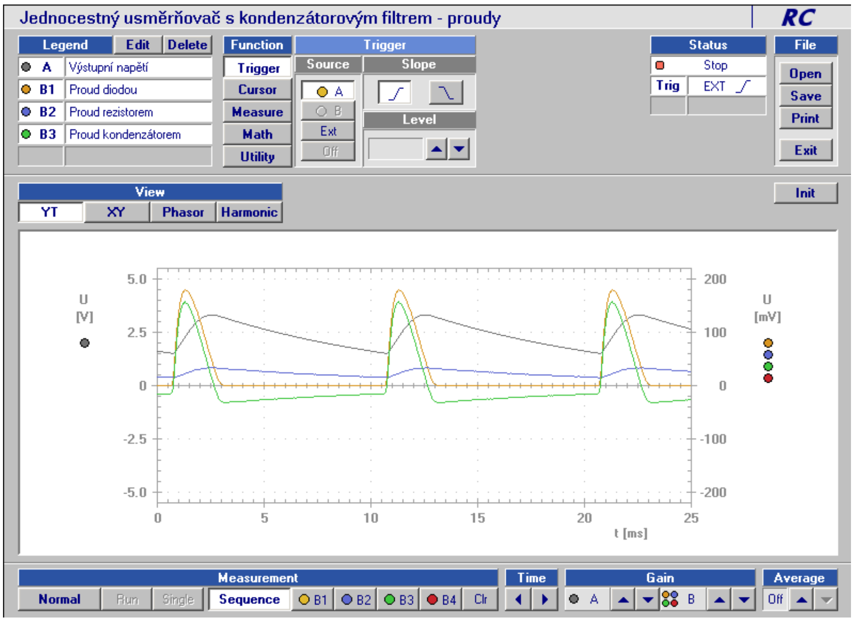
Exercise

Display currents in different parts of the half-wave rectifier with capacitor filter.

Schema



Measurement



Currents in rectifier

schema Fig. 1

measuring mode

oscilloscope

connection of trigger

measured waveforms

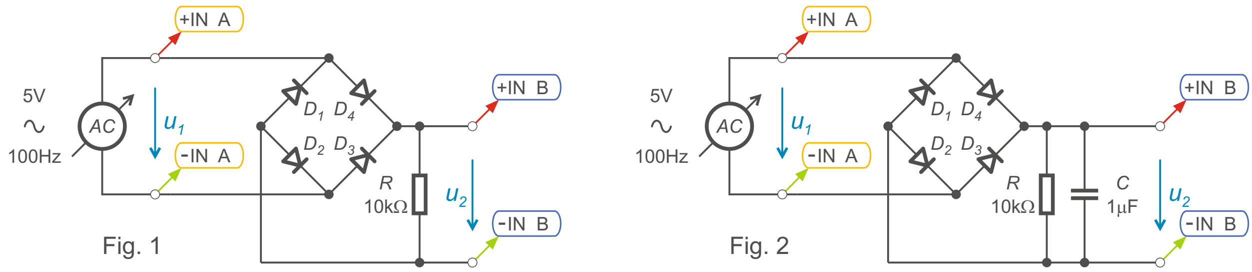
- $u_R(t)$ (V)
- $i_1(t) = \dfrac{1}{R_{i1}} u_{i1}(t)$ (mA, kΩ, V)
- $i_2(t) = \dfrac{1}{R_{i2}} u_{i2}(t)$ (mA, kΩ, V)
- $i_3(t) = \dfrac{1}{R_{i3}} u_{i3}(t)$ (mA, kΩ, V)

Full-Wave Rectifier

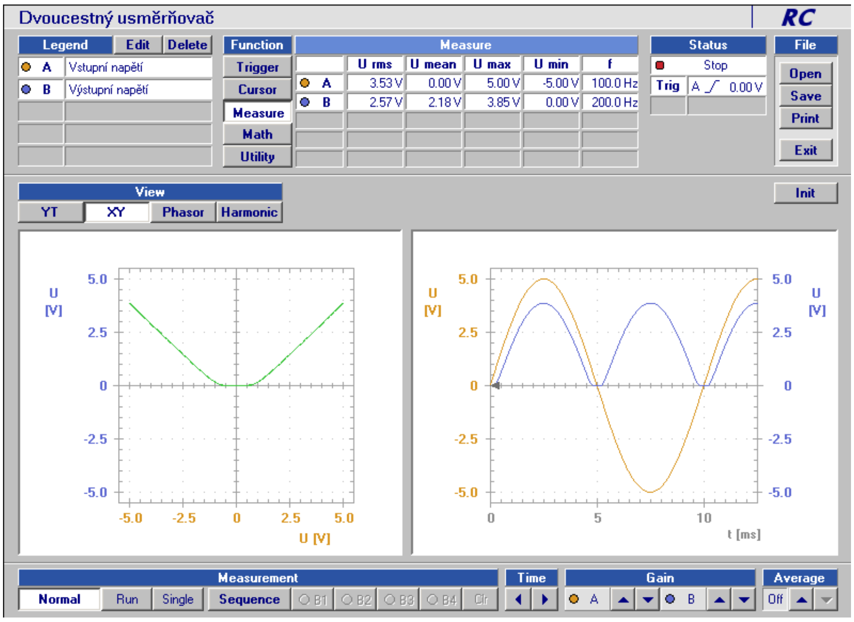
Exercise

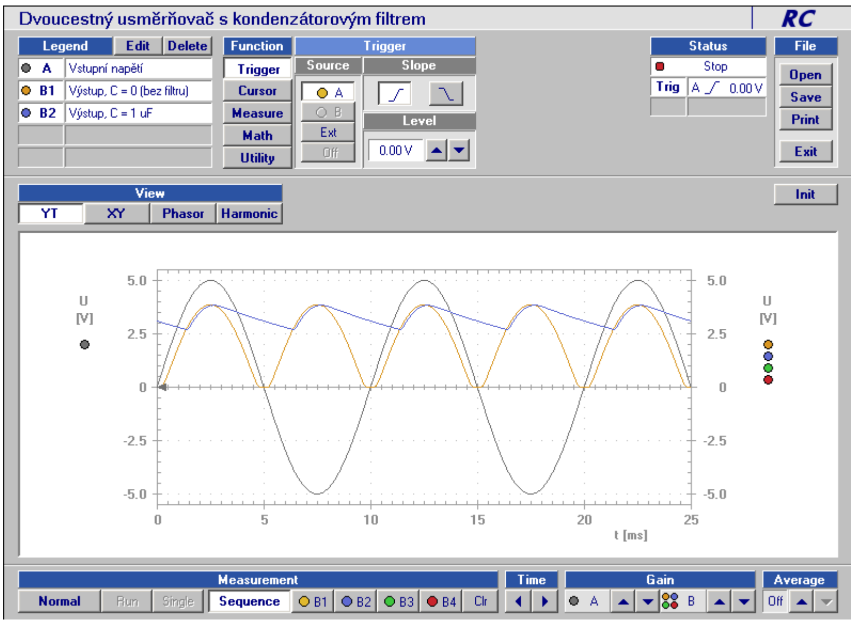
Display the input and output voltage of the full-wave rectifier without (Fig. 1) and with capacitor filter (Fig. 2).

Schema



Measurement





4.5 Diode Limiter

Exercise

Display the input and output voltage of the diode limiter (Fig. 1) and the diode limiter with the adjustable voltage (Fig. 2). Compare output waveforms for different voltage settings.

Schema

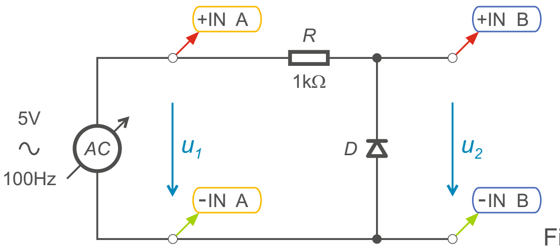


Fig. 1

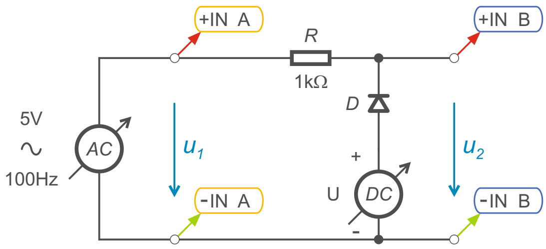
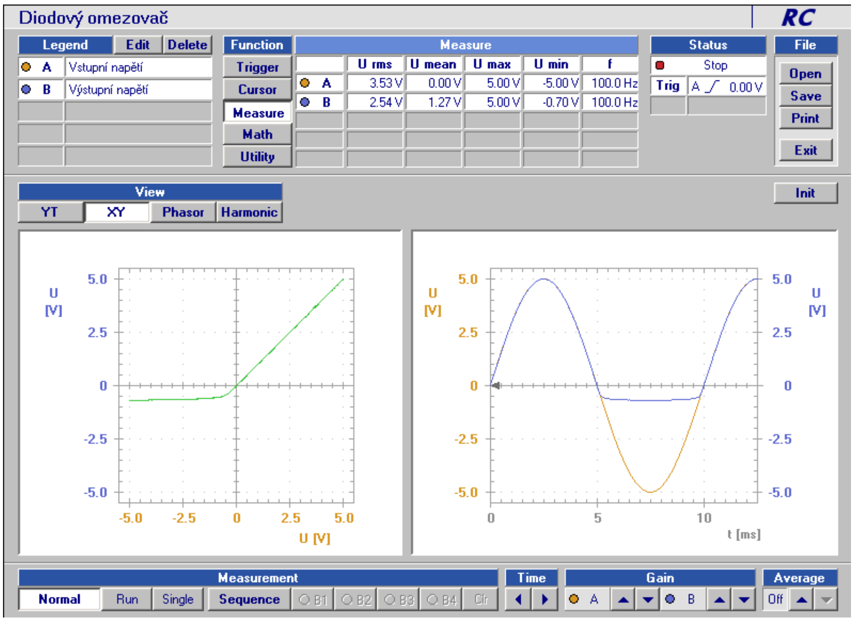
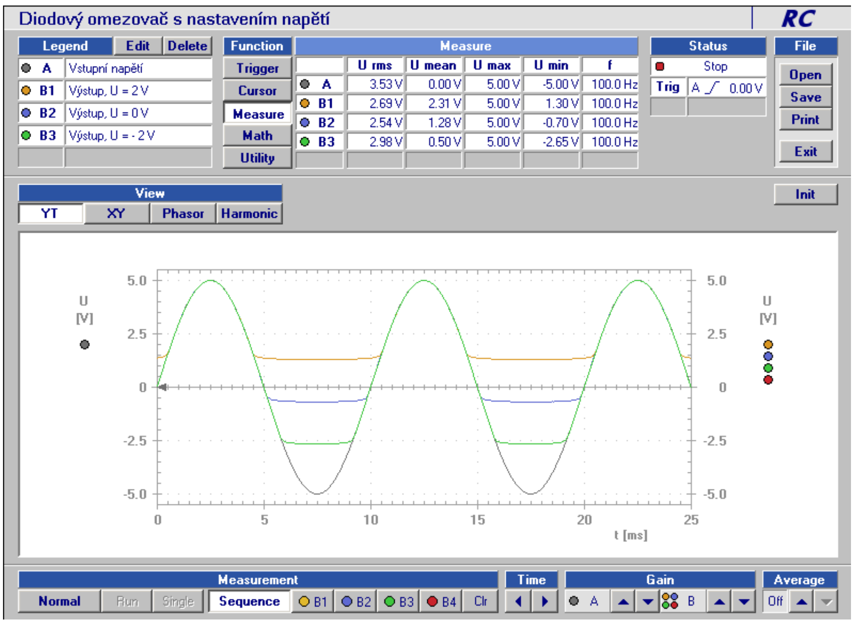


Fig. 2

Measurement



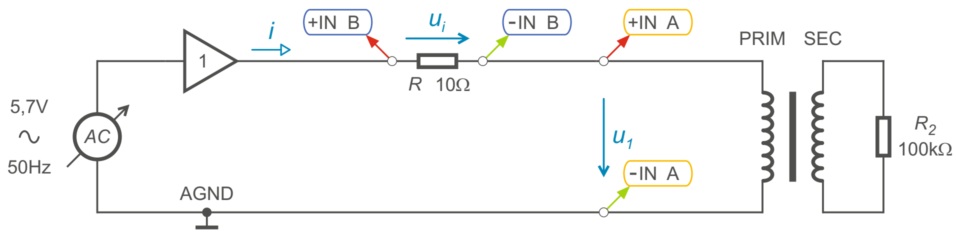


4.6 Transformer - Voltage and Current in Primary Winding

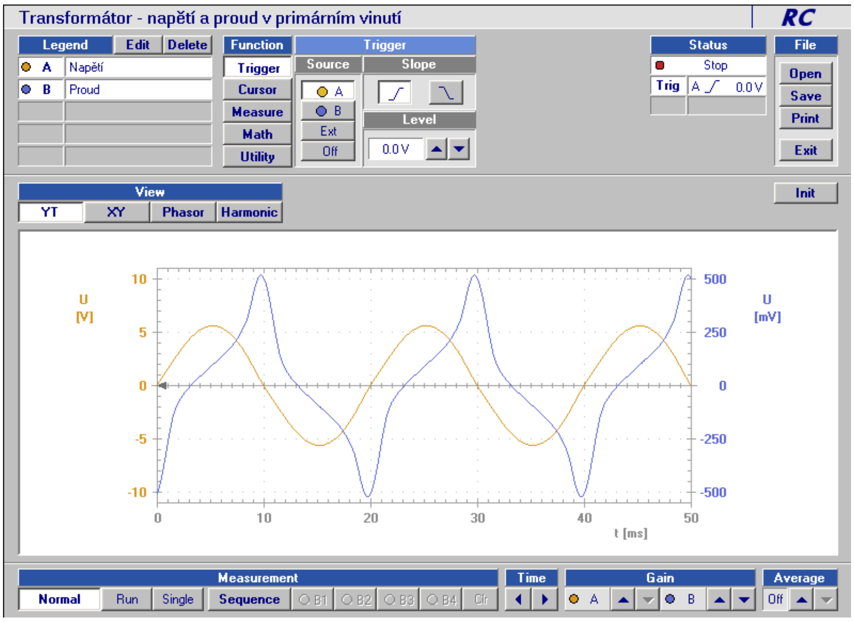
Exercise

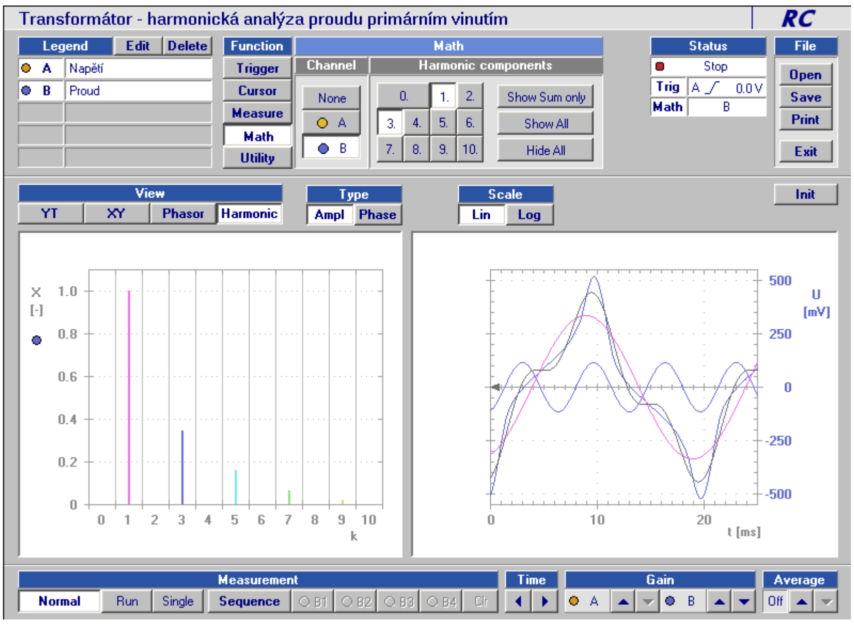
Display current and voltage in the primary winding of the transformer.

Schema



Measurement



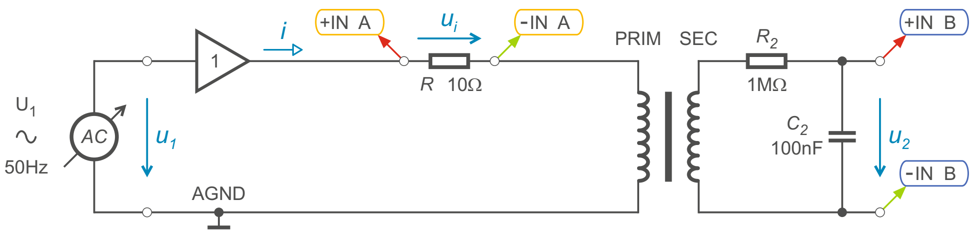


Transformer - Hysteresis Curve

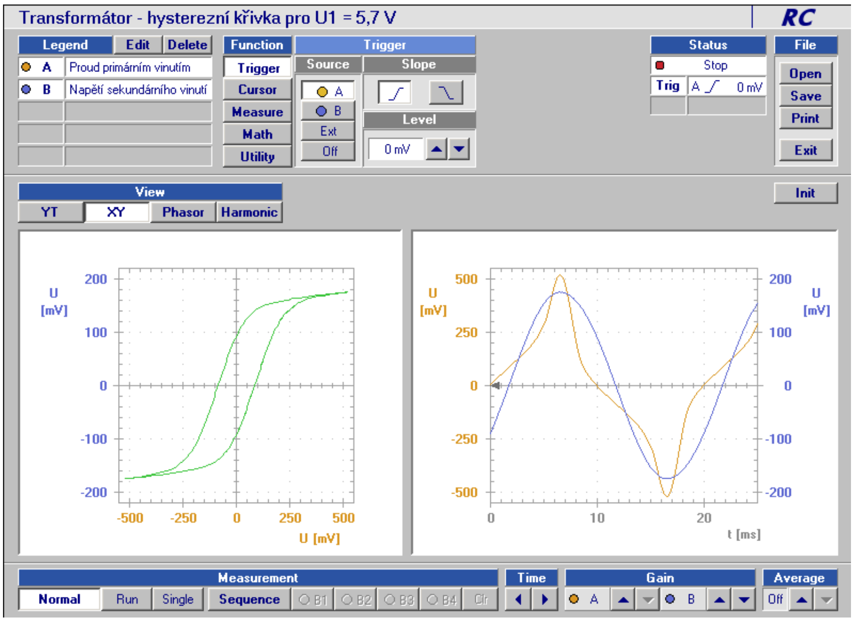
Exercise

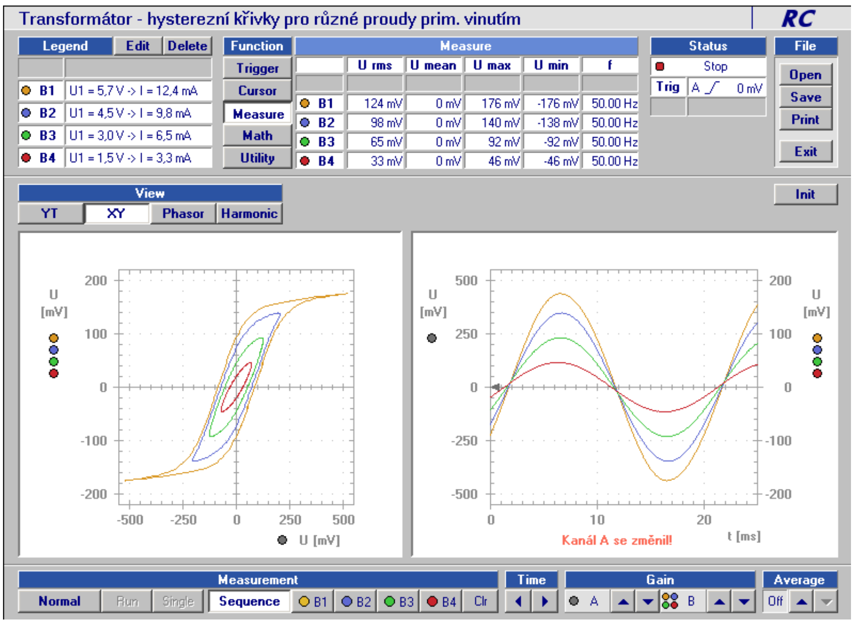
Display the hysteresis curve of the transformer. Compare hysteresis curves for various currents of the primary winding of the transformer.

Schema



Measurement





Bipolar Transistor as Amplifier with Common Emitter

Exercise

Display the input and output voltage of the transistor amplifier.

Schema

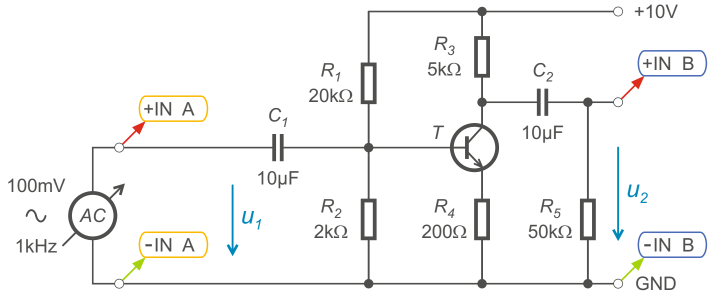


Fig. 1

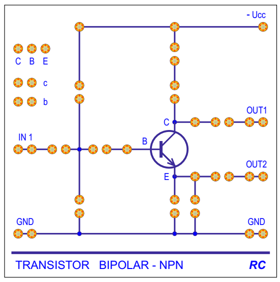
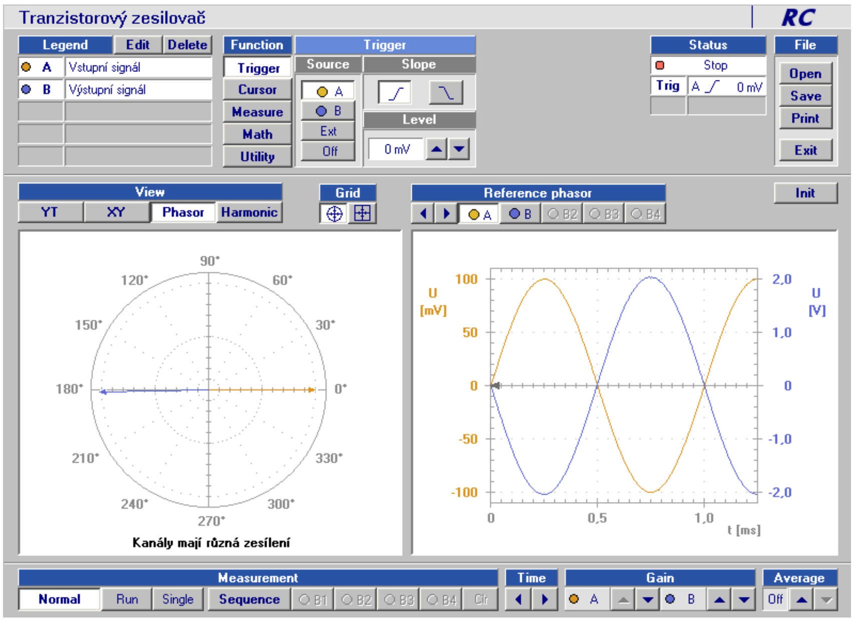


Fig. 2

Measurement



Vector diagram

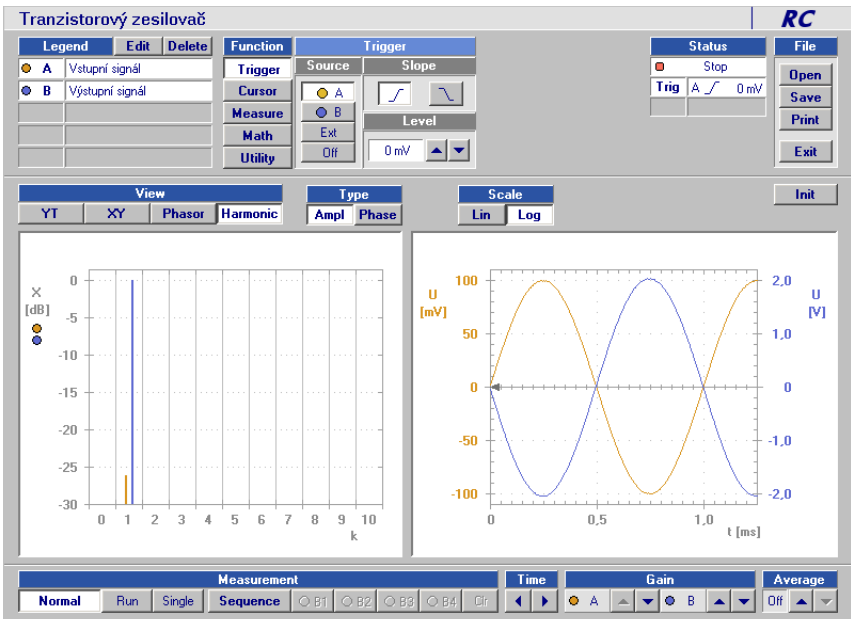
schema Fig. 1

measuring mode

Oscilloscope

notices

- we plug 3-pin element **BC546B** into the module (Fig. 2)
- we bridge safeties ***b*** and ***c*** with couplings
- supply voltage 10V we get from **Component Board**



Harmonic analysis

schema Fig. 1

measuring mode

Oscilloscope

4.9 Frequency Characteristic of the Amplifier with Bipolar Transistor

Exercise

Measure the frequency characteristics of the transistor amplifier and consider the effect of the coupling capacitor C_2

Schema

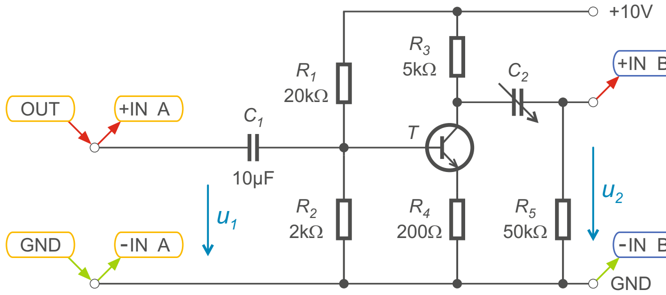


Fig. 1

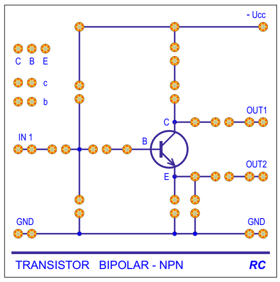
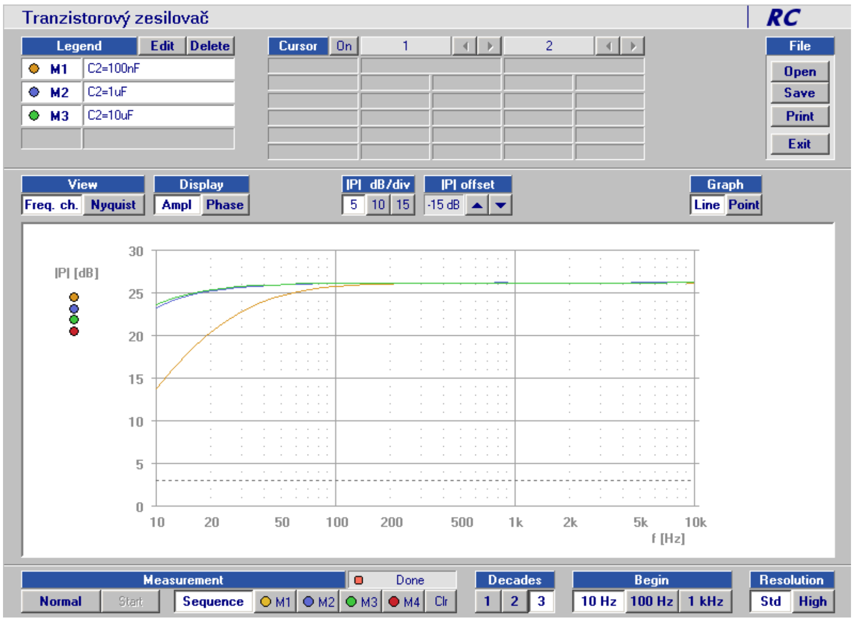


Fig. 2

Measurement



Amplitude characteristics

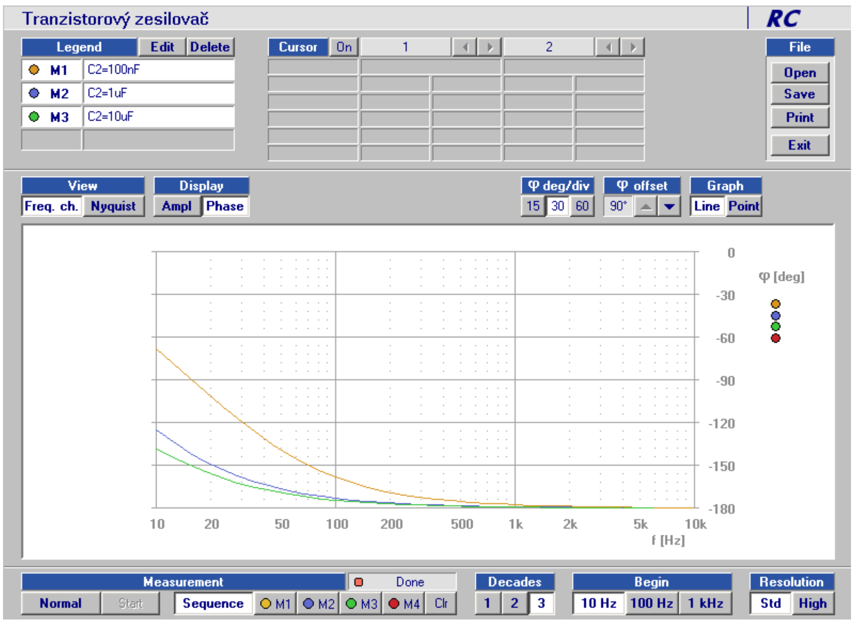
schema Fig. 1

measuring mode

Frequency characteristics

notices

- we plug 3-pin element **BC546B** into the module (Fig. 2)
- we bridge safeties ***b*** and ***c*** with couplings
- supply voltage 10V we get from **Component Board**



Phase characteristics

schema Fig. 1

measuring mode

Frequency characteristics

Exercise

Turn on an astable multivibrator using two NPN transistors.

Schema

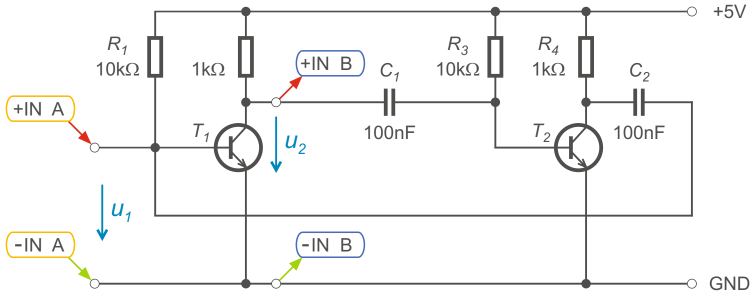


Fig. 1

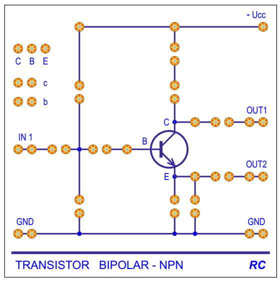
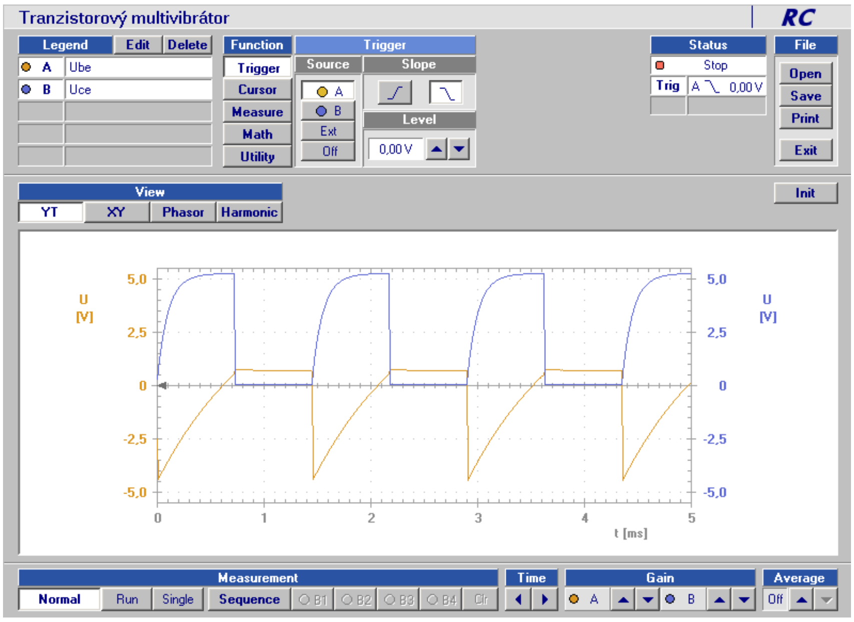


Fig. 2

Measurement



Mutivibrator

schema Fig. 1

measuring mode

Oscilloscope

Notice

- plug 3-pin element ***BC546B*** into a ***Module of bipolar transistor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safeties ***b*** and ***c*** with couplings

4.11 Thyristor Control of the Output Voltage

Exercise

Check the options of thyristor control.

Schema

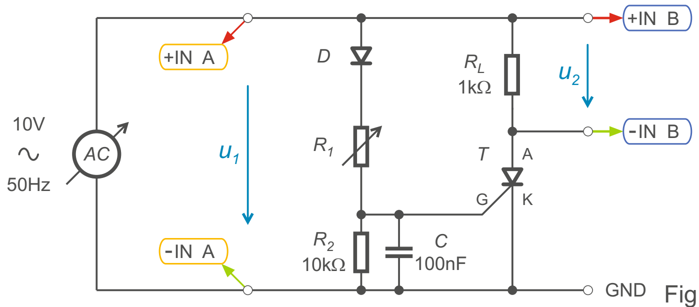


Fig. 1

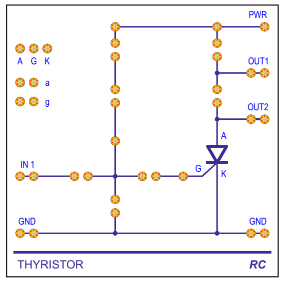
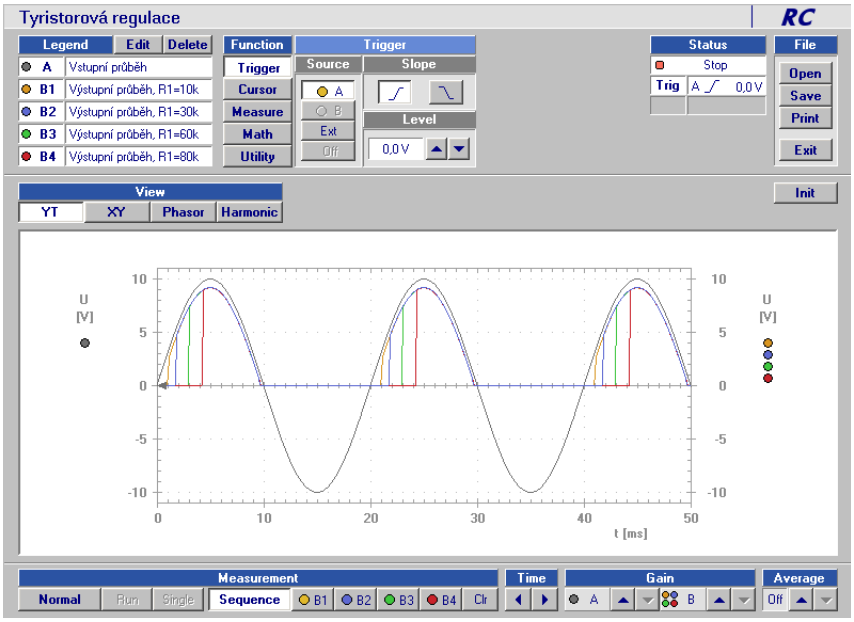


Fig. 2

Measurement



Thyristor control

schema Fig. 1

measuring mode

Oscilloscope

Notice

- plug 3-pin element ***2N5060*** into a ***module of thyristor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safety ***a*** *with coupling*

4.12 Thyristor Control - Voltage Curves

Exercise

Display the individual voltage profiles during thyristor control.

Schema

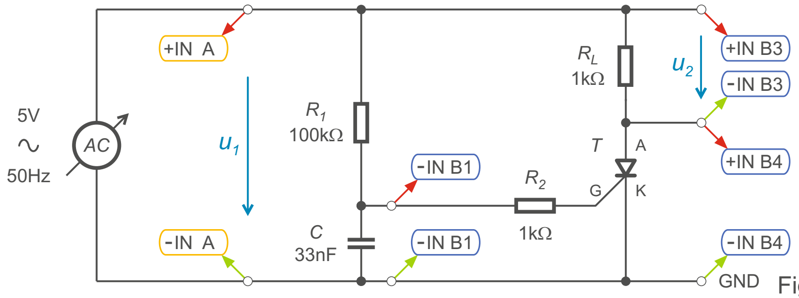


Fig. 1

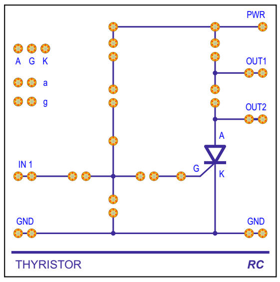
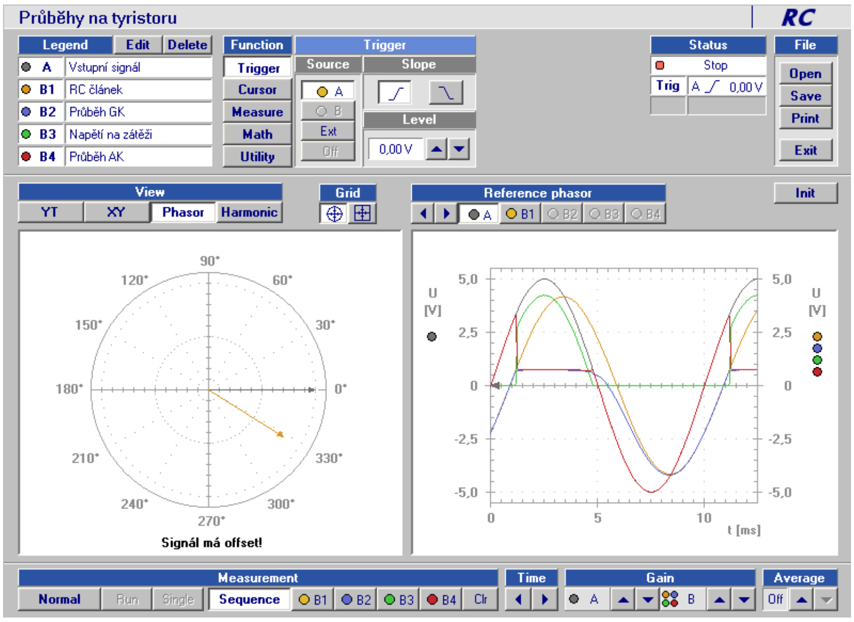


Fig. 2

Measurement



Thyristor control	
schema	Fig. 1
measuring mode	Oscilloscope

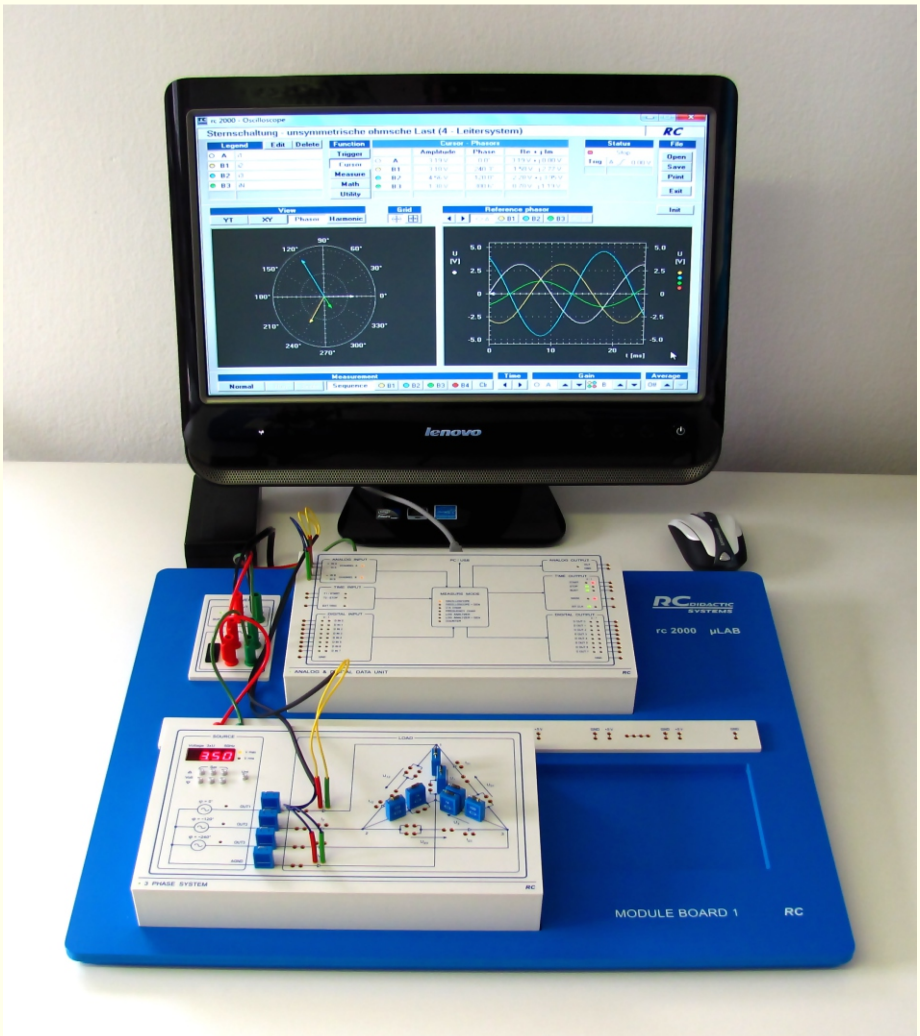
Notice

- plug 3-pin element ***2N5060*** into a ***module of thyristor*** (Fig. 2)
- after checking that the circuit is correctly connected, we bridge the safety ***a** with a coupling*
- we change curve B1 by plugging-out the resistor R_2
- curve *B2* is measured on the same spot as *B1*, but with plugged-in resistor R_2

RC DIDACTIC SYSTEMS

Teaching System rc2000 - µLAB

Three-Phase System



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

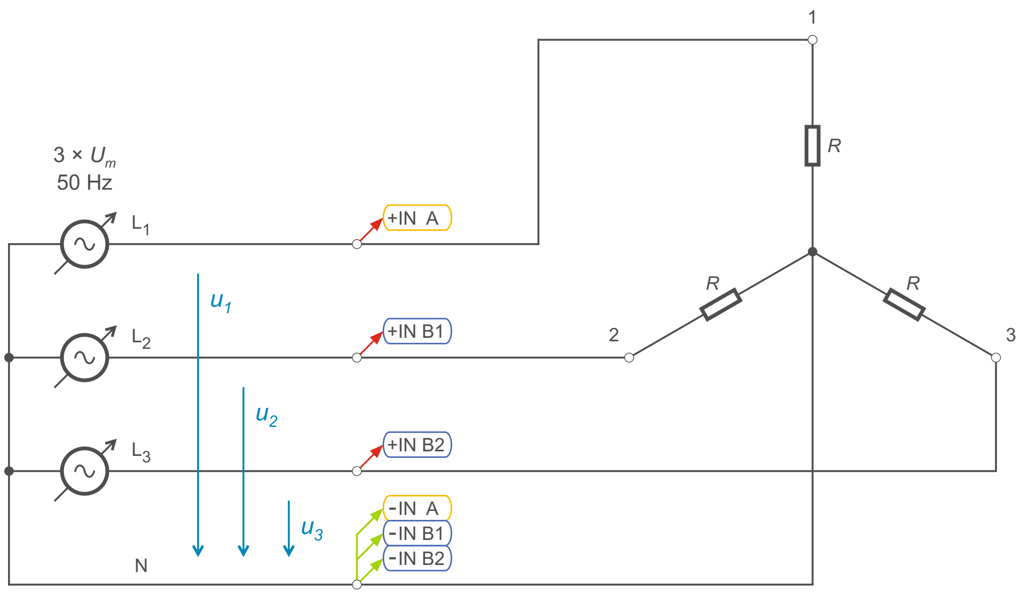
Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

Content

Exercise

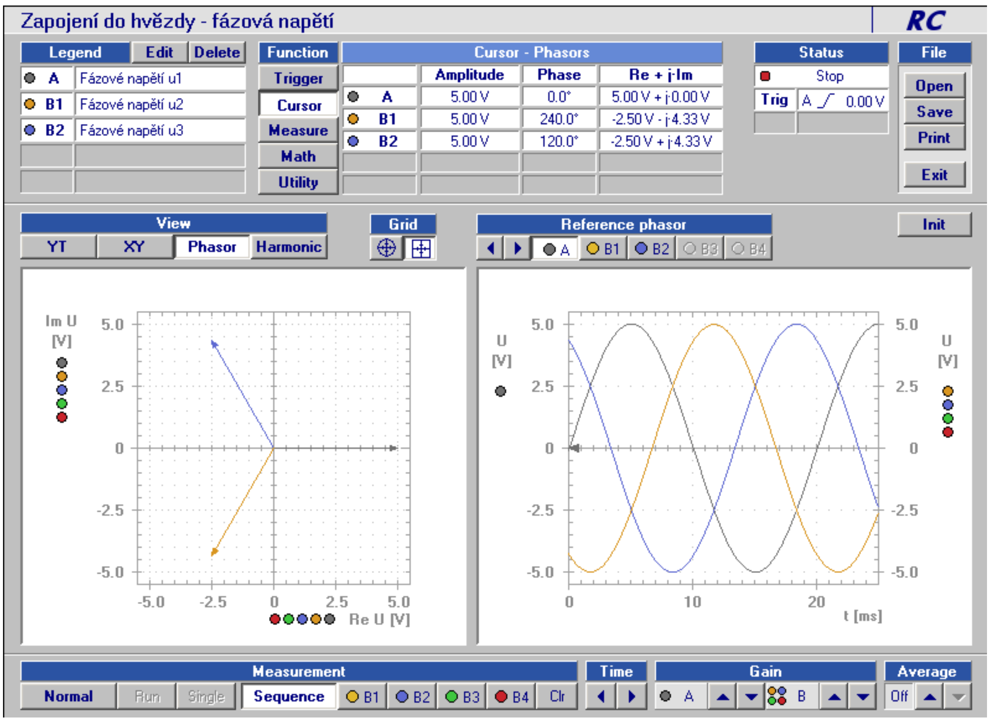
Display individual phase voltages u_1, u_2, u_3 in a four-wire system with symmetrical ohmic load.

Schema



U_m = 5V
R = 1kΩ

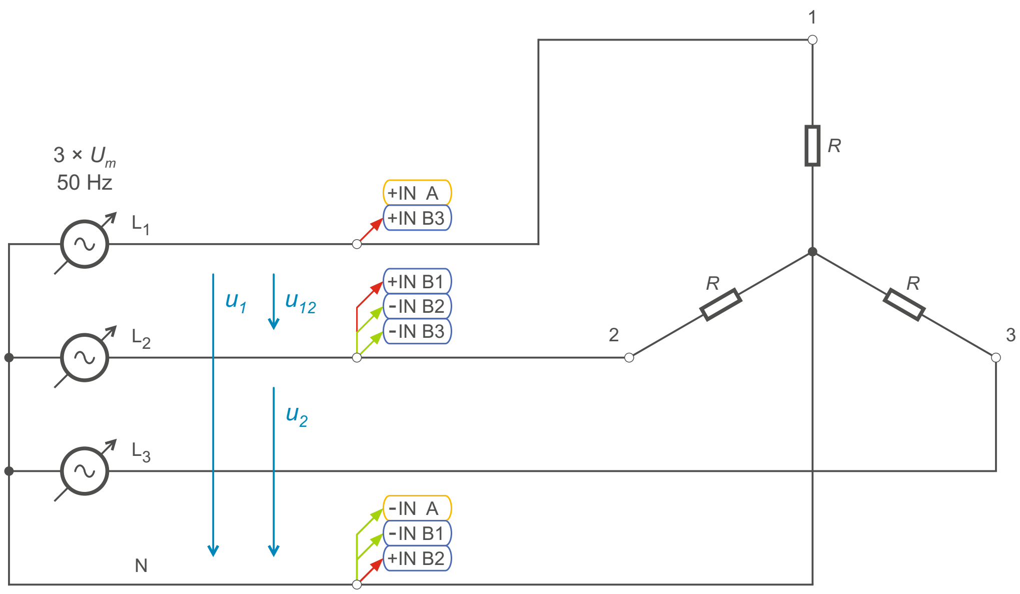
Measurement



Exercise

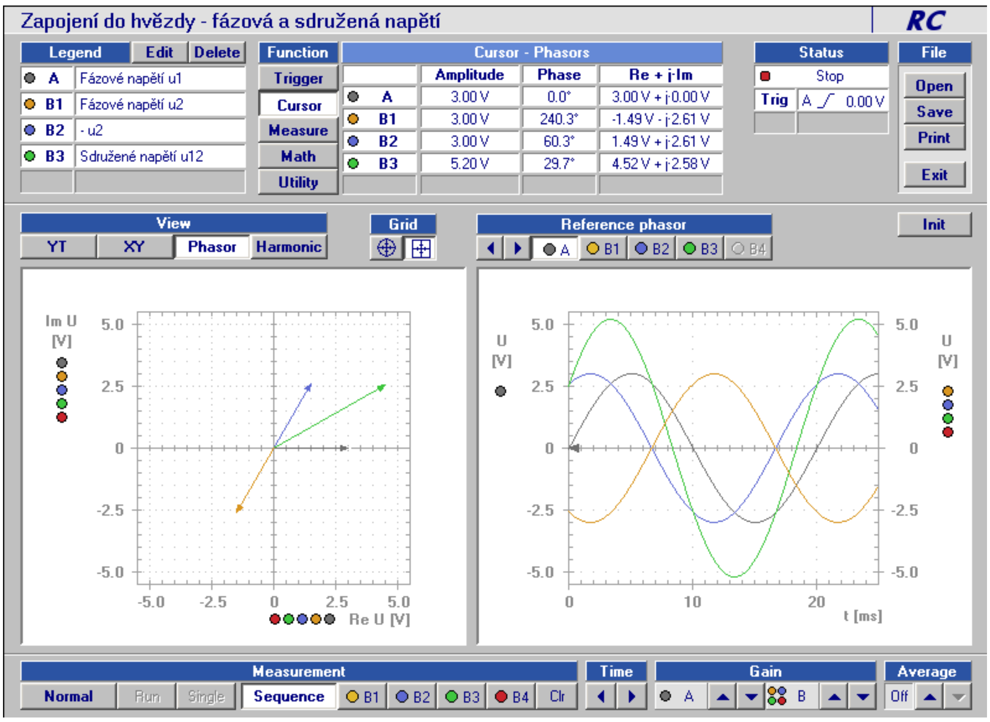
Display relation between phase voltages u_1, u_2 and collective voltage u_{12} in a four-wire system with symmetrical ohmic load.

Schema



U_m = 3V
R = 1kΩ

Measurement

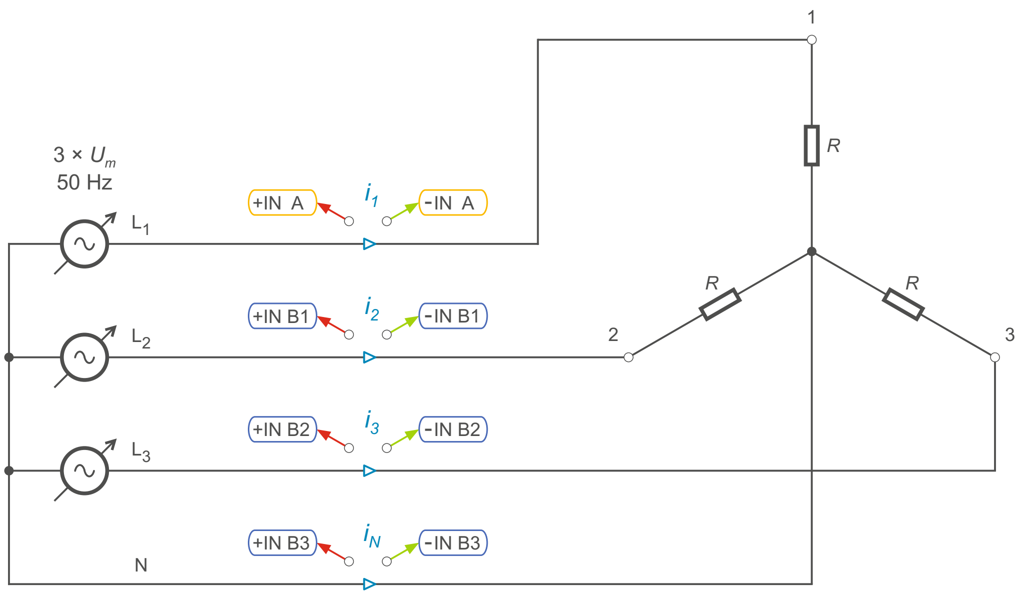


5.3 Star Connection - Symmetrical Ohmic Load

Exercise

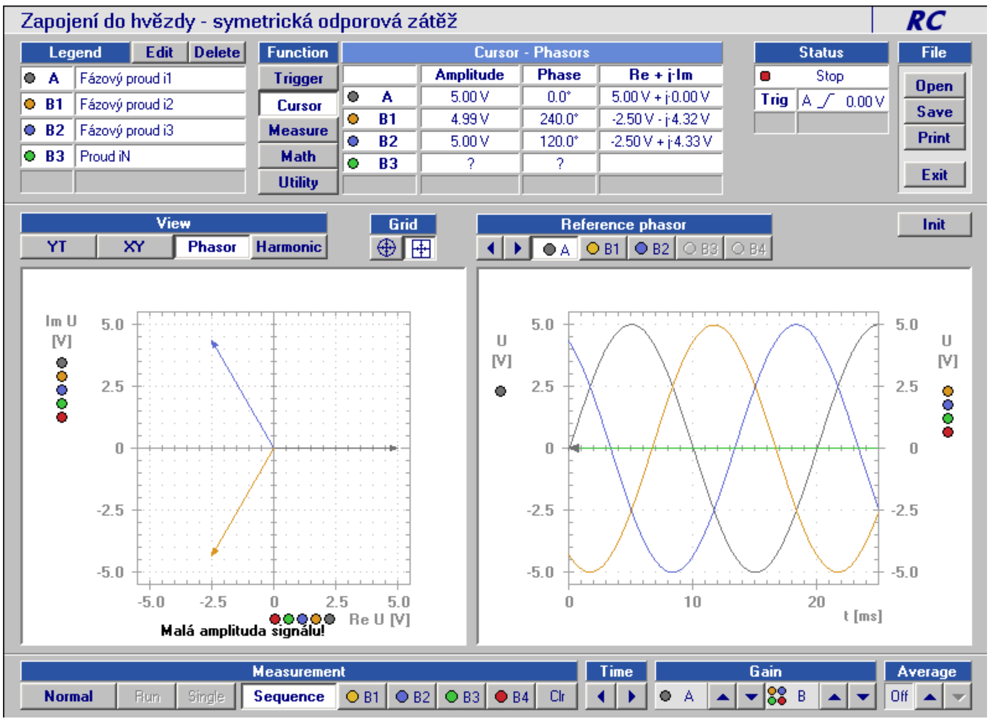
Display individual phase currents i_1, i_2, i_3 and current i_N in a four-wire system with symmetrical ohmic load.

Schema



U_m = 5V
R = 1kΩ

Measurement

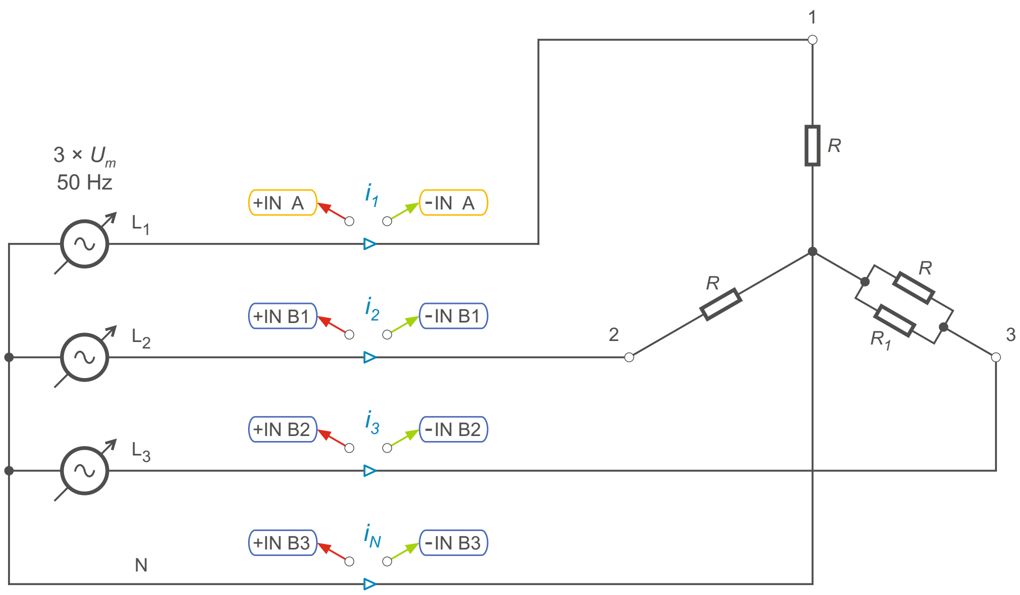


5.4 Star Connection - Asymmetrical Resistance Load (four-wire)

Exercise

Display individual phase currents i_1 , i_2 , i_3 a proud i_N in a four-wire system with asymmetrical ohmic load.

Schema

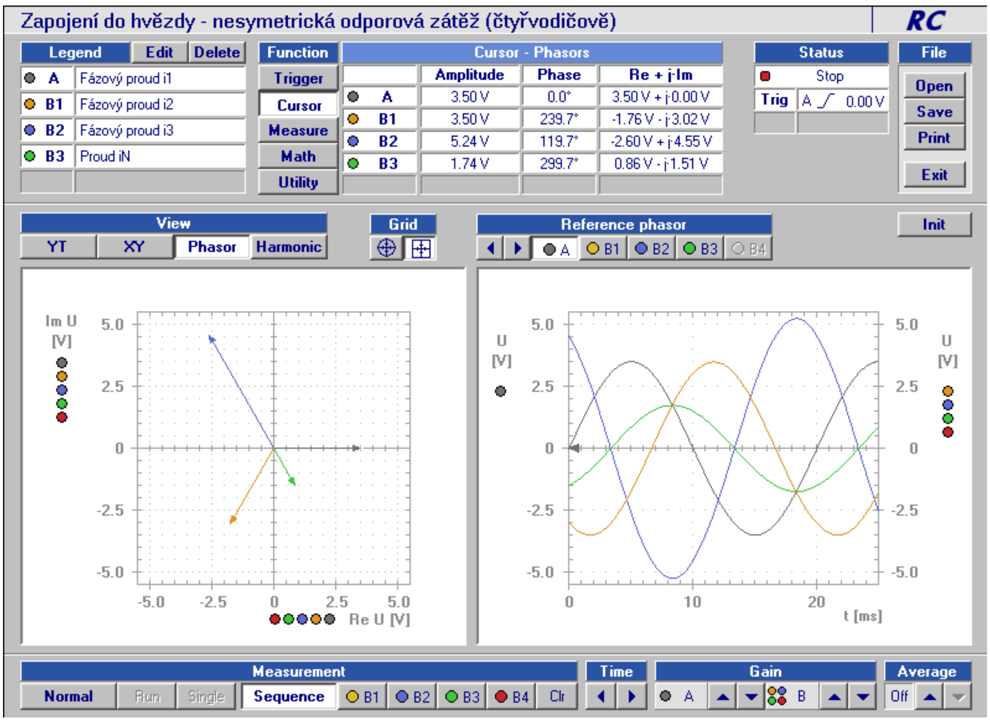


U_m = 3,5V

R = 1kΩ

R_1 = 2kΩ

Measurement

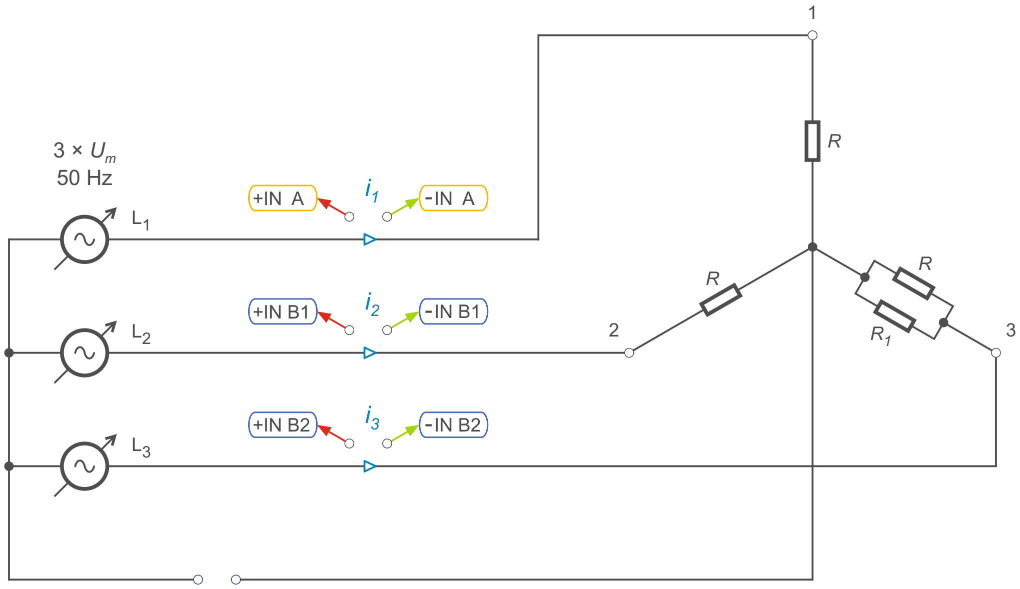


5.5 **Star Connection - Asymmetrical Resistance Ohmic Load (three-wire)**

Exercise

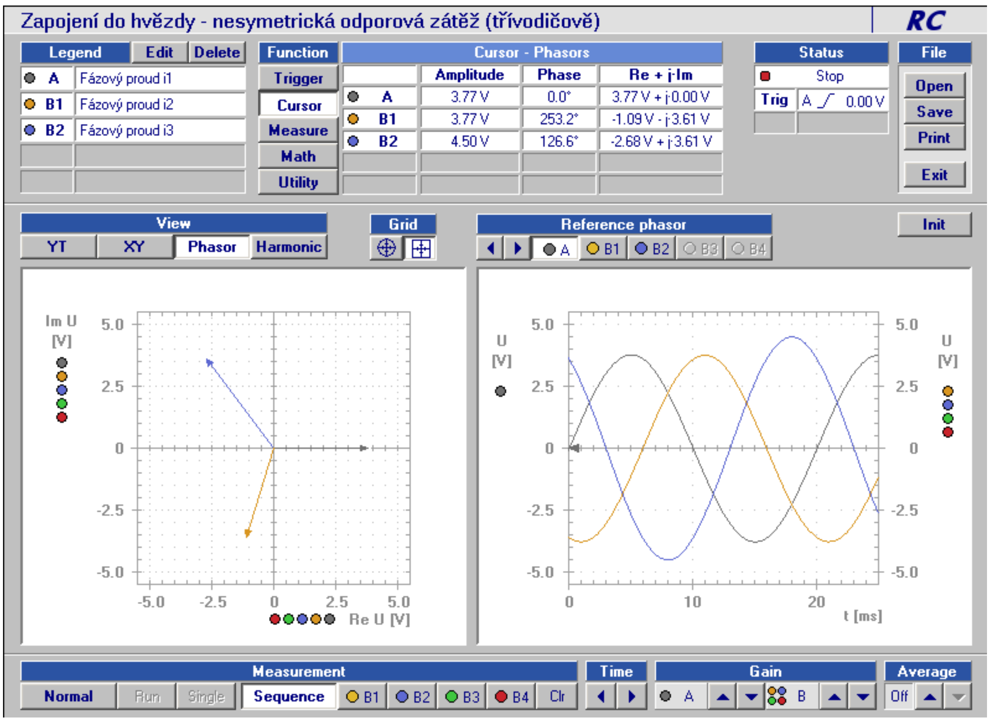
Display individual phase currents i_1, i_2, i_3 in a three-wire system with asymmetrical ohmic load.

Schema



U_m = 3,5V
R = 1kΩ
R_1 = 2kΩ

Measurement

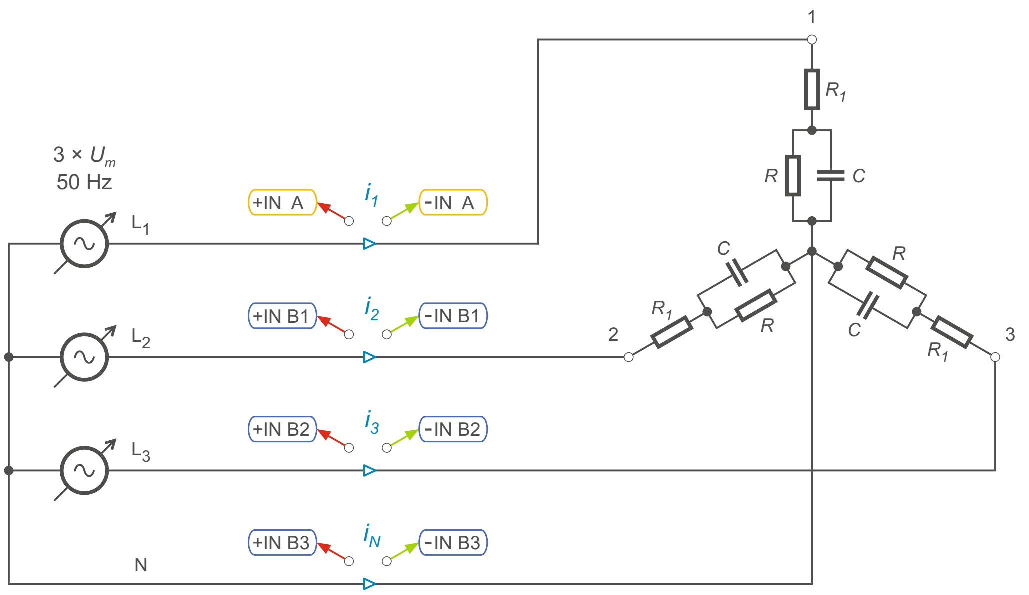


5.6 Star Connection - Symmetrical Impedance Load

Exercise

Display individual phase currents i_1, i_2, i_3 a proud i_N in a four-wire system with symmetrical impedance load.

Schema



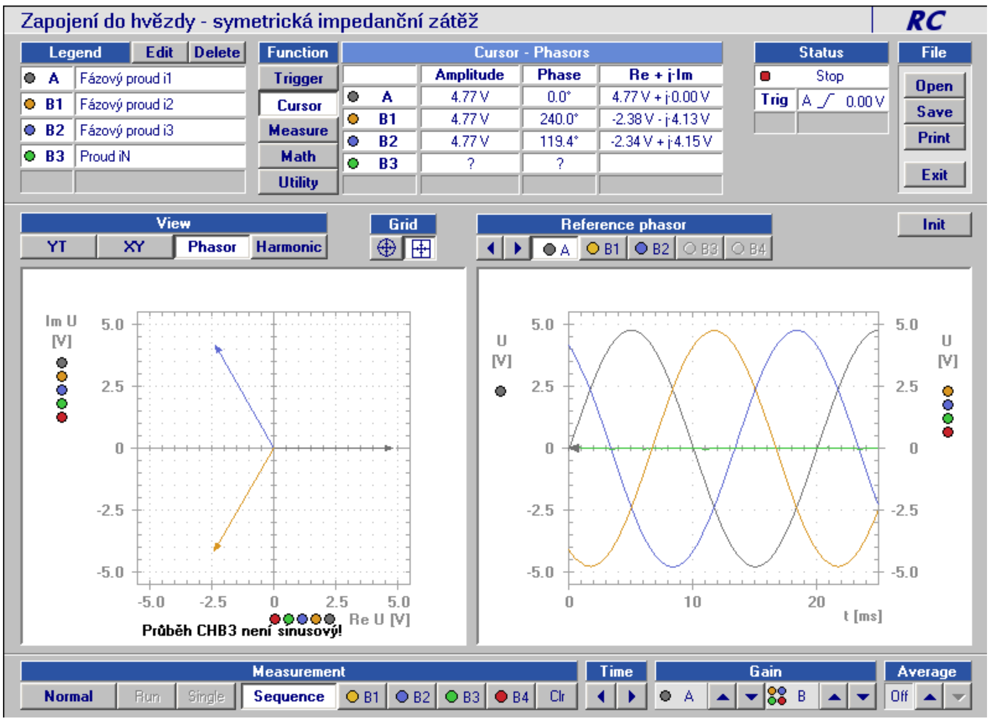
U_m= 5V

R = 1kΩ

R_1= 100Ω

C = 1μF

Measurement

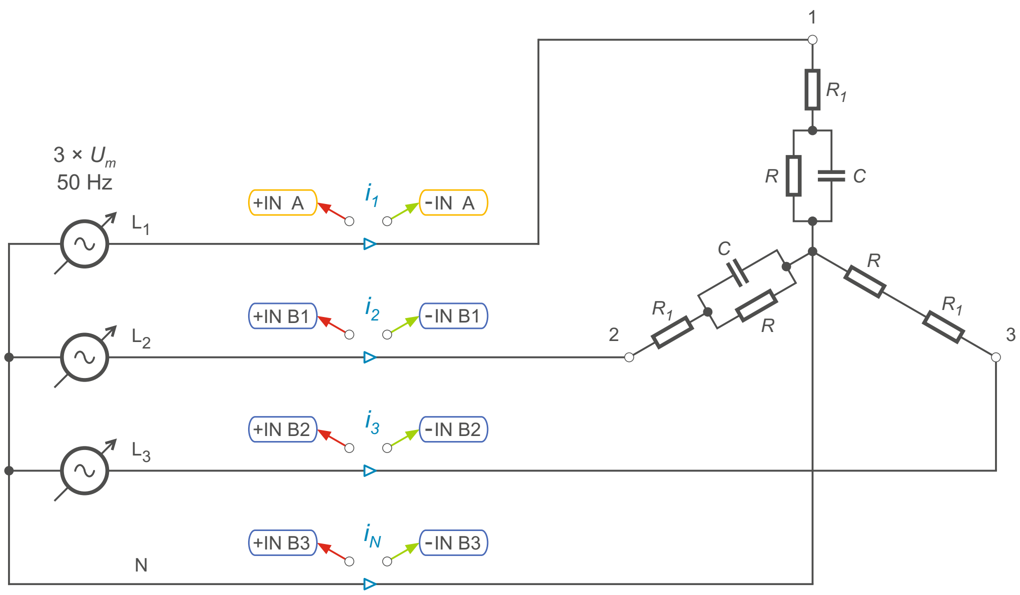


5.7 Star Connection - Asymmetrical Impedance Load

Exercise

Display individual phase currents i_1 , i_2 , i_3 a proud i_N in a four-wire system with asymmetrical impedance load.

Schema



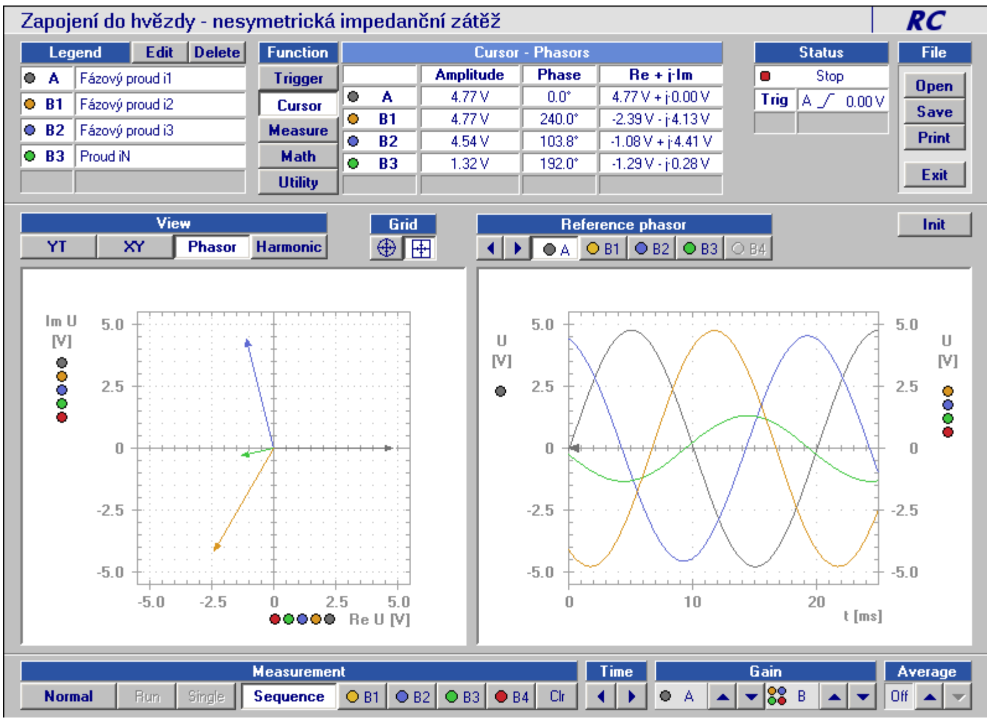
U_m= 5V

R = 1kΩ

R_1= 100Ω

C = 1µF

Measurement

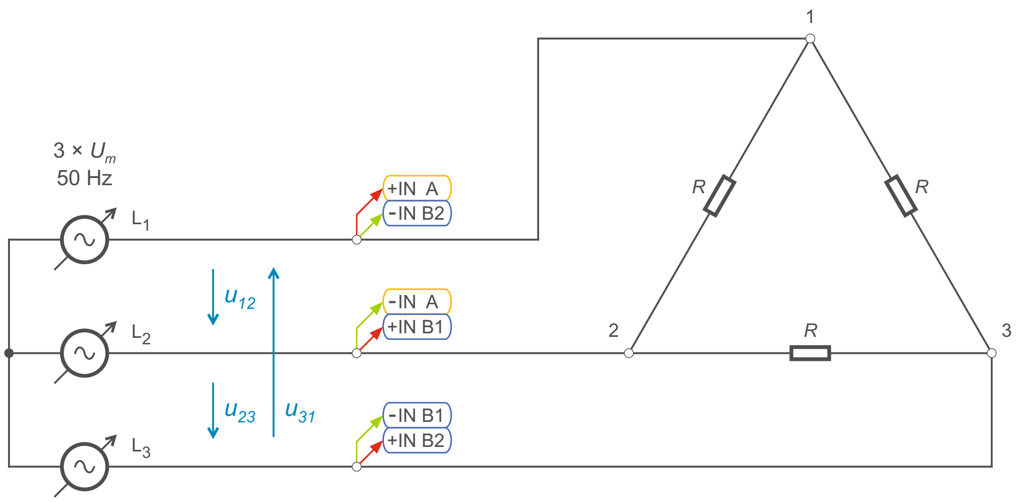


Delta Connection - Collective Voltages

Exercise

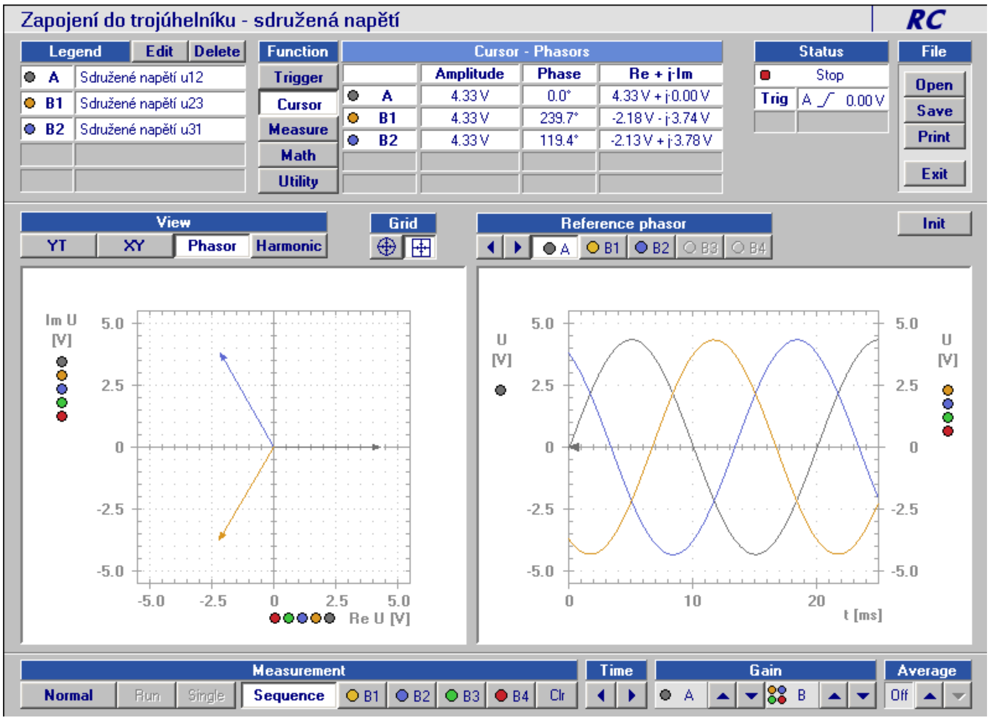
Display individual collective voltages u_{12}, u_{23} and u_{31} for symmetrical ohmic load in delta connection.

Schema



U_m= 2,5V
R = 1kΩ

Measurement

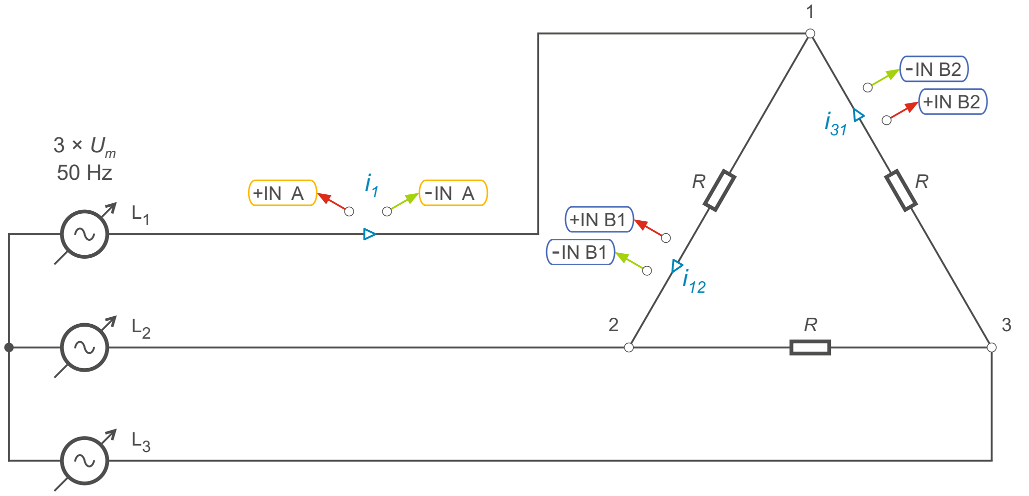


Delta connection - Phase Collective Current

Exercise

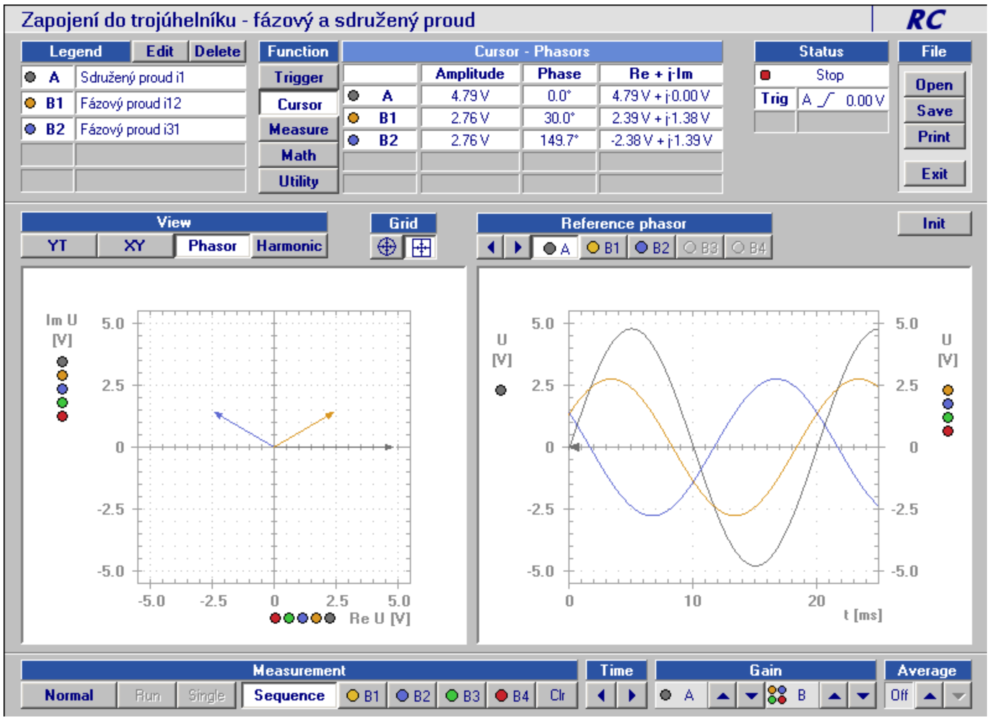
Display relation between collective current i_1 and corresponding phase currents i_{12} and i_{31} for symmetrical ohmic load in delta connection.

Schema



U_m = 1,6V
R = 1kΩ

Measurement

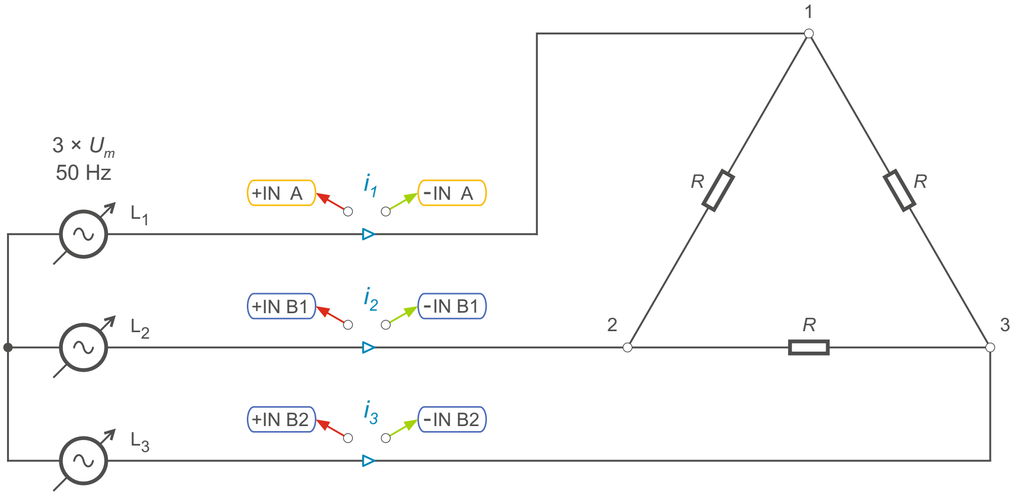


Delta Connection - Symmetrical Ohmic Load

Exercise

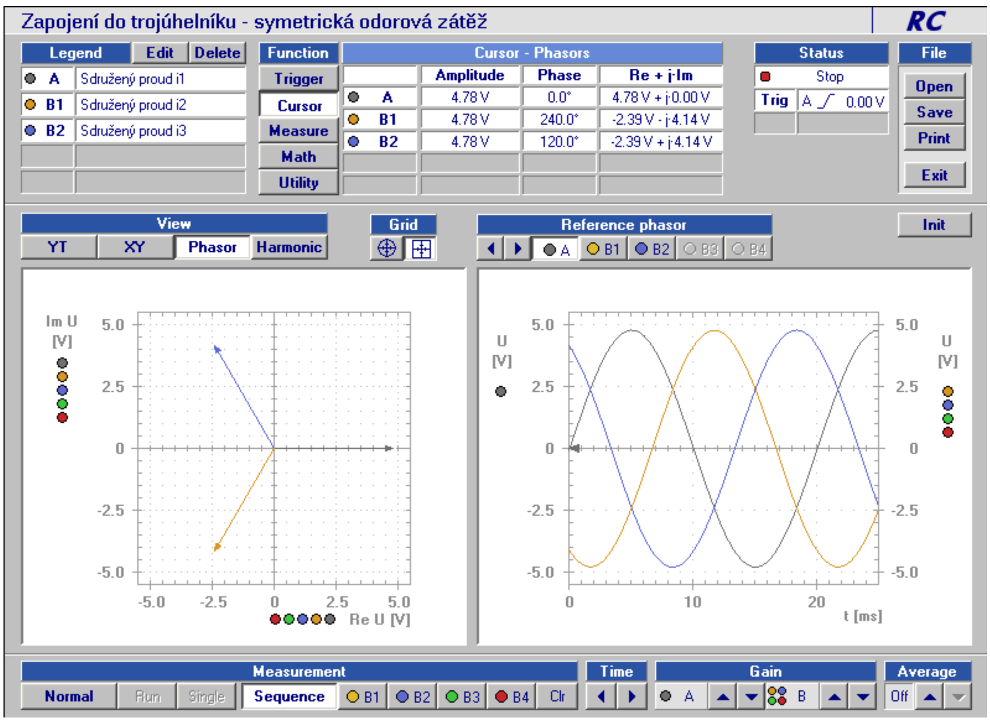
Display collective currents i_1, i_2 and i_3 for symmetrical ohmic load in delta connection.

Schema



U_m= 1,6V
R = 1kΩ

Measurement

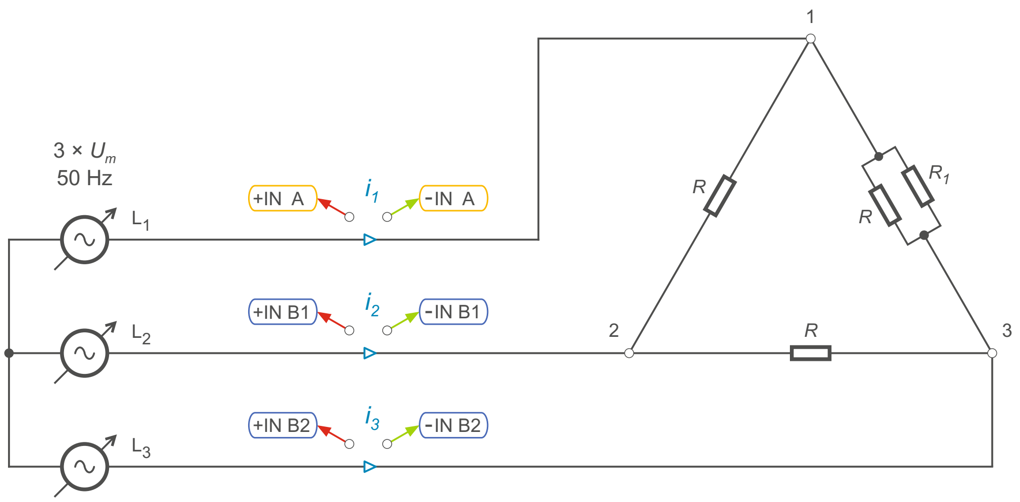


Delta Connection - Asymmetrical Ohmic Load

Exercise

Display collective currents i_1 , i_2 and i_3 for asymmetrical ohmic load in delta connection.

Schema

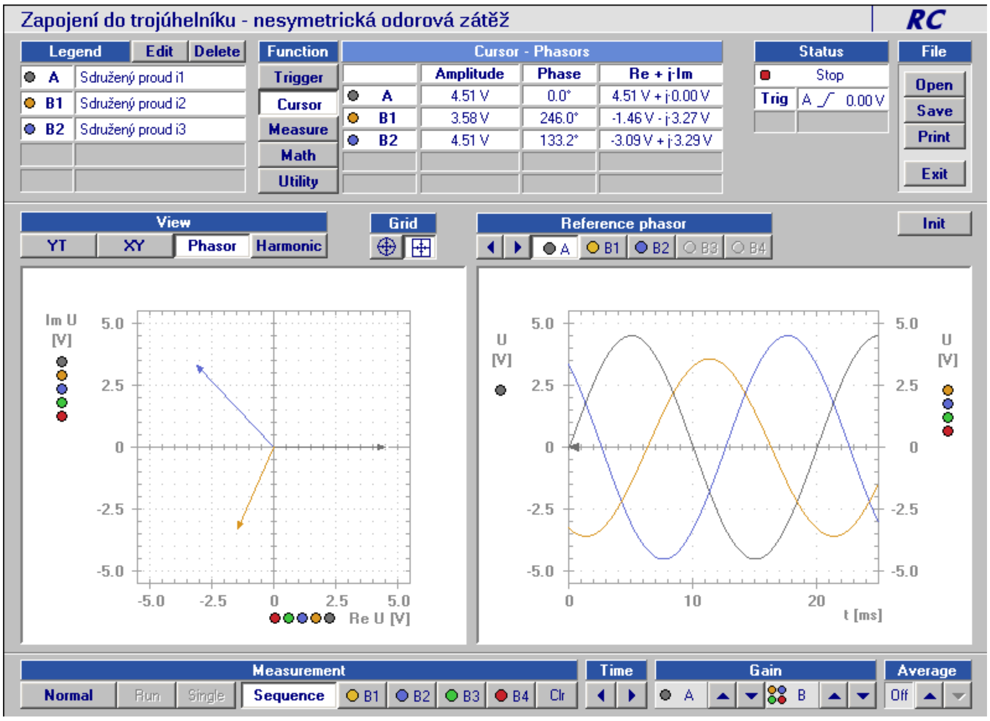


U_m= 1,2V

R = 1kΩ

R_1= 2kΩ

Measurement

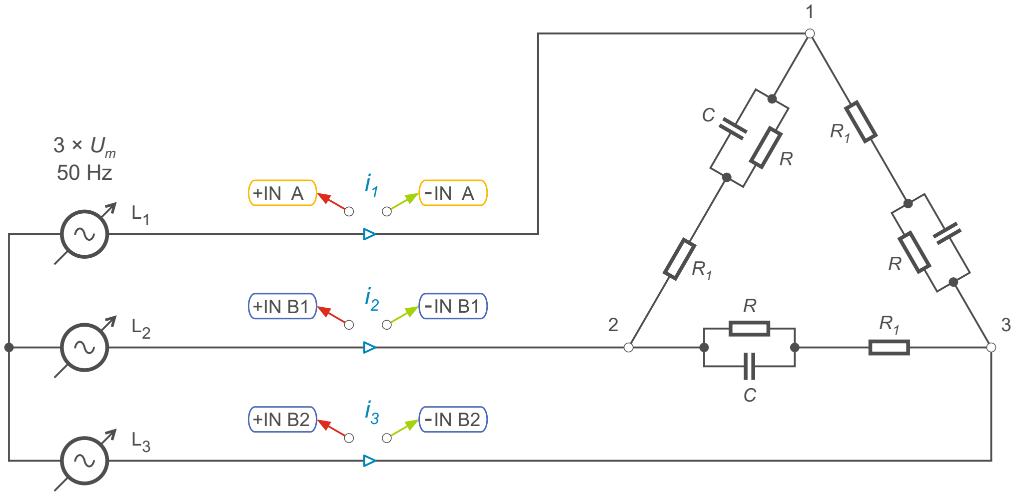


Delta Connection - Symmetrical Impedance Load

Exercise

Display collective currents i_1 , i_2 and i_3 for symmetrical impedance load in delta connection.

Schema



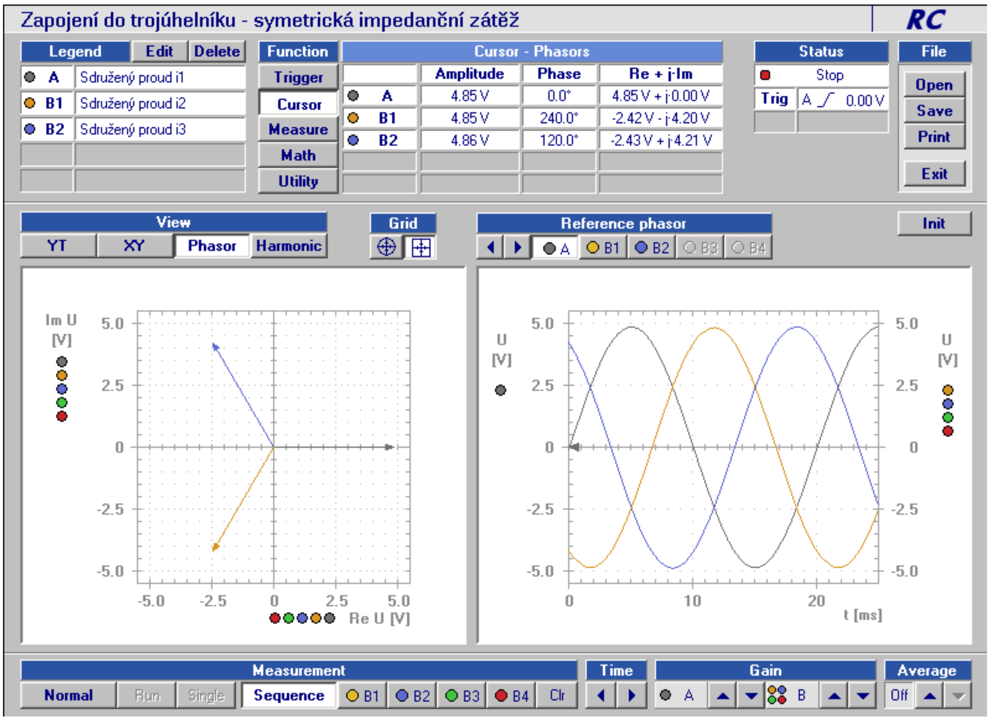
U_m = 1,7V

R = 1kΩ

R_1 = 100Ω

C = 1μF

Measurement

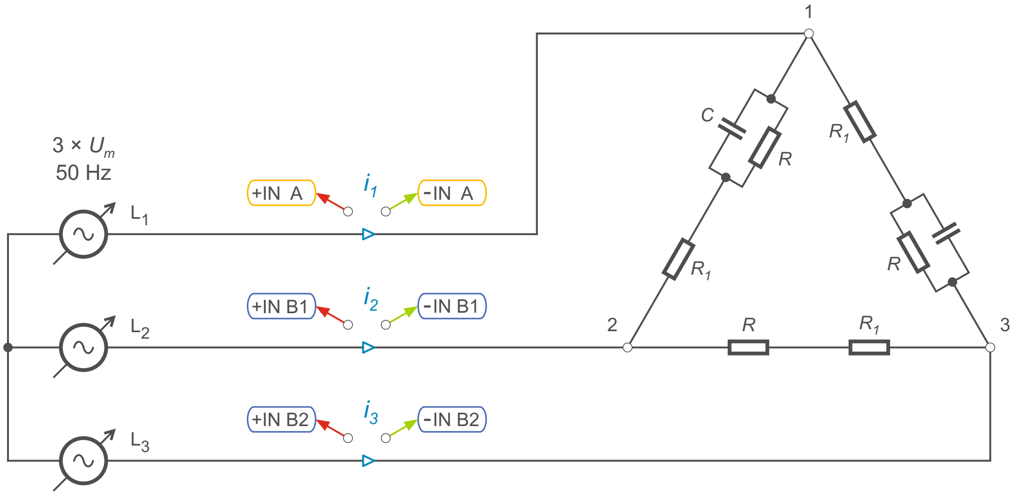


5.13 Delta Connection - Asymmetrical Impedance Load

Exercise

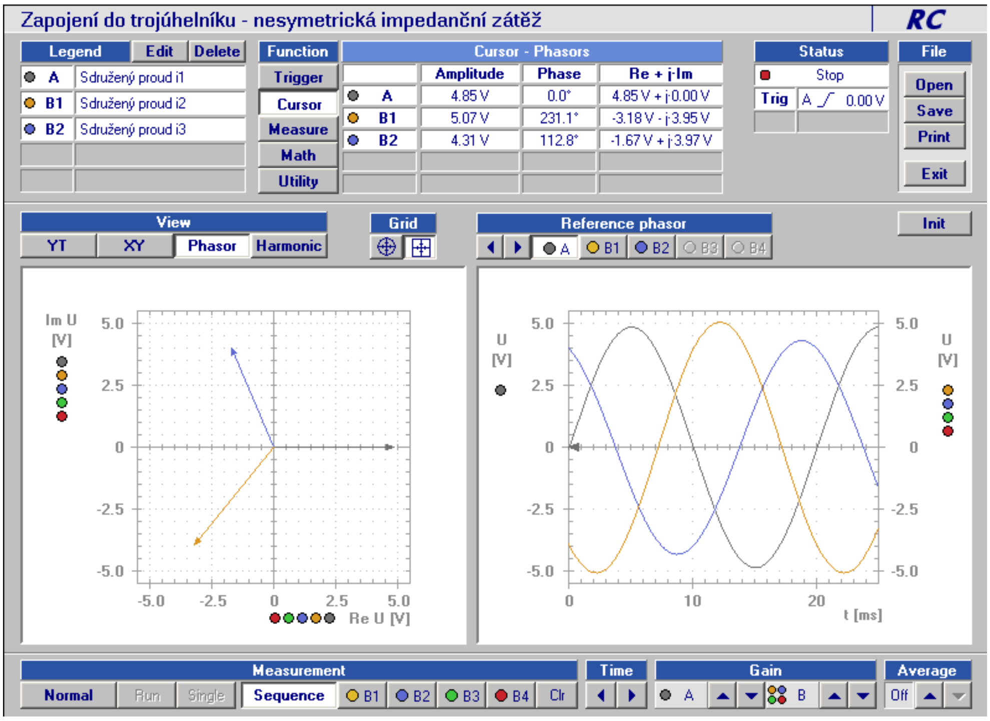
Display collective currents i_1 , i_2 and i_3 for asymmetrical impedance load in delta connection.

Schema



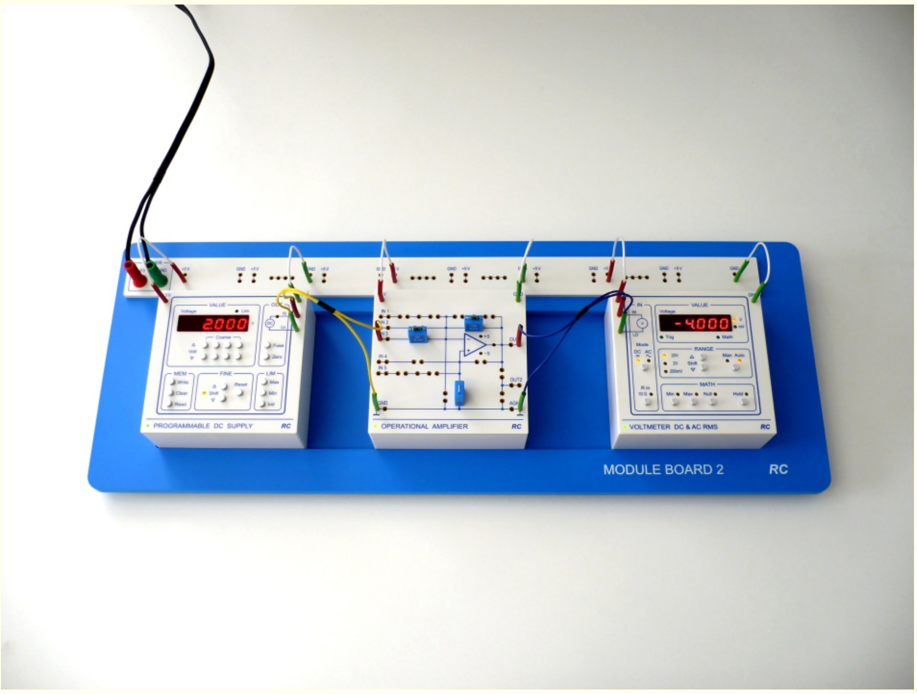
U_m = 1,7V
R = 1kΩ
R_1 = 100Ω
C = 1μF

Measurement



Teaching System rc2000 - µLAB

Operational Amplifier



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

Content

Inverting Amplifier

Exercise

Verify the connection of operational amplifier as a inverting amplifier. Make the measurement for direct and alternating voltage. Choose amplification A = - 2 and A = - 5.

Schema

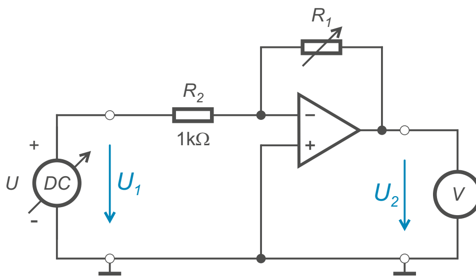


Fig. 1

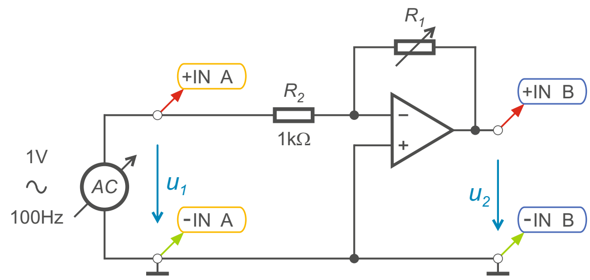
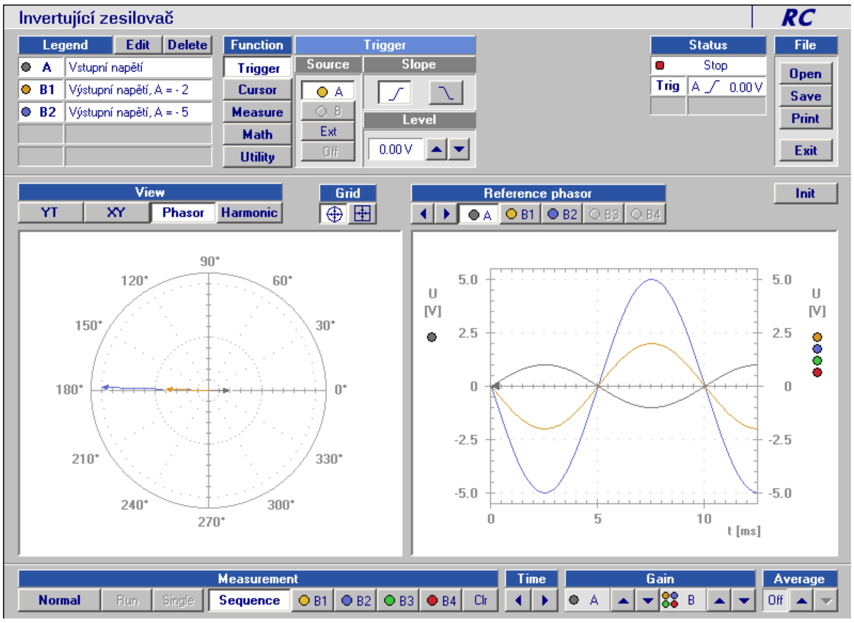


Fig. 2

Measurement



Inverting amplifier - AC voltage

schema Fig. 2

mode Oscilloscope

display Phasor

formula $A = \frac{U_2}{U_1} = -\frac{R_1}{R_2}$

values

A = -2 ... R_2 = 2kΩ

A = -5 ... R_2 = 5kΩ

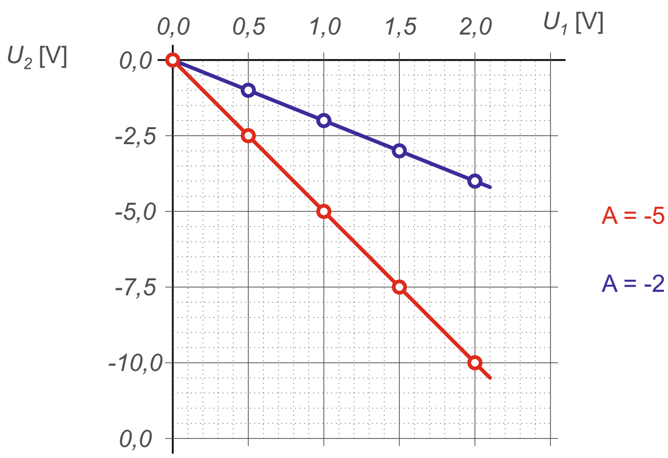
modules

Measuring unit ADDU

Function generator

Voltmeter AC&DC

U_1 [V]	0,0	0,5	1,0	1,5	2,0	*amplification*
U_2 [V]	0,0	-1,0	-2,0	-3,0	-4,0	-2
U_2 [V]	0,0	-2,5	-5,0	-7,5	-10,0	-5



Inverting amplifier - DC voltage

schema Fig. 1

formula $A = \frac{U_2}{U_1} = -\frac{R_1}{R_2}$

modules

Operational amplifier

Programmable DC supply

Voltmeter AC&DC

Non-inverting Amplifier

Exercise

Verify connection of operational amplifier as a non-inverting amplifier. Measure direct and alternating voltage. Choose amplification $A = 2$ and $A = 5$.

Schema

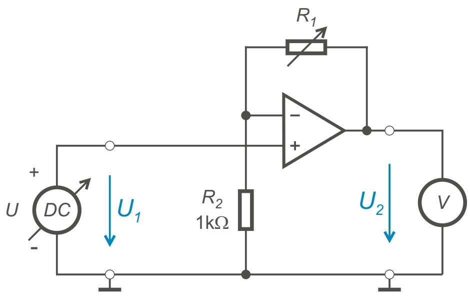


Fig. 1

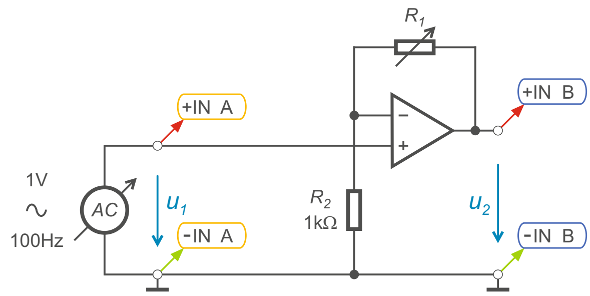
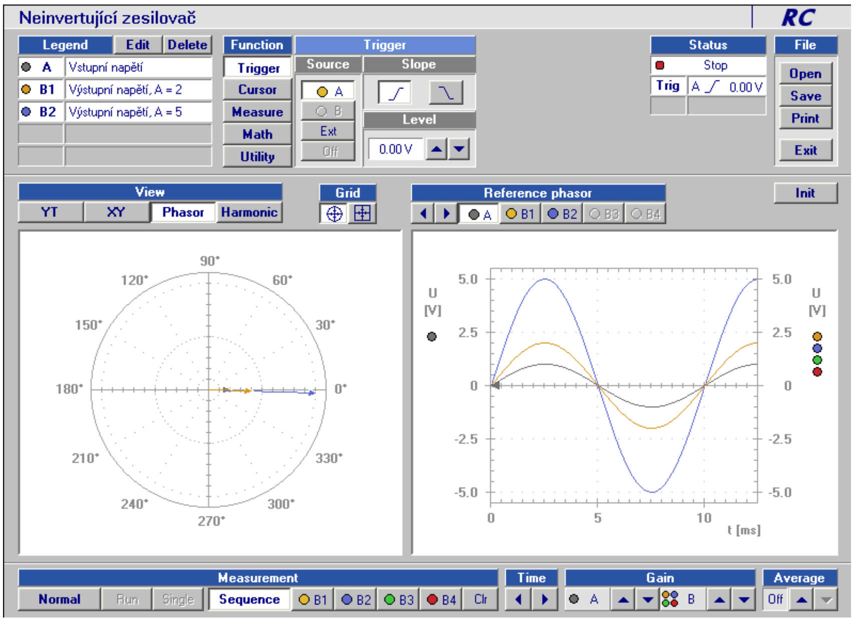


Fig. 2

Measurement



Non-inverting amplifier - AC

schema	Fig. 2
mode	Oscilloscope
display	Phasor
formula	$A = \frac{U_2}{U_1} = \frac{R_1 + R_2}{R_2}$

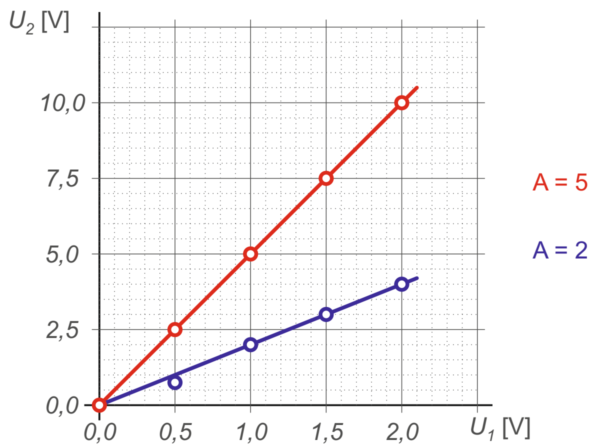
values

- $A = 2$ ... $R_2 = 1\text{k}\Omega$
- $A = 5$ ... $R_2 = 4\text{k}\Omega$

modules

Measuring unit ADDU
Function generator
Voltmeter AC&DC

U_1 [V]	0,0	0,5	1,0	1,5	2,0	*amplification*
U_2 [V]	0,0	1,0	2,0	3,0	4,0	2
U_2 [V]	0,0	2,5	5,0	7,5	10,0	5



Non-inverting amplifier - DC

schema	Fig. 1
formula	$A = \frac{U_2}{U_1} = \frac{R_1 + R_2}{R_2}$

modules

Operational amplifier
Programmable DC supply
Voltmeter AC&DC

Voltage Follower

Exercise

Verify the connection of operational amplifier as a voltage follower. Measure both direct and alternating voltage.

Schema

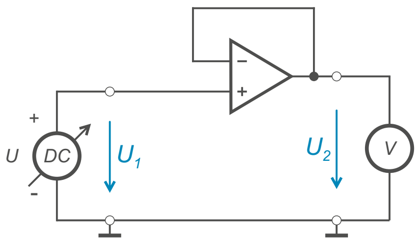


Fig. 1

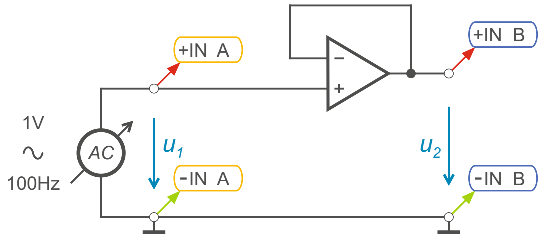
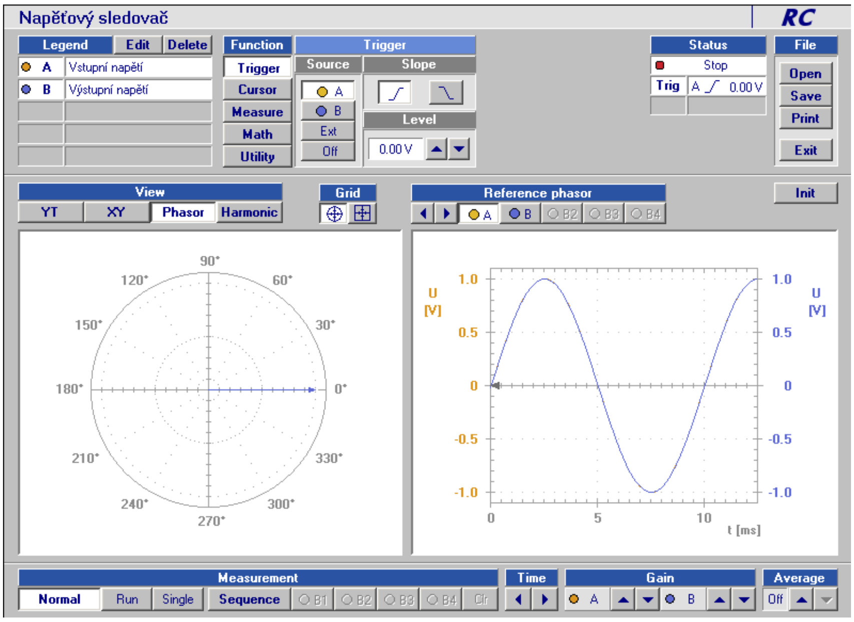


Fig. 2

Measurement



Voltage follower

schema Fig. 2

mode Oscilloscope

display Phasor

formula $A = \frac{U_2}{U_1} = 1$

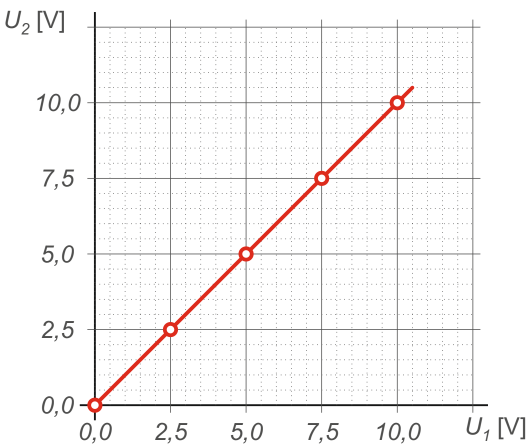
modules

Operational amplifier

Function generator

Measuring unit ADDU

U_1 [V]	0,0	2,5	5,0	7,5	10,0	amplification
U_2 [V]	0,0	2,5	5,0	7,5	10,0	1



Voltage follower

schema Fig. 1

formula $A = \frac{U_2}{U_1} = 1$

modules

Operational amplifier

Programmable DC sourcej

Voltmeter AC&DC

6.4 Integrator

Exercise

Verify the connection of operational amplifier as an integrator. Choose different values of damping by resistor R_1. Make the measurement in frequency domain.

Schema

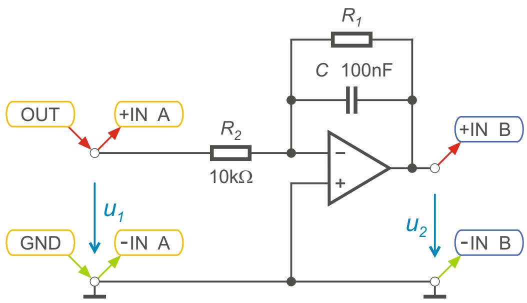
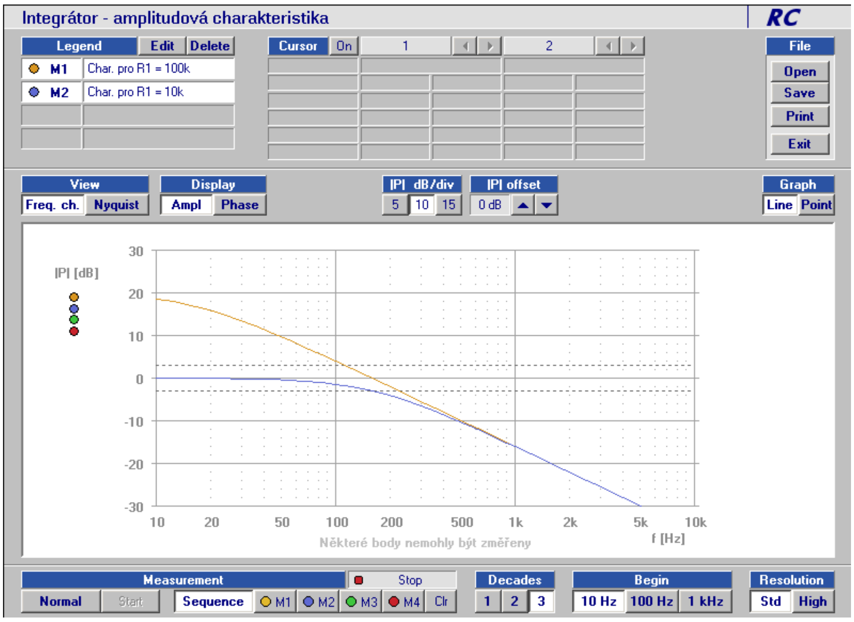


Fig. 1

Measurement



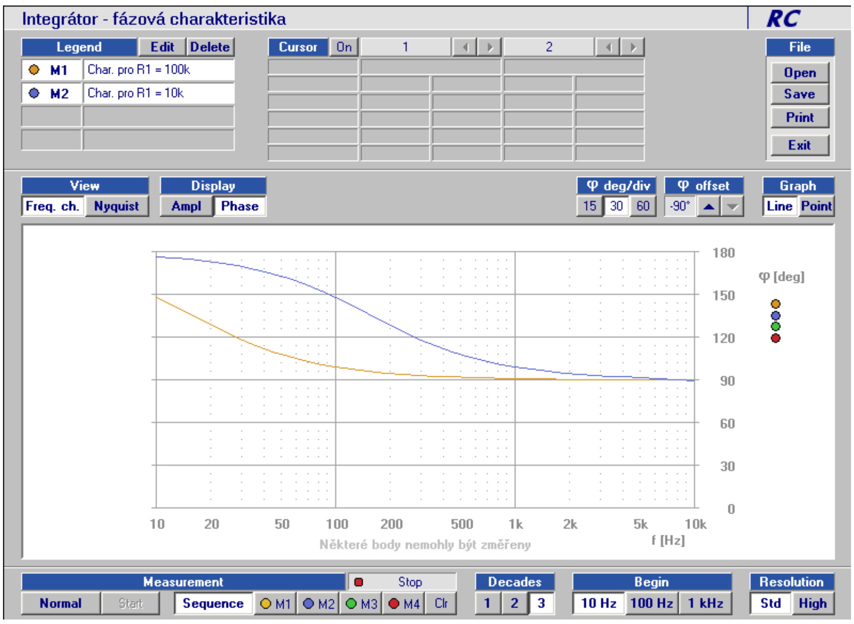
Amplitude characteristic

schema	Fig. 1
mode	Frequency char.
display	Amplitude

modules

Operational amplifier

Measuring unit ADDU



Phase characteristic

schema	Fig. 2
mode	Frequency char.
display	Phase

modules

Operational amplifier

Measuring unit ADDU

Derivator

Exercise

Verify the connection of operational amplifier as a derivator. Make the measurement in frequency domain.

Schema

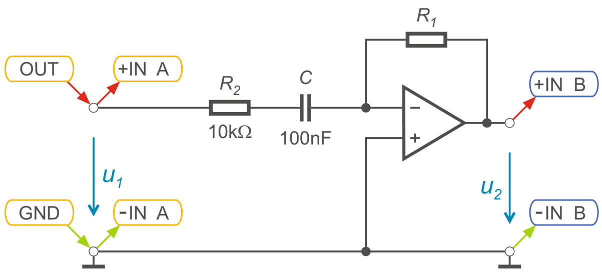
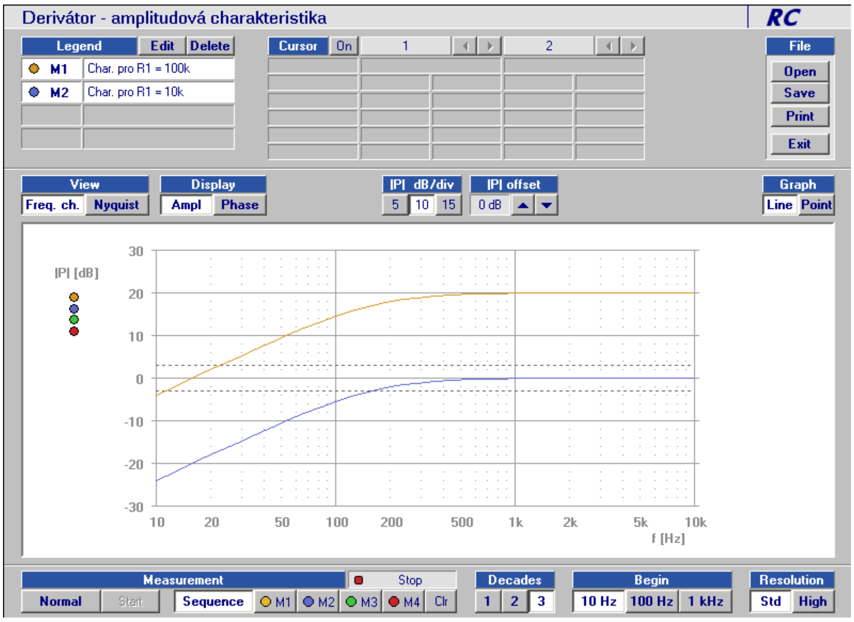


Fig. 1

Measurement

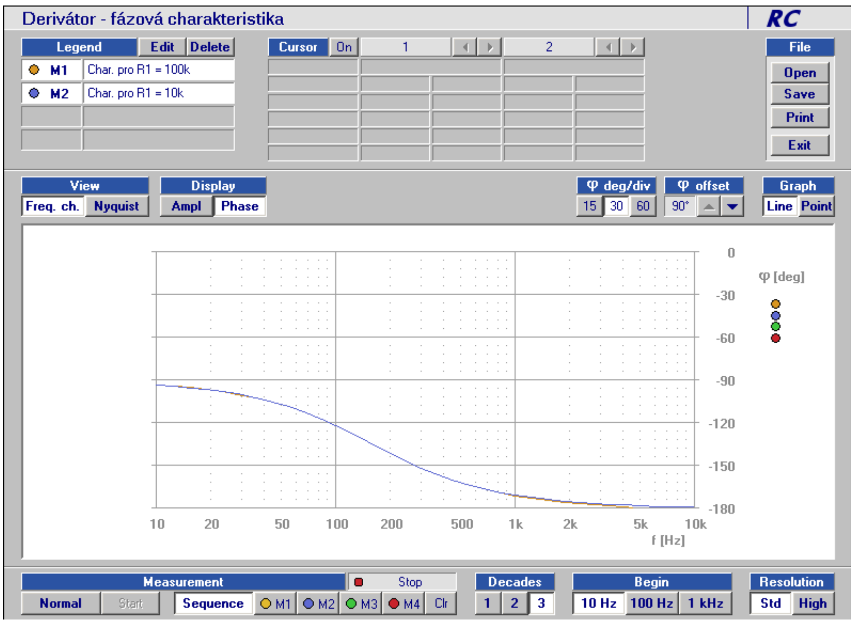


Amplitude characteristic

schema	Fig. 1
mode	Frequency char.
display	Amplitude

modules

Operational amplifier
Measuring unit ADDU



Phase characteristic

schema	Fig. 2
mode	Frequency char.
display	Phase

modules

Operational amplifier
Measuring unit ADDU

Comparator

Exercise

Display course of input and output voltage of comparator. Make the measurement for zero level of comparation (Fig. 1) and for non-zero reference level of comparation (Fig. 2).

Schema

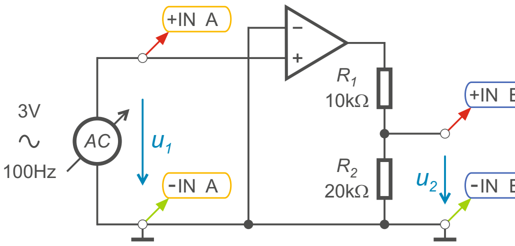


Fig. 1

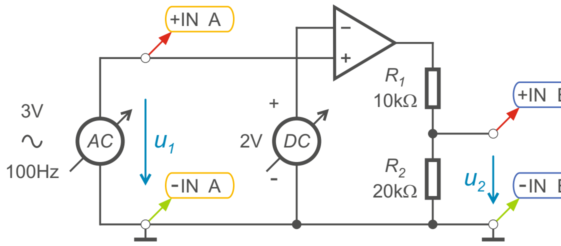
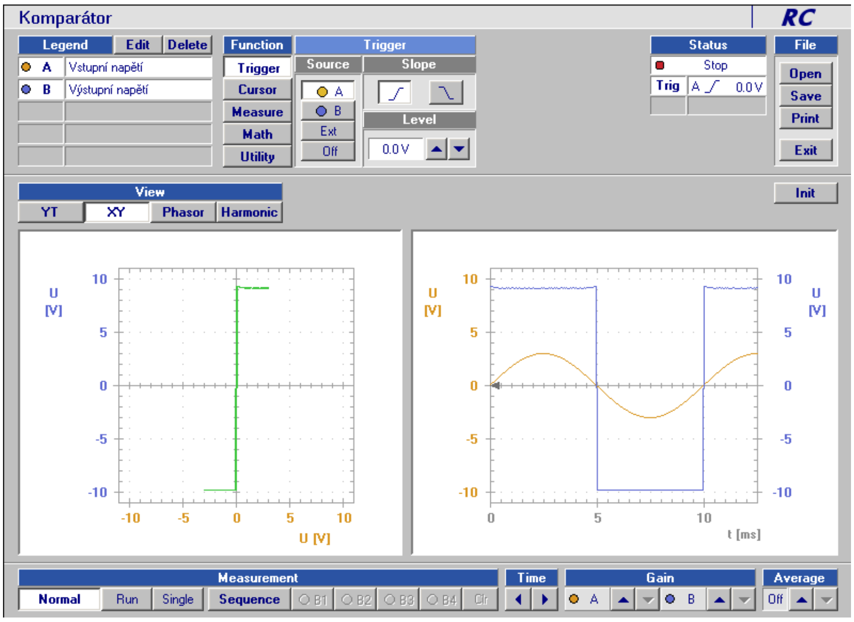


Fig. 2

Measurement

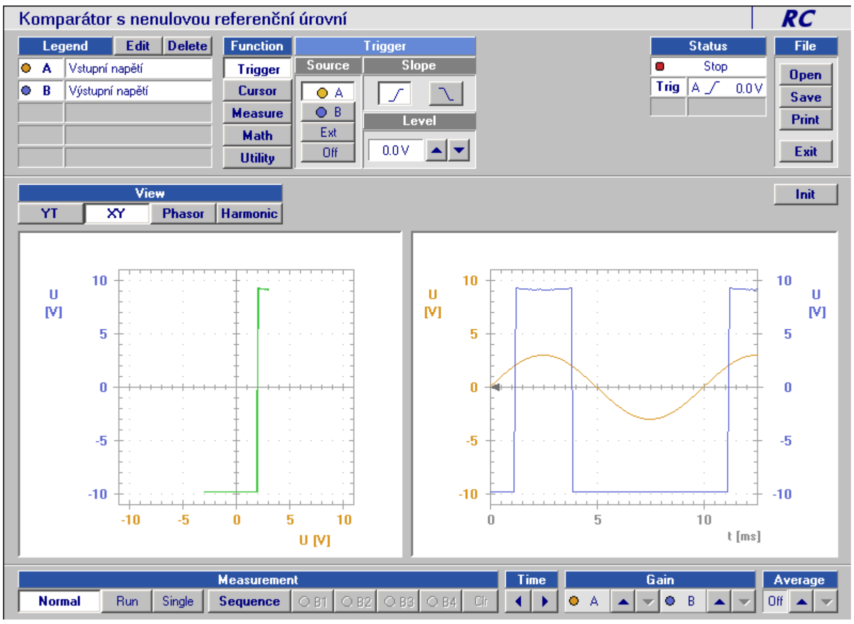


Comparator

schema	Fig. 1
mode	Oscilloscope
display	XY

modules

Operational amplifier
Measuring unit ADDU
Function generator



Comparator with non-zero level

mode	Fig. 2
schema	Oscilloscope
display	XY

modules

Operational amplifier
Measuring unit ADDU
Function generator
Programmable DC supply

Notice Thanks to output divider consisting of R_1 and R_2 we display saturation voltage bigger than 10V.

Comparator with Hysteresis

Exercise

Display course of input and output voltage of comparator with hysteresis. Make the measurement for zero level of comparation (Fig. 1) and for non-zero reference level of comparation (Fig. 2).

Schema

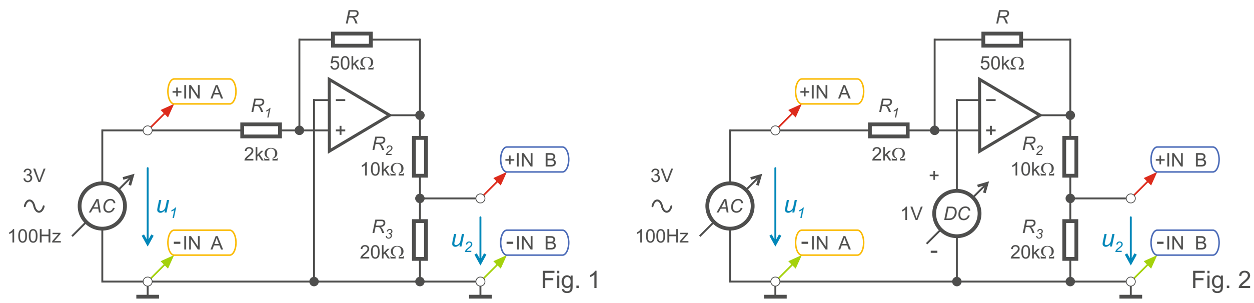
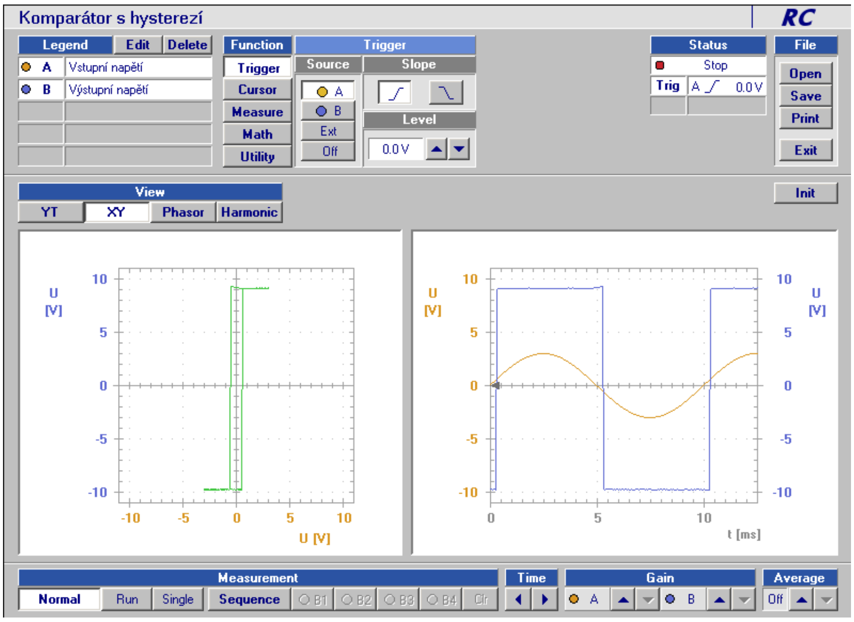


Fig. 1 Fig. 2

Measurement

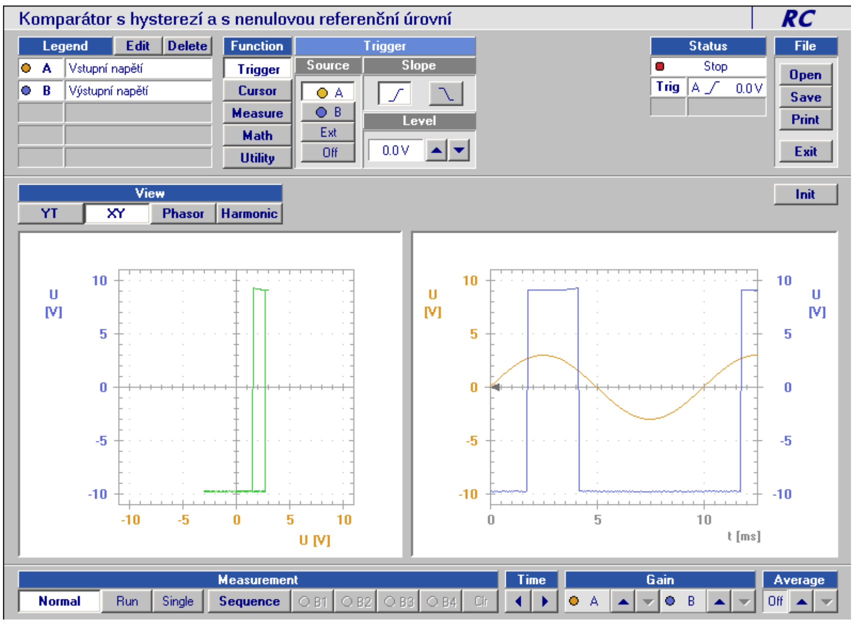


Comparator with hysteresis 1

schema	Fig. 1
mode	Oscilloscope
display	XY

modules

Operational amplifier
Measuring unit ADDU
Function generator



Comparator with hysteresis 2

mode	Fig. 2
schema	Oscilloscope
display	XY

modules

Operational amplifier
Measuring unit ADDU
Function generator
Programmable DC supply

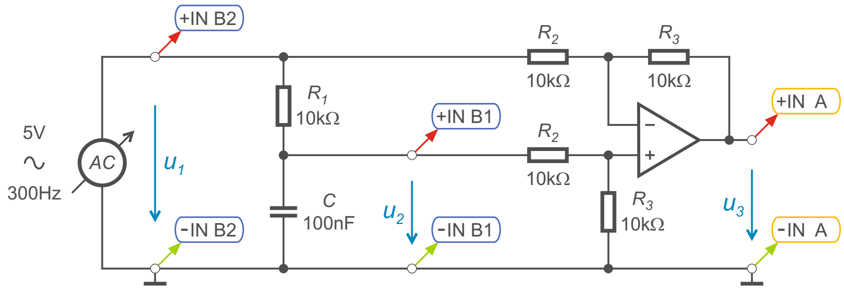
Notice Thanks to output divider consisting of R_1 and R_2 we display saturation voltage bigger than 10V.

6.8 Differential Amplifier

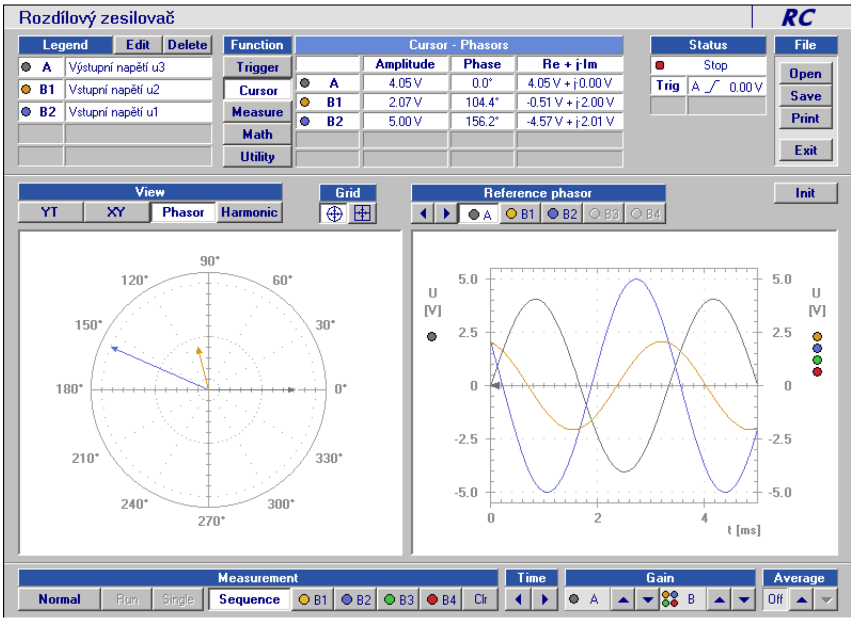
Exercise

Display courses of input voltages of differential amplifier u_1 ,u_2 and its output voltage u_3 . With the help of cursors prove the validity of formula $u_3 = u_2 - u_1$.

Schema



Measurement



Differential amplifier

schema	Fig. 1
mode	Oscilloscope
display	Phasor

modules

Operational amplifier
Measuring unit ADDU
Function generator

Phasenglied

Exercise

Display the amplitude and phase frequency characteristics for two variations of connecting the Phasenglied.

Schema

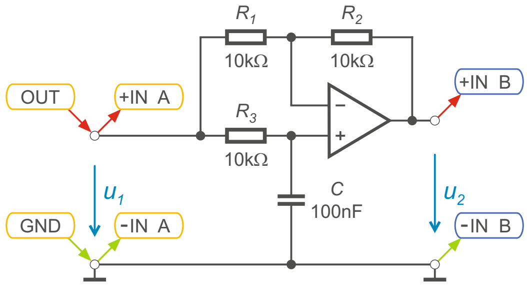


Fig. 1

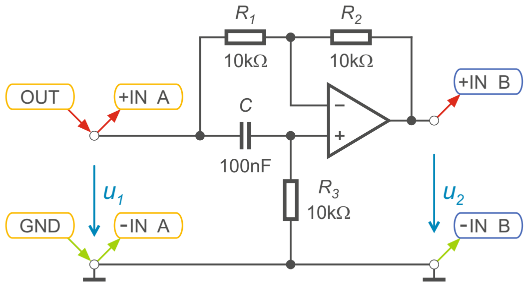
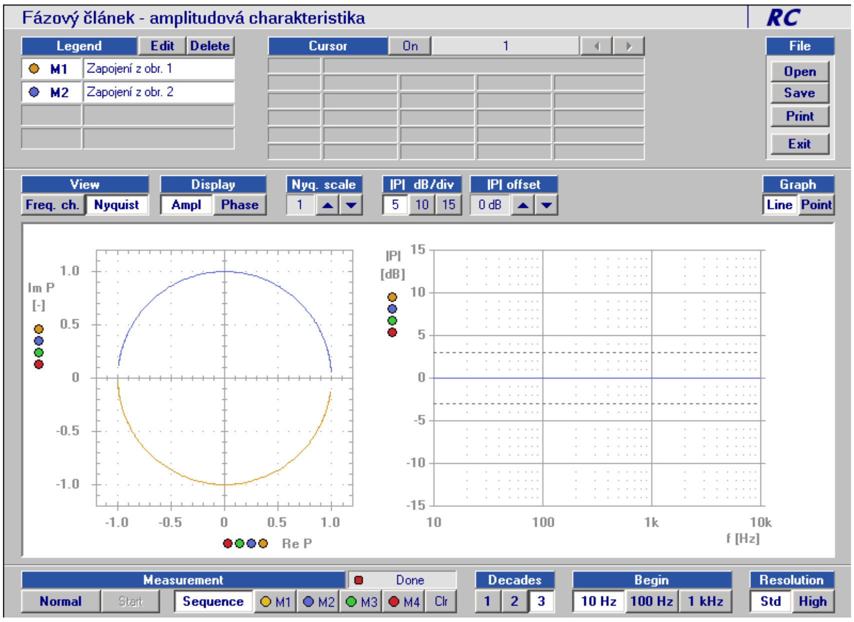


Fig. 2

Measurement

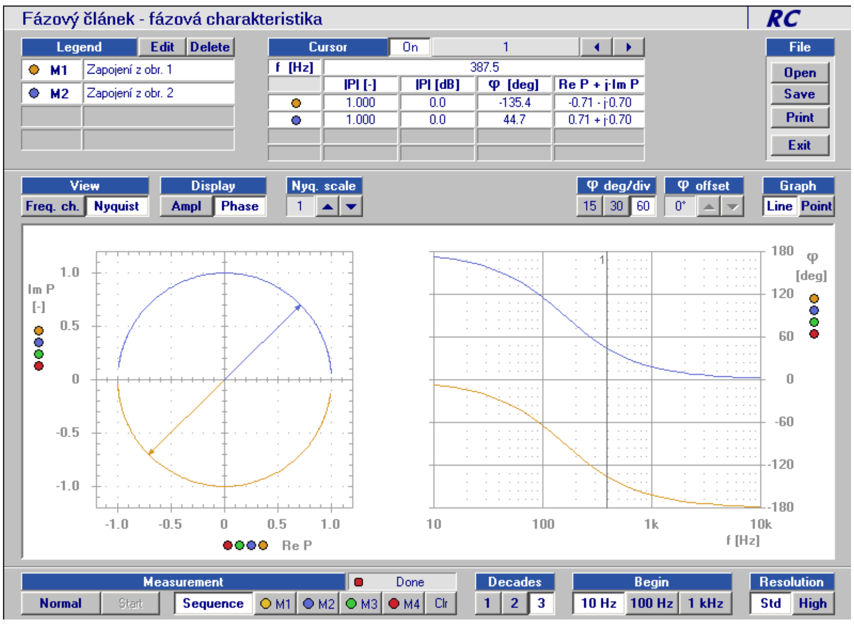


Amplitude characteristic

schema	Fig. 1
mode	Frequency char.
display	Amplitude

modules

Operational amplifier
Measuring unit ADDU



Phase characteristic

schema	Fig. 2
mode	Frequency char.
display	Phase

modules

Operational amplifier
Measuring unit ADDU

Astable Multivibrator

Exercise

Display the voltage on capacitor *C* and on the output of the circuit. Output period is given by the formula 1). To simplify the calculation of generated frequency 2) choose $R_2 = 0{,}86\ R_1$.

Schema

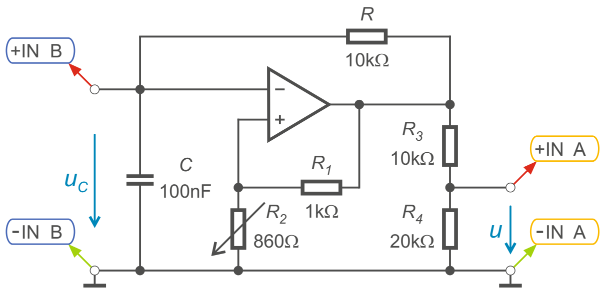


Fig. 1

$$T = 2.R.C.ln(1+\frac{2.R_2}{R_1}) \qquad 1)$$

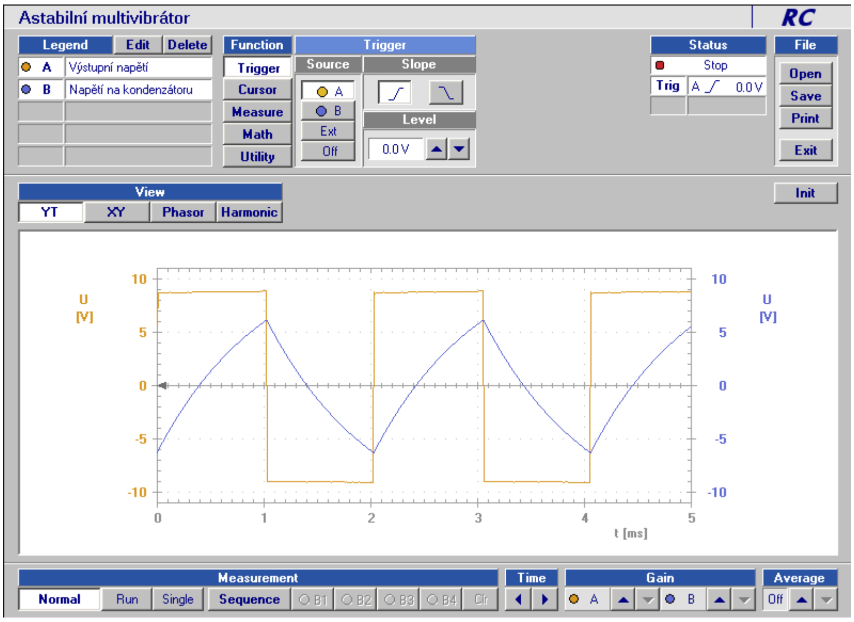
$$ln(1+\frac{2.R_2}{R_1}) = 1.0006 \doteq 1$$

$R_1 = 1000\Omega \quad R_2 = 860\Omega$

$$f \doteq \frac{1}{2.R.C} \qquad 2)$$

$$f \doteq \frac{1}{2.10^4.10^{-7}} = 500\ \text{Hz}$$

Measurement



Astable

schema	Fig. 1
mode	Oscilloscope
display	YT

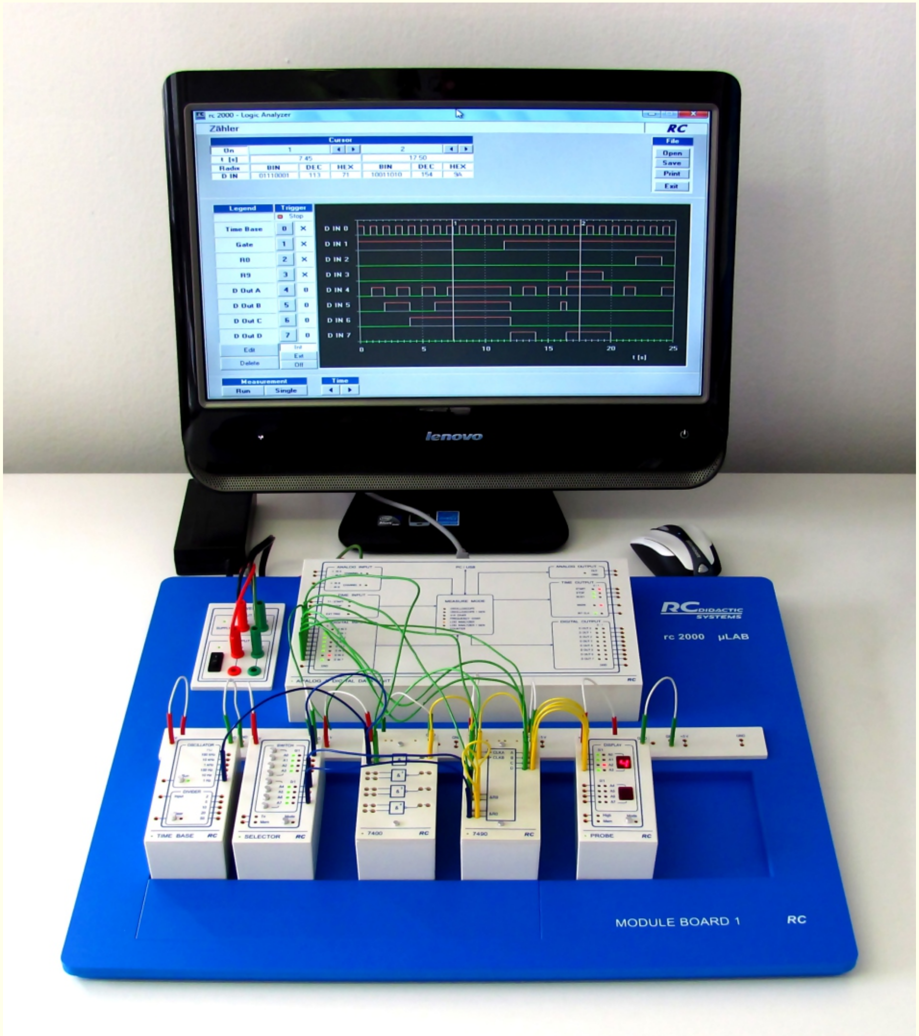
modules

Operational amplifier
Measuring unit ADDU
Resistor decade R1

Notice Thanks to output divider consisting of R_1 and R_2 we display saturation voltage bigger than 10V.

Teaching System rc2000 - µLAB

Digital Technics



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

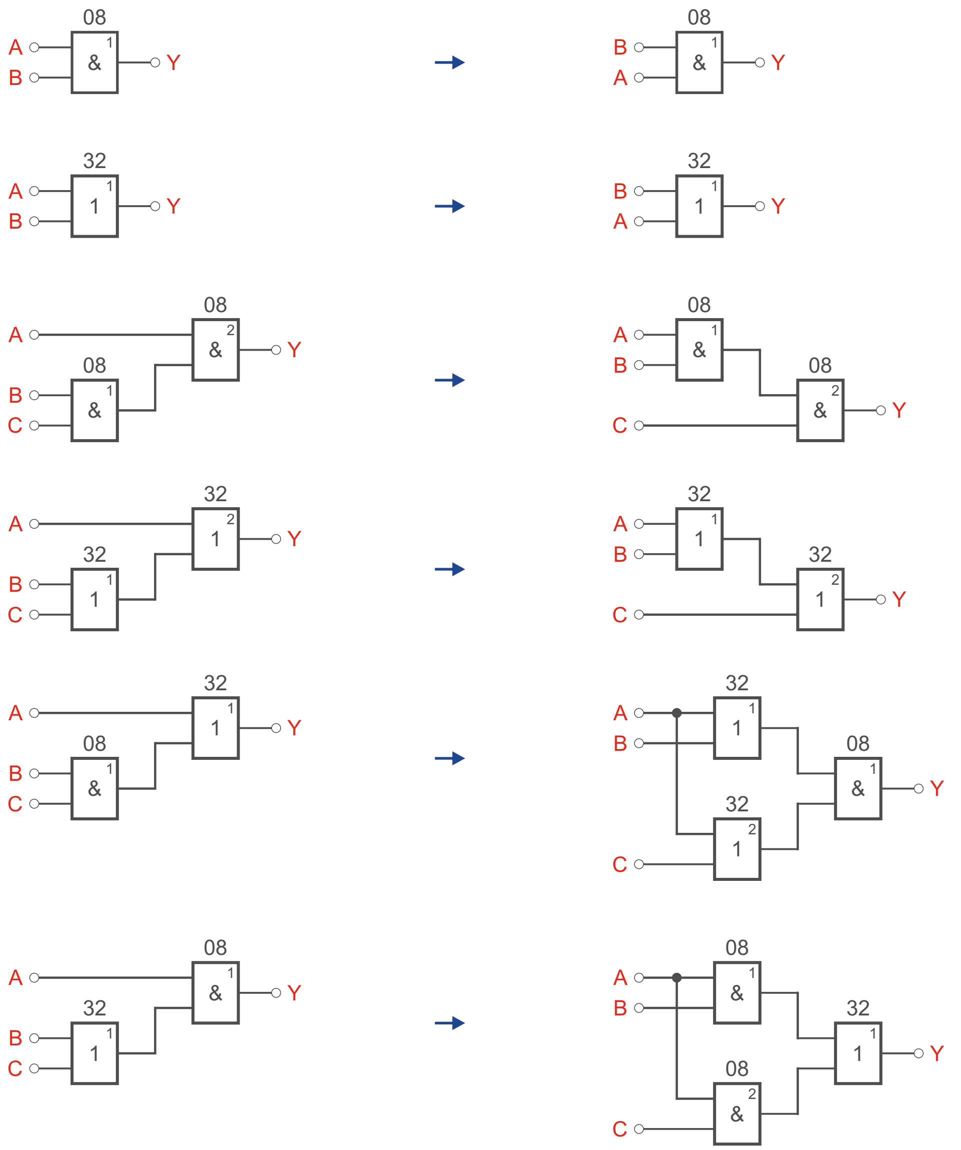
Content

7.1 Boolean Algebra - Laws

Exercise

Verify the validity of the laws of Boolean algebra.

Schema



$$Y = A \,.\, B$$
$$= B \,.\, A$$

$$Y = A + B$$
$$= B + A$$

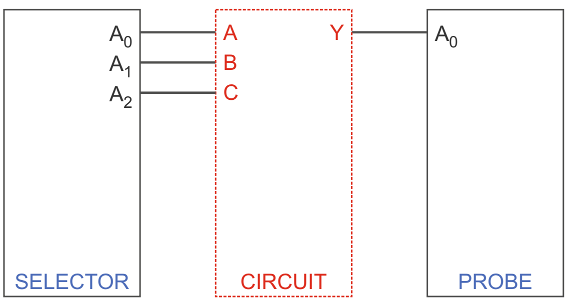
$$Y = A \,.\, (B \,.\, C)$$
$$= (A \,.\, B) \,.\, C$$

$$Y = A + (B + C)$$
$$= (A + B) + C$$

$$Y = A + (B \,.\, C)$$
$$= (A + B) \,.\, (A + C)$$

$$Y = A \,.\, (B + C)$$
$$= (A \,.\, B) + (A \,.\, C)$$

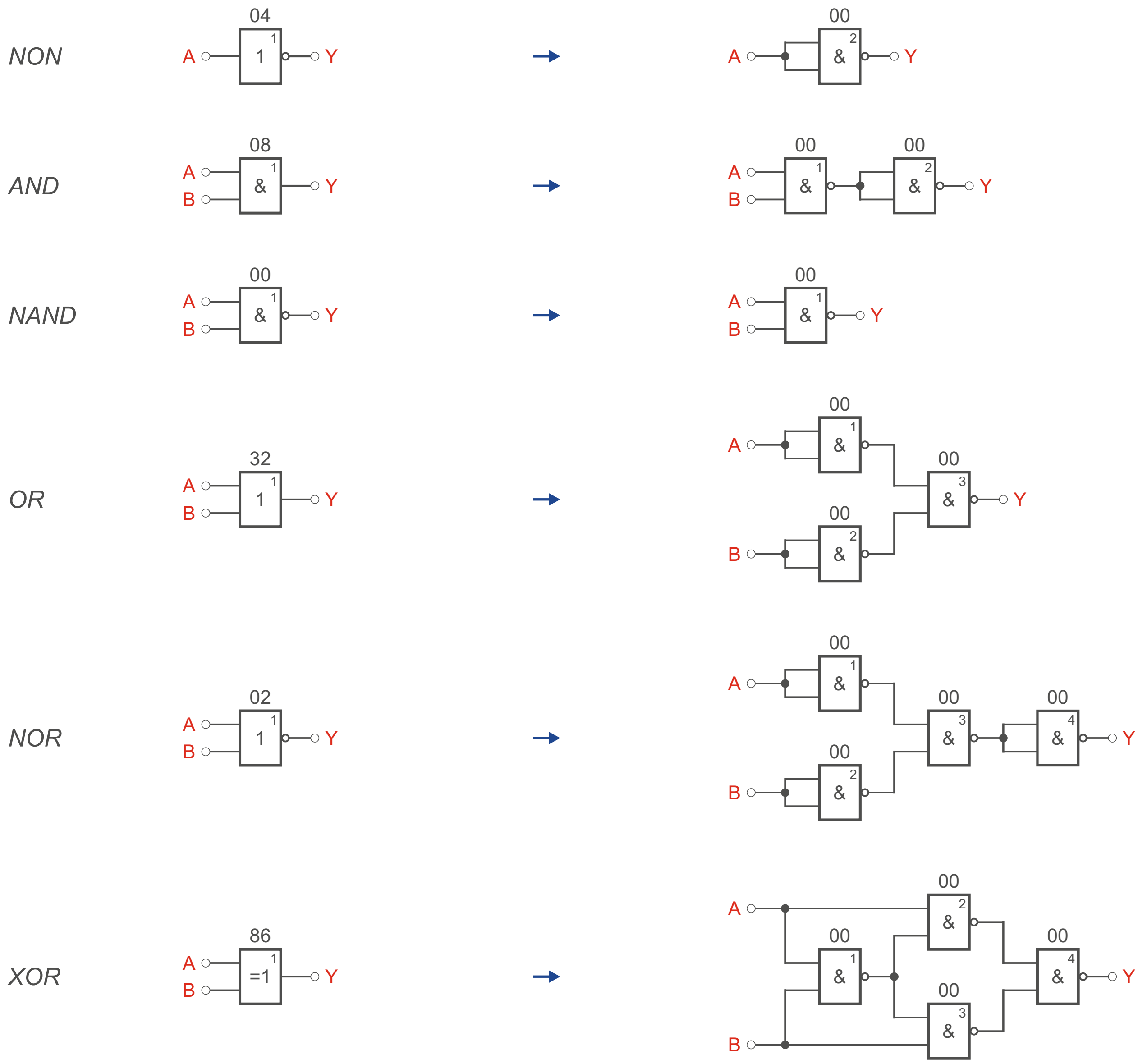
Circuit



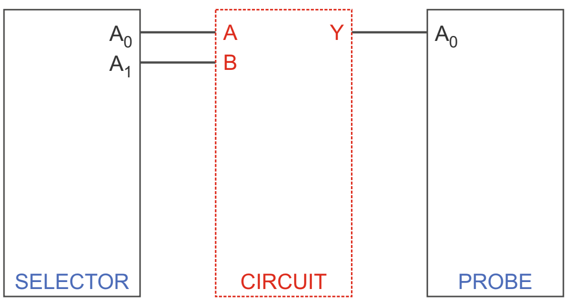
Exercise

Design and implement circuiting of basic logic functions NON, AND, NAND, OR, NOR and XOR using NAND function.

Schema



Circuit



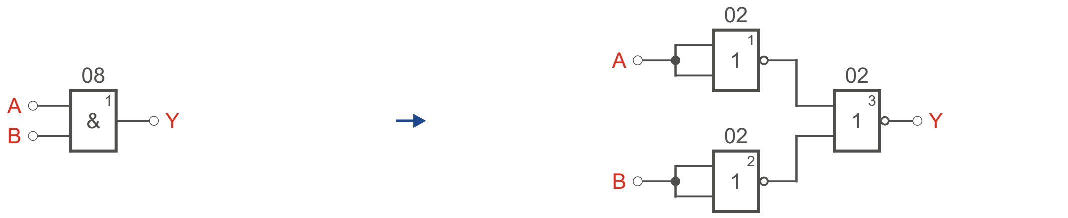
Exercise

Design and implement circuiting of basic logic functions NON, AND, NAND, OR and NOR using NOR function.

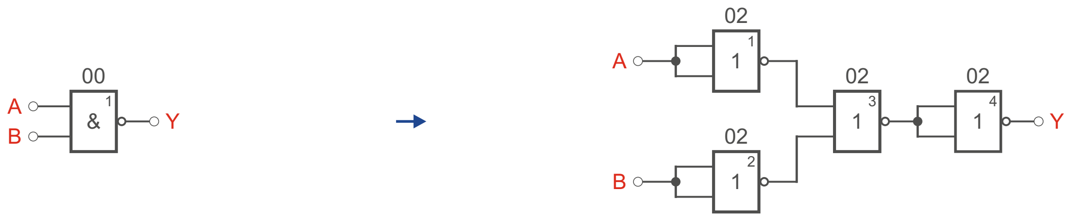
Schema

NON

AND



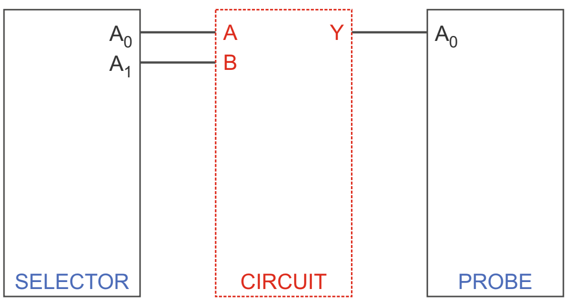
NAND



OR

NOR

Circuit



Exercise

Minimize the specified logical function and verify the results by measurement.

Schema

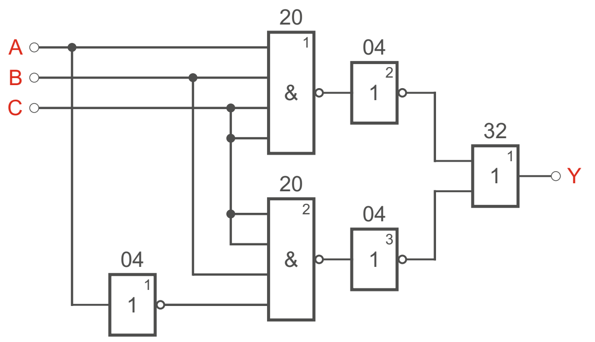


Fig. 1

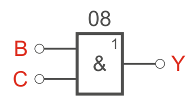


Fig. 2

Circuit

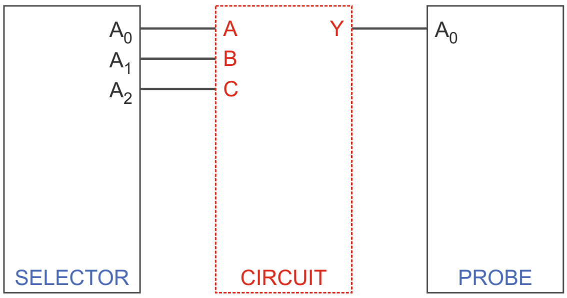


Fig. 1

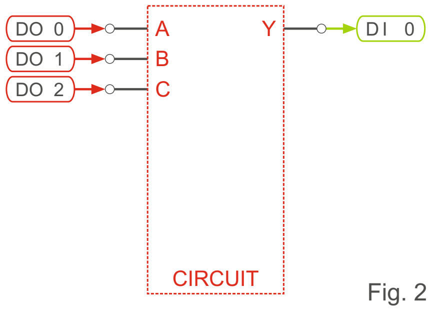
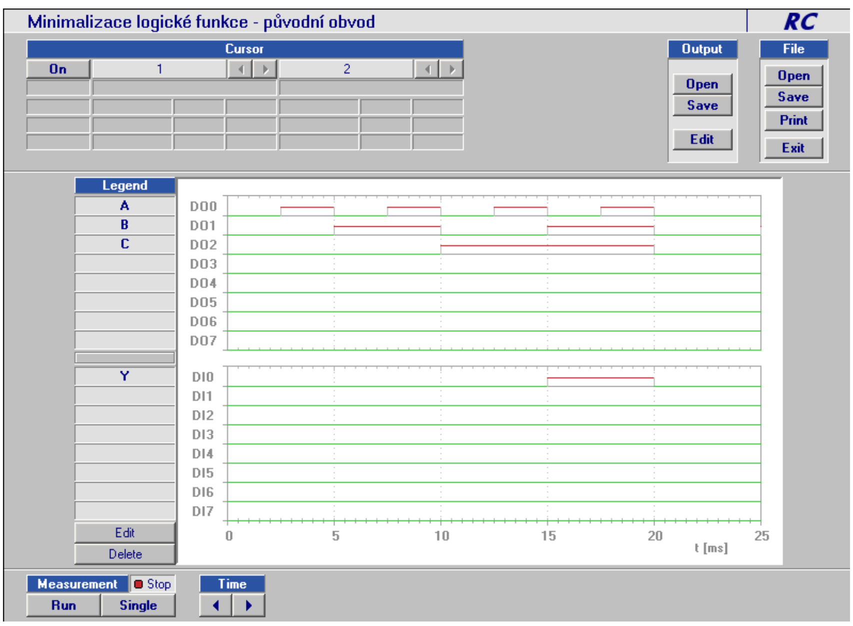


Fig. 2

Measurement

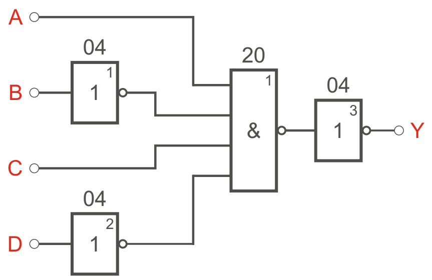


Elevator Control

Exercise

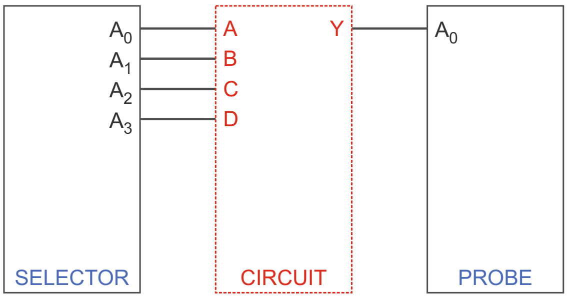
Design and implement a logical function for elevator control. The motor starts when the floor choice button is pressed and simultaneously the stop button is not, the doors are closed and the elevator is not overloaded.

Schema



A	0	The floor selection key is not pressed
	1	The floor selection key is pressed
B	0	The emergency button STOP is not pressed
	1	The emergency button STOP is pressed
C	0	The doors are not closed
	1	The doors are closed
D	0	The lift is not overloaded
	1	The lift is overloaded
Y	0	The lift motor is not running
	1	The lift motor is running

Circuit

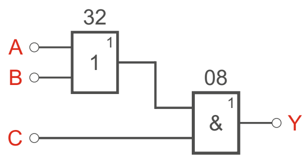


7.6 Alarm Switching

Exercise

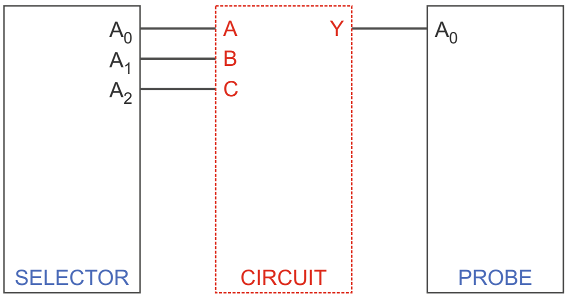
Design and implement the logical function of a safety device to monitor the window and the door of the building. When the device is switched on, a window, a door or both are triggered at the same time.

Schema



A	0	The window is closed
	1	The window is opened
B	0	The doors are closed
	1	The doors are opened
C	0	Device switched off
	1	Device switched on
Y	0	The siren does not howl
	1	The siren howles

Circuit

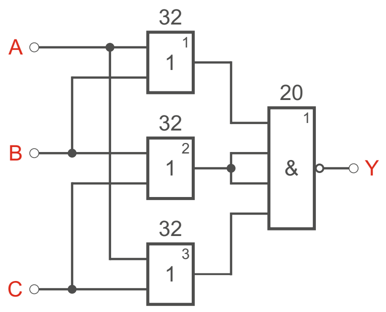


7.7 Fan Control

Exercise

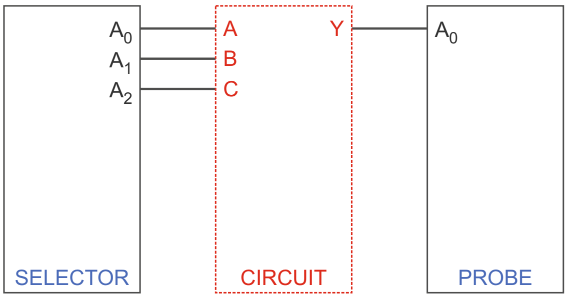
Design and implement the logic function of the signaling of the fan operation in the tunnel. The indicator light starts to light when less than two (ie one or none) of the three installed fans are working.

Schema



A	0	Fan 1 is not running
	1	Fan 1 is running
B	0	Fan 2 is not running
	1	Fan 2 is running
C	0	Fan 3 is not running
	1	Fan 3 is running
Y	0	The signaling is switched off
	1	The signaling is switched on

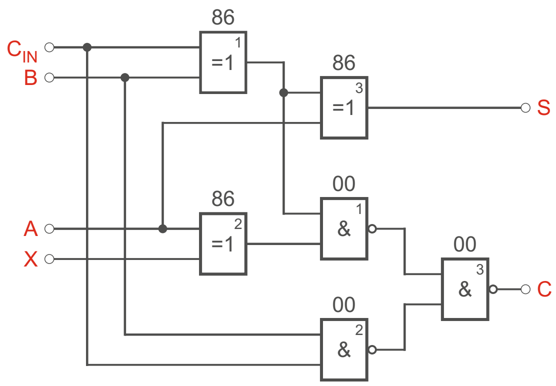
Circuit



Exercise

Make a circuit connection for addition and subtraction of two one-bit numbers with a transmission from low-order and into higher-order.

Schema



Circuit

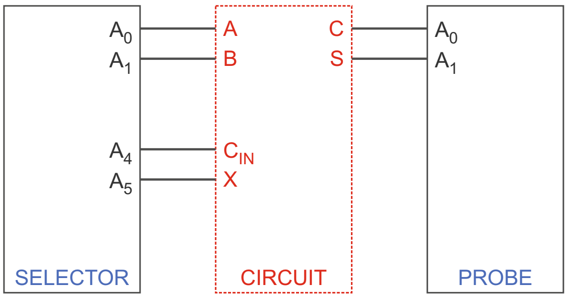


Fig. 1

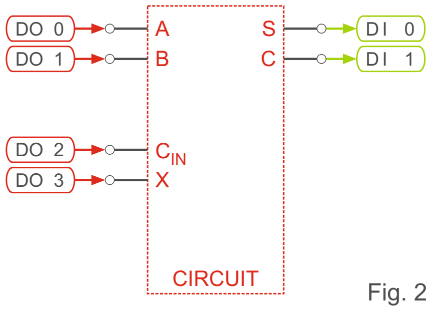
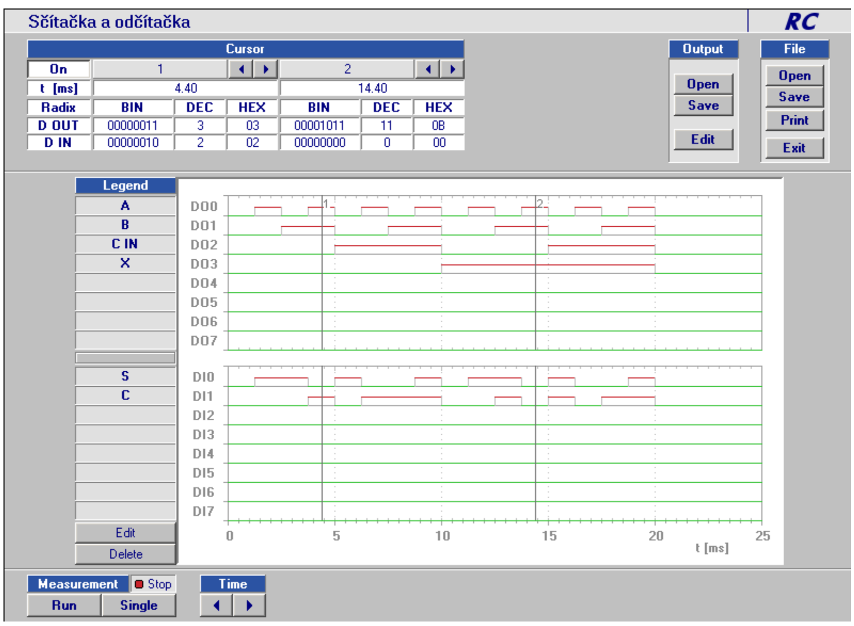


Fig. 2

Measurement



Half Adders and Full Adders

Exercise

Make a circuit connection to add two one-bit numbers without transmission (half-adders) and with transmission (full adders).

Schema

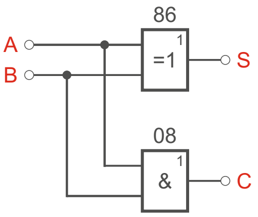


Fig. 1

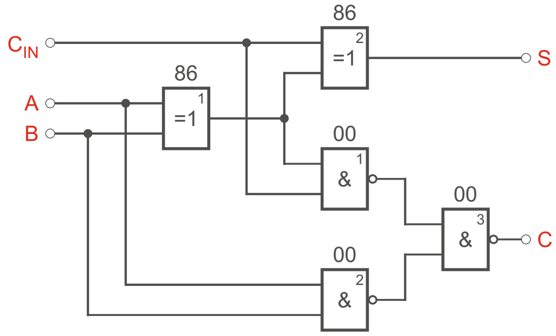


Fig. 2

Circuit

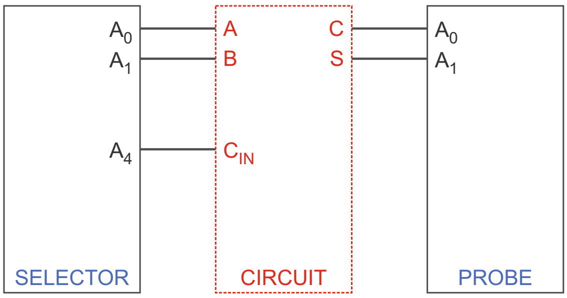


Fig. 1

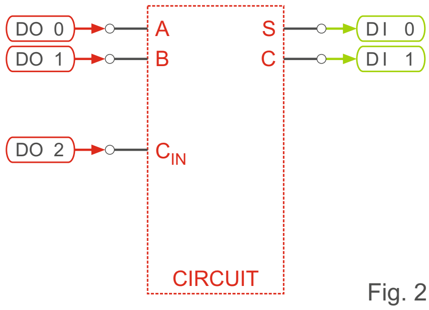
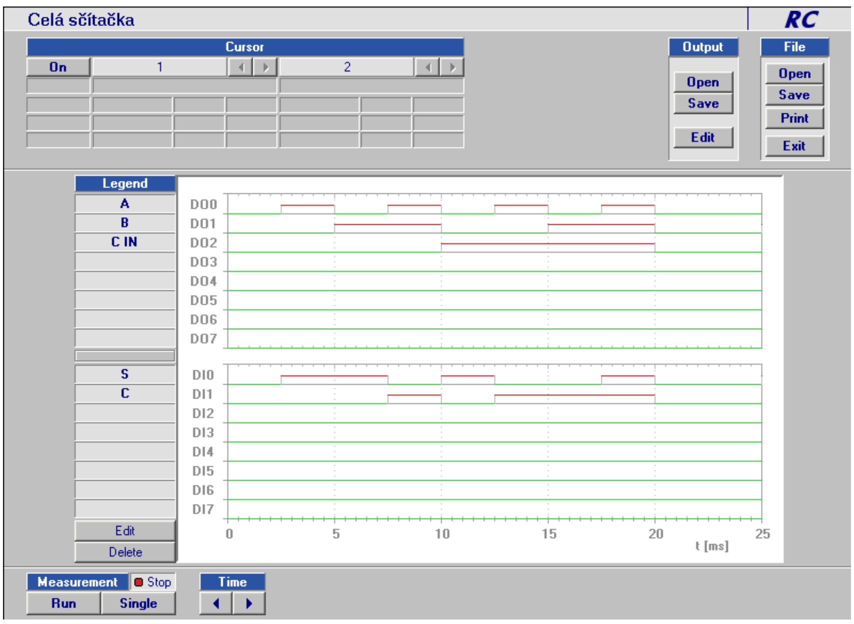


Fig. 2

Measurement



7.10 1-bit Comparator

Exercise

Design and check the circuit that compares two one-bit numbers.

Schema

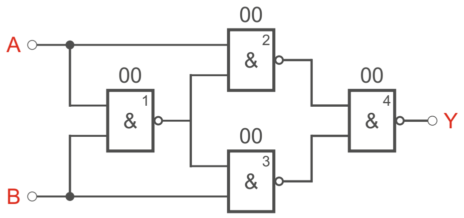


Fig. 1

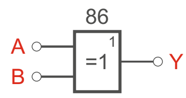


Fig. 2

Circuit

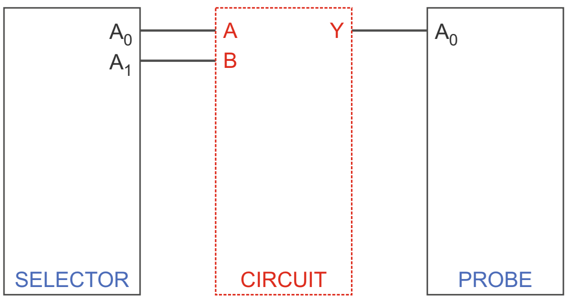


Fig. 1

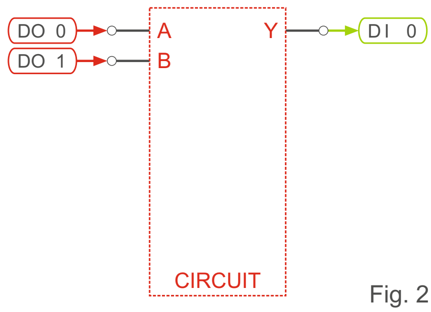
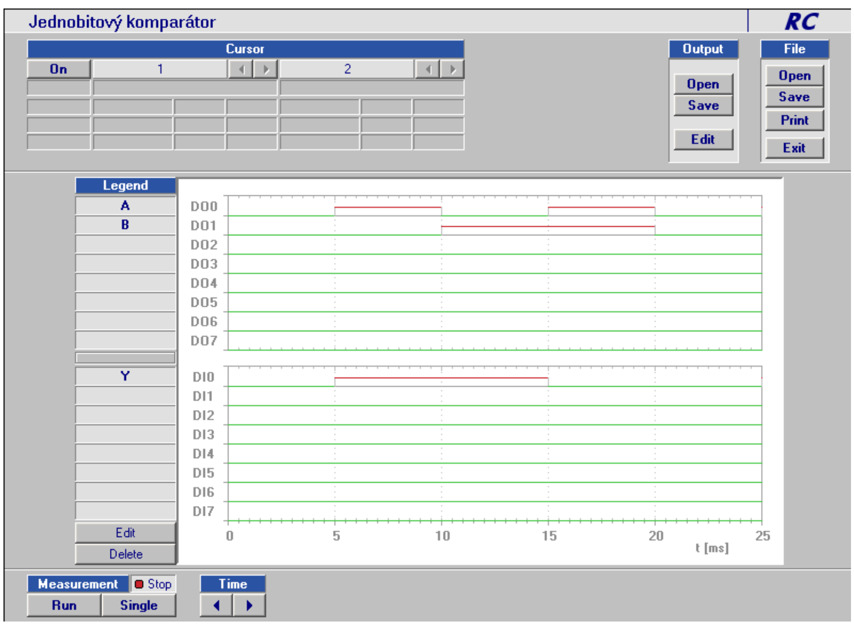


Fig. 2

Measurement

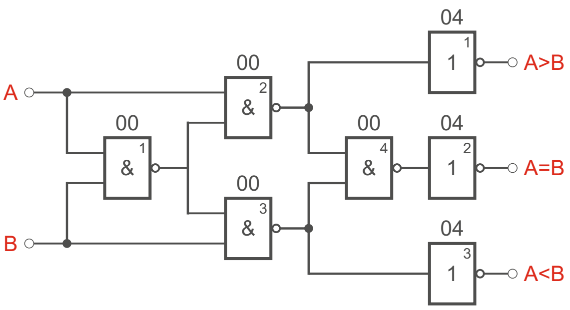


Comparison Circuit

Exercise

Make a circuit connection to compare two one-bit numbers. The circuit has outputs A> B, A = B, A <B.

Schema



Circuit

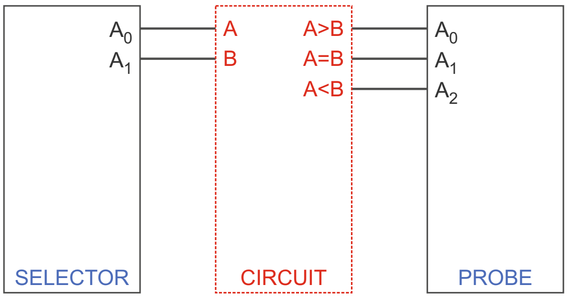


Fig. 1

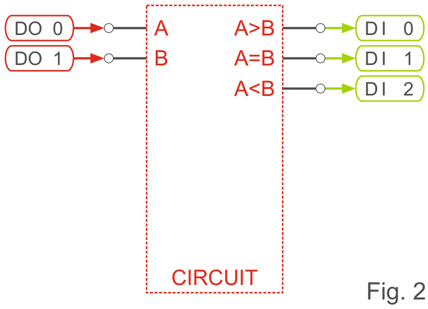
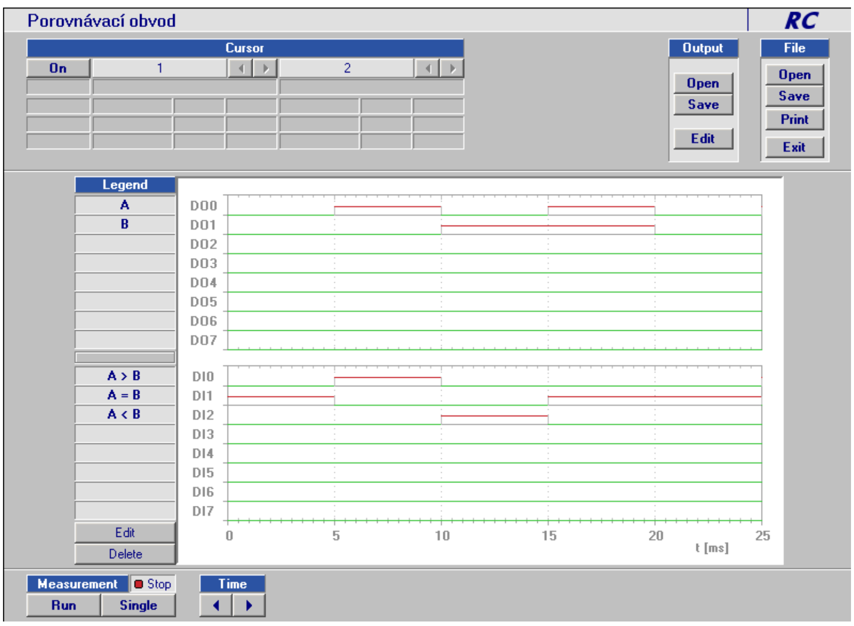


Fig. 2

Measurement



Binary <-> Gray Code Converter

Exercise

Create the circuit of the converter, which converts the numbers from the binary code to the Gray code.

Schema

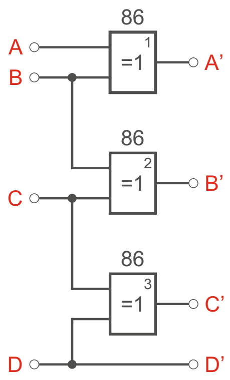


Fig. 1

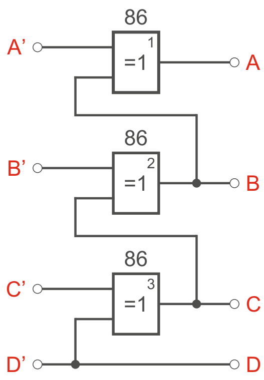


Fig. 2

Decimal system	Binary code	Gray code
	DCBA	D`C`B`A`
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

Circuit

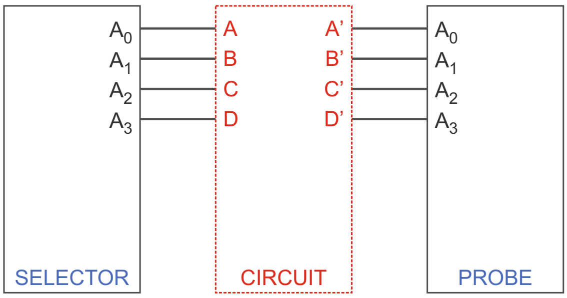


Fig. 1

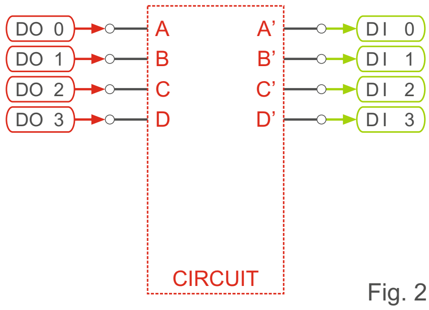
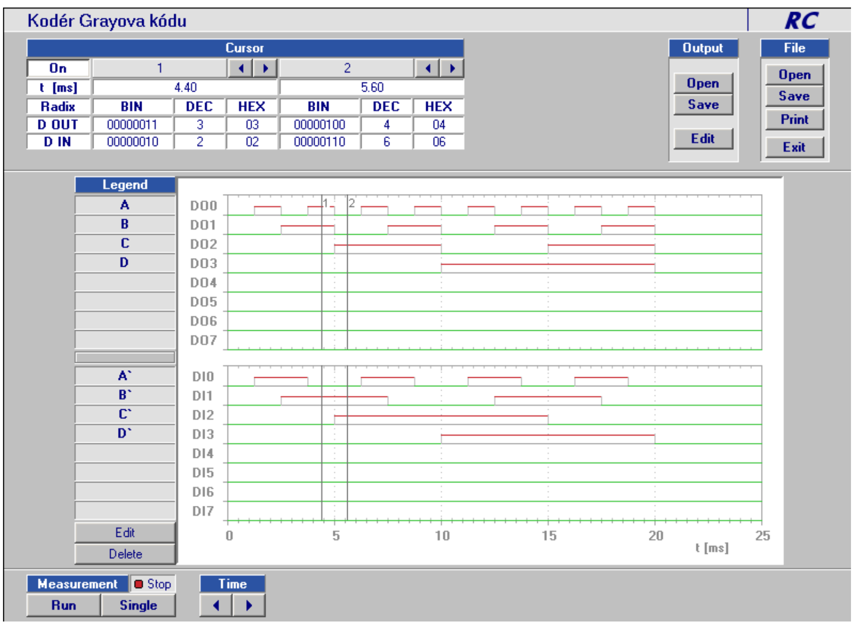


Fig. 2

Measurement

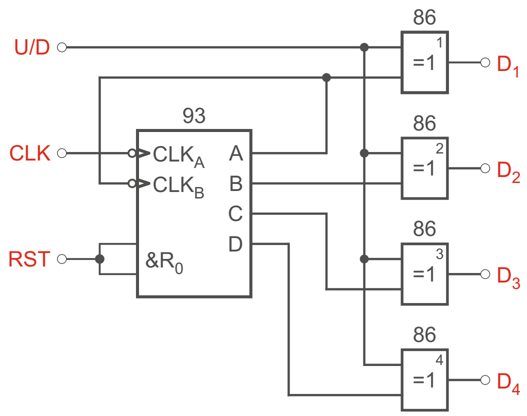


Counter (up / down)

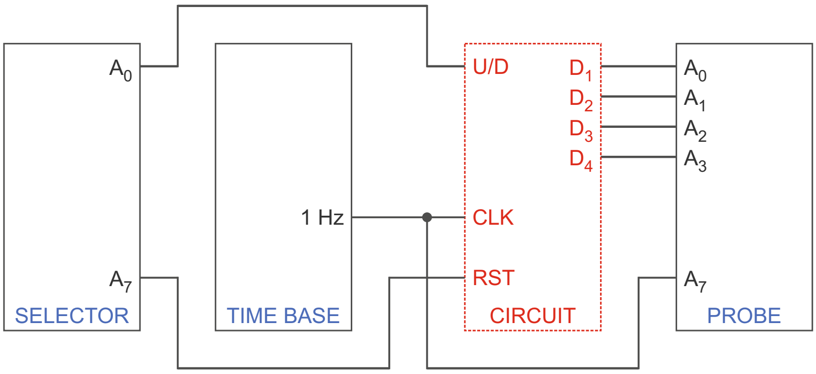
Exercise

Design and implement the counter with the 7493 circuit, which can read up and down. Check the function.

Schema



Circuit

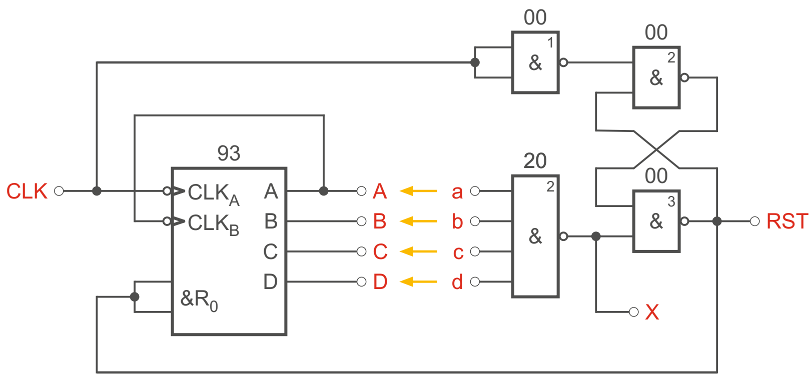


7.14 # Modulo - N - Counter

Exercise

Design and implement the Modulo - N - Counter 2 - 15 with the 7493 circuit. Check the function.

Schema



Circuit

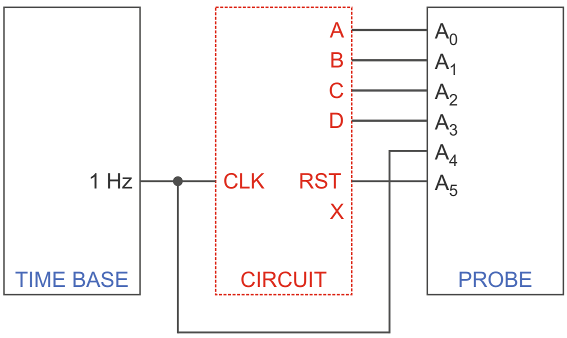


Fig. 1

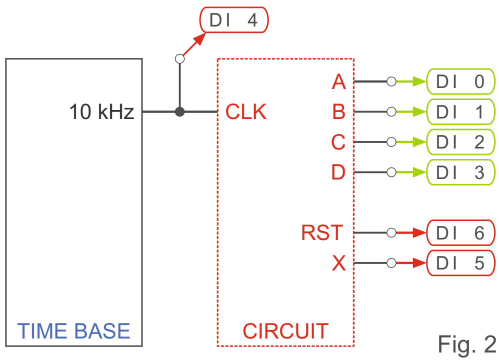
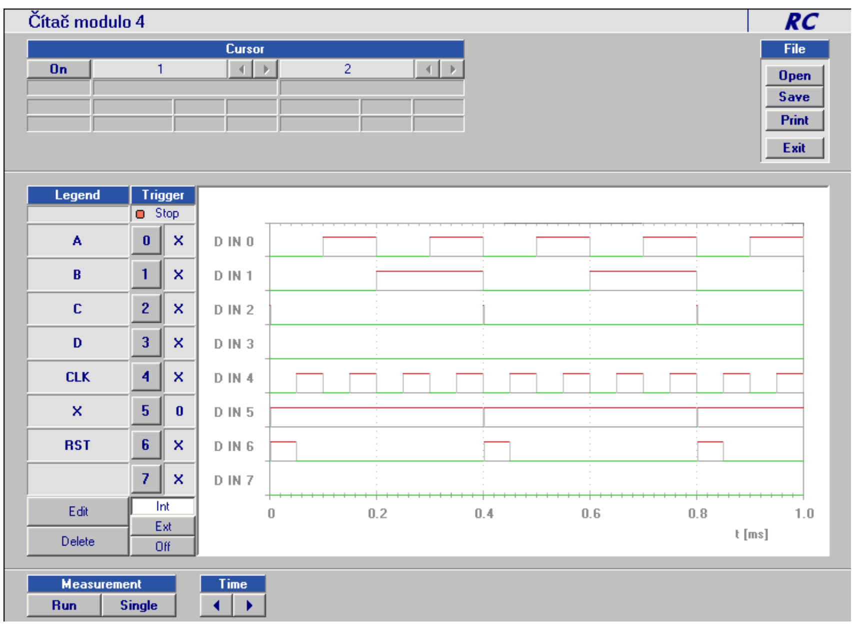


Fig. 2

Measurement

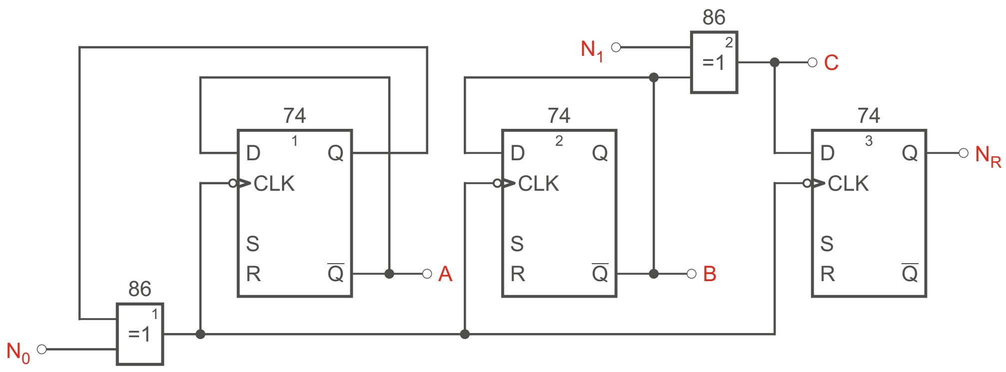


7.15 Sequence Circuit - Digital Differential Circuit

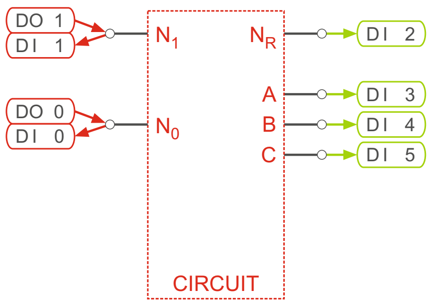
Exercise

Design and measure the circuit that generates the difference in the number of pulses of the two waveforms. Measure the circuit for synchronized waveforms when $N_0>N_1$ resp. $N_1>N_0$, and for unsynchronized waveforms.

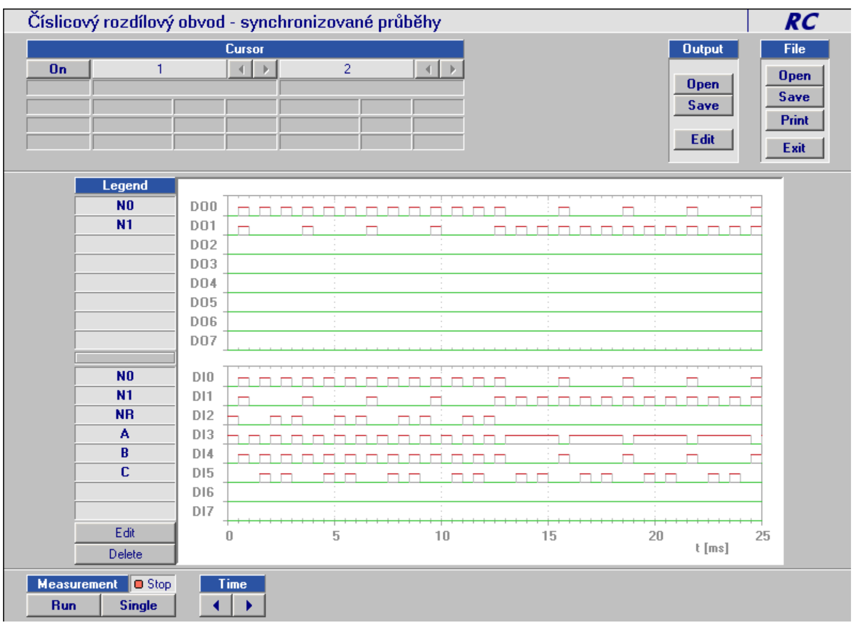
Schema



Circuit



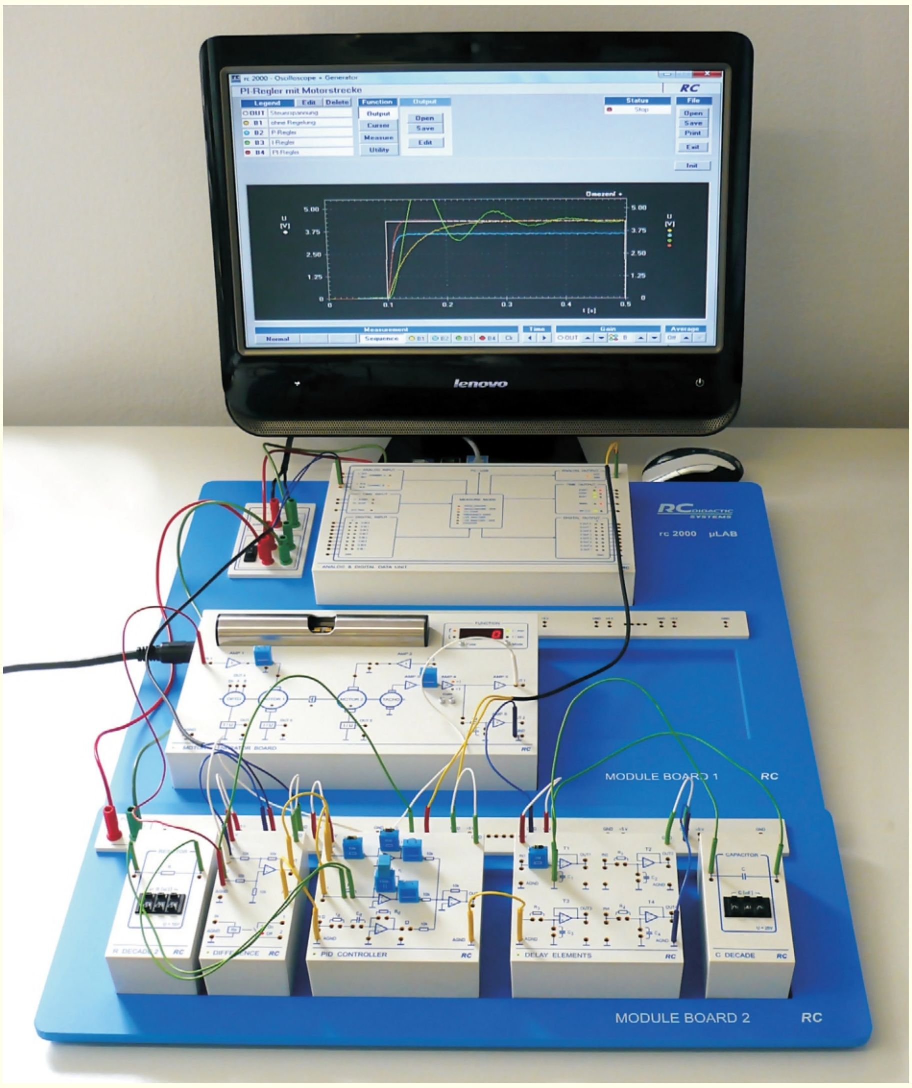
Measurement



RC DIDACTIC SYSTEMS

Teaching System rc2000 - µLAB

Regulation



RC společnost s r. o.
přístroje pro vědu a vzdělání
Cholupická 38
CZ - 142 00 Praha 4

Tel./Fax: 00420-244 464 176
Mobile: 00420-603 158 544
E-mail: info@rcdidactic.cz
Web: www.rcdidactic.cz

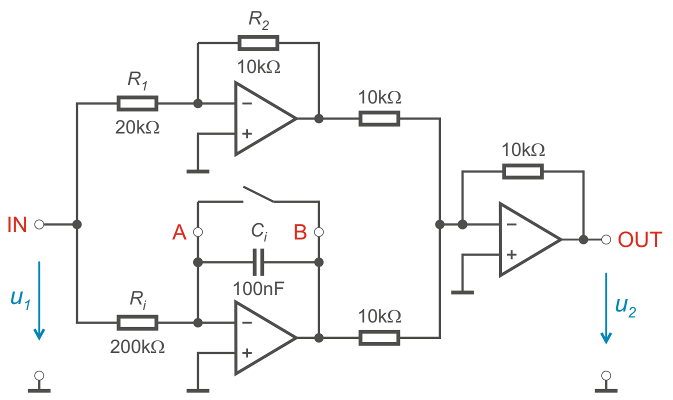
Content

PI control element - time analysis

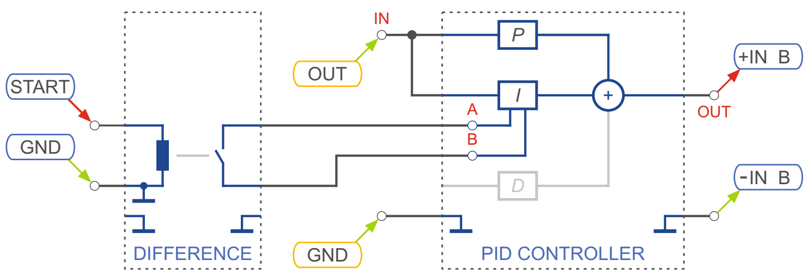
Exercise

Measure the transition characteristic of the PI controller.

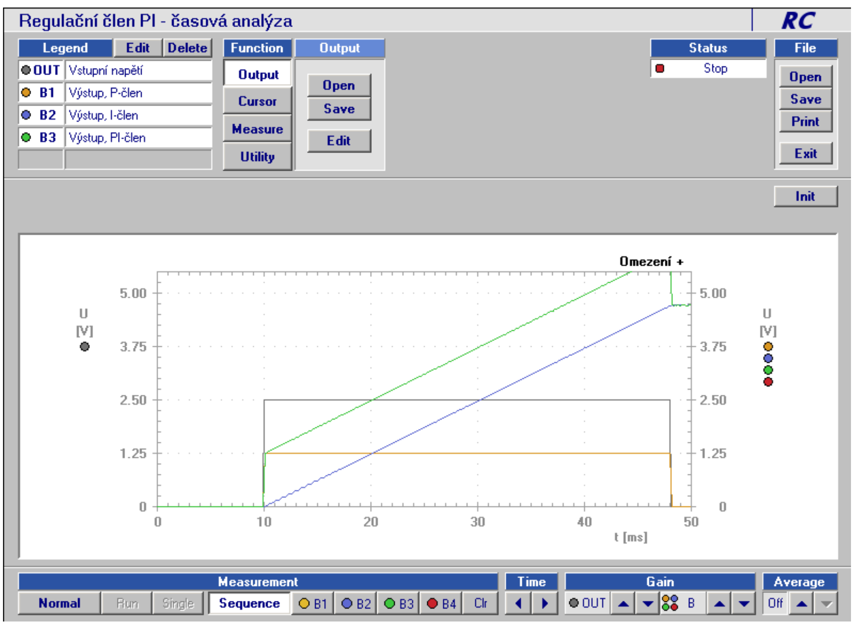
Schema



Circuit



Measurement

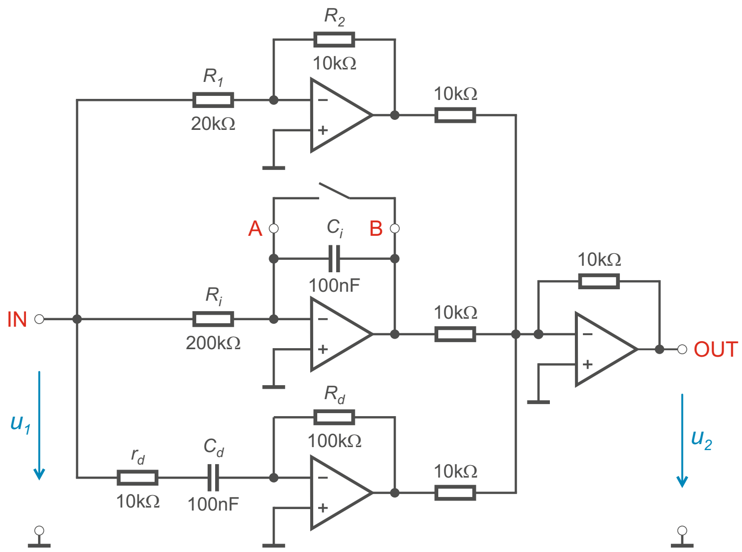


PID control element - time analysis

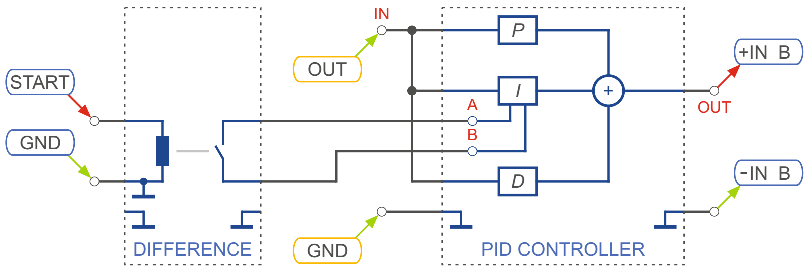
Exercise

Measure the transition characteristic of the PID controller.

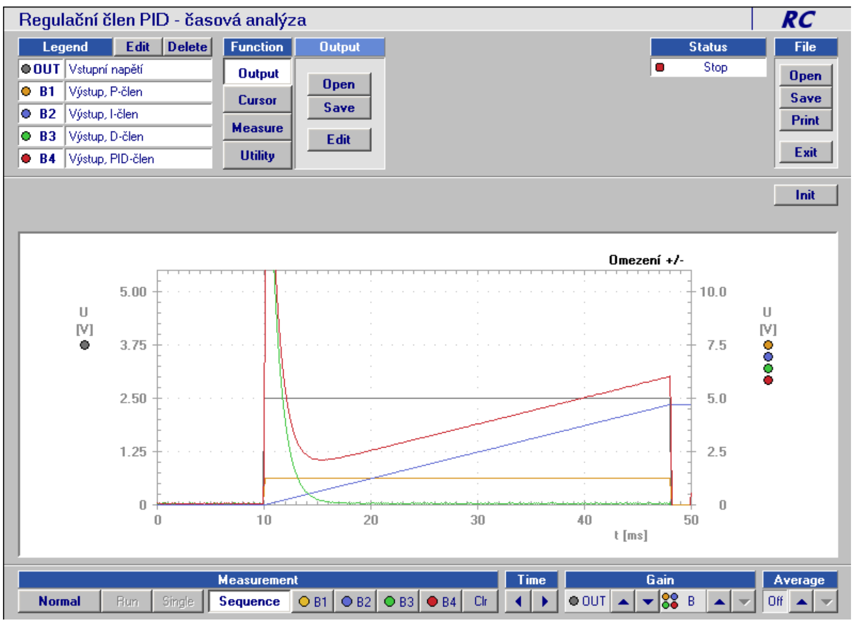
Schema



Circuit



Measurement

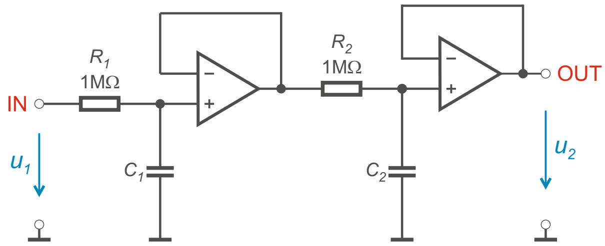


8.3 Delay element of the second order - time analysis

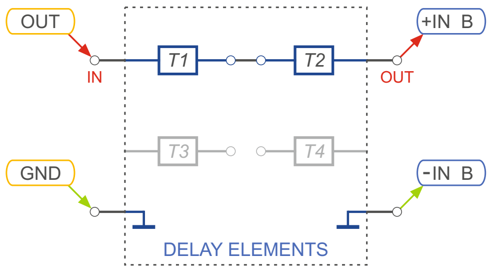
Exercise

Measure the transition characteristics of the second-order delay element.

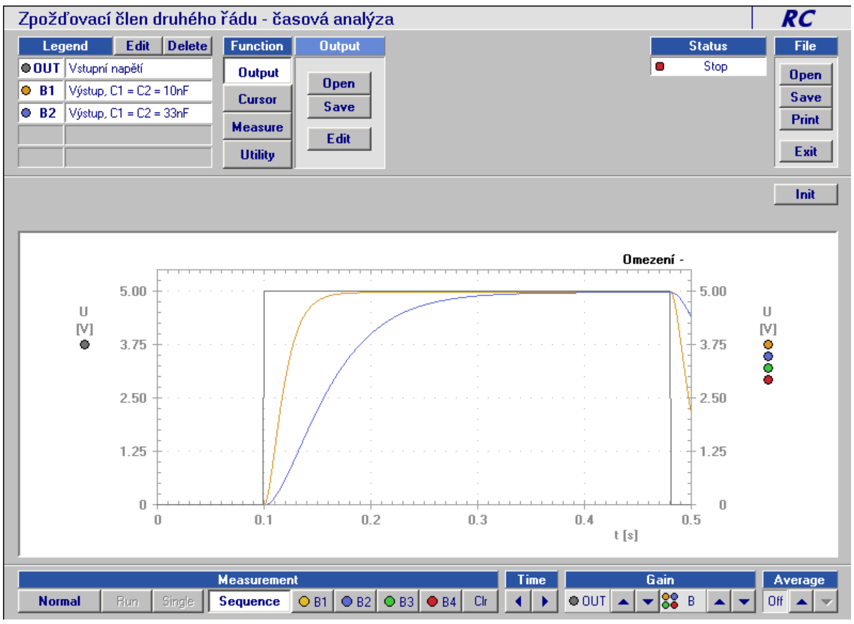
Schema



Circuit



Measurement



8.4 Identification of the delay element with a system of motor

Exercise

Find such a circuit of the delay element that has the best match in transition characteristics with the motor system and with tachodynamo from the motor - generator module. The value C_1 shall be about 40 nF.

Schema

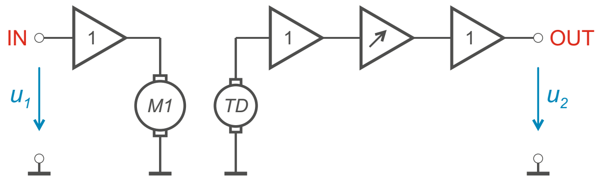


Fig. 1

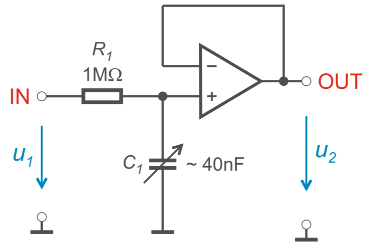


Fig. 2

Circuit

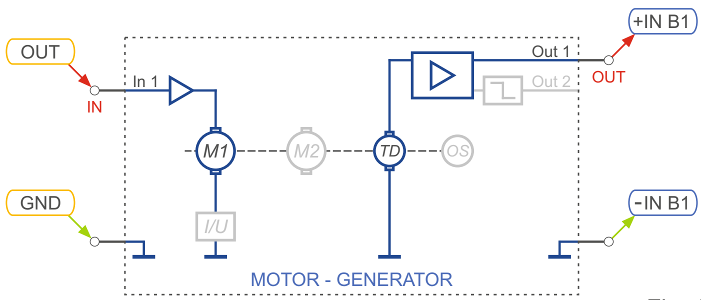


Fig. 1

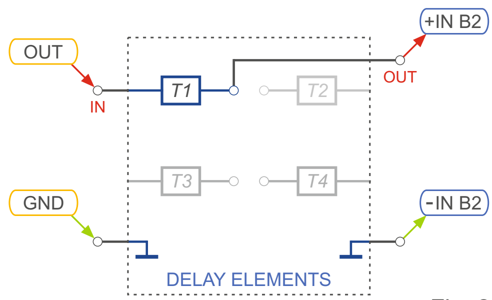
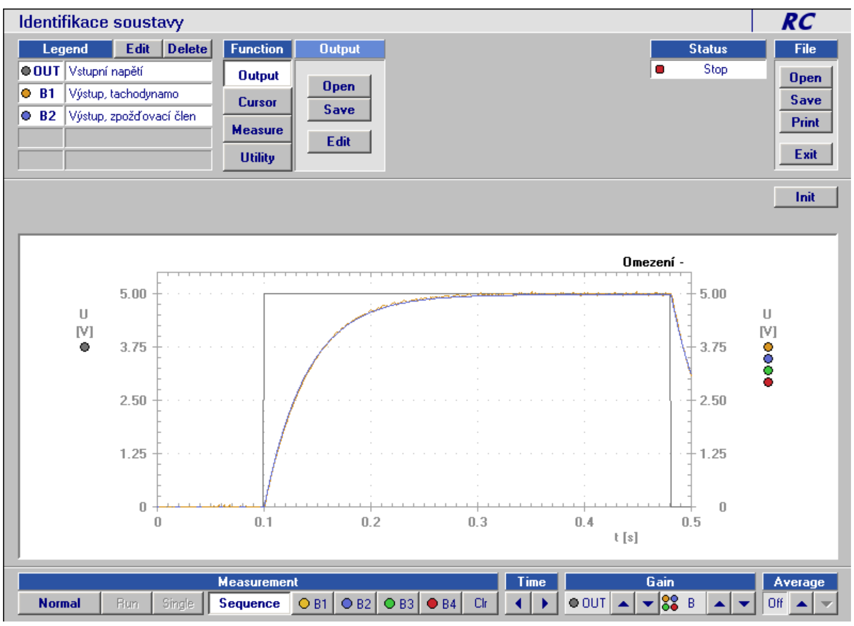


Fig. 2

Measurement

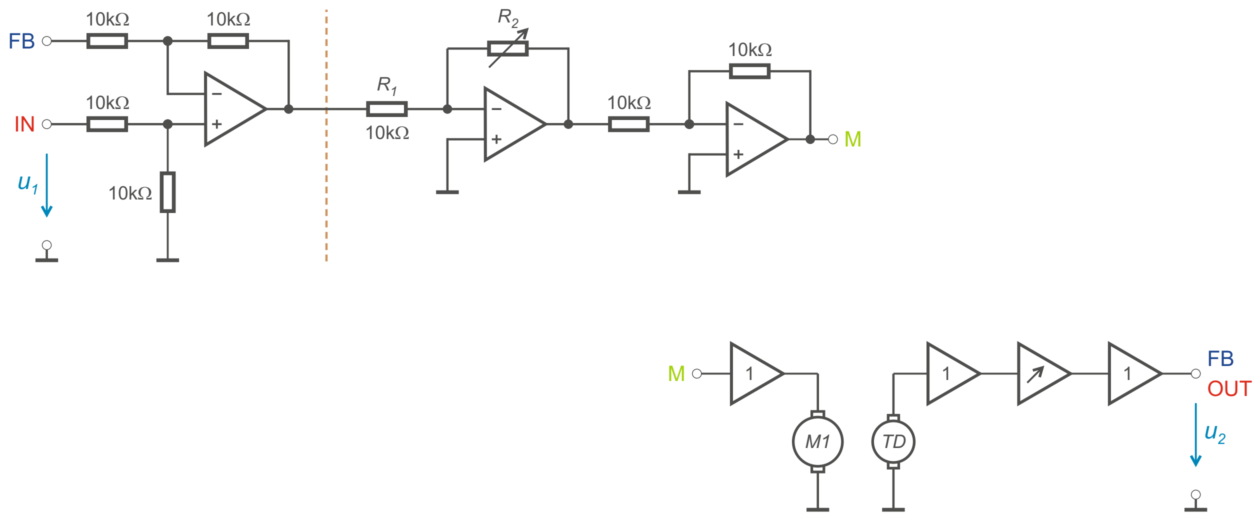


P-Controller - Measurement with motor

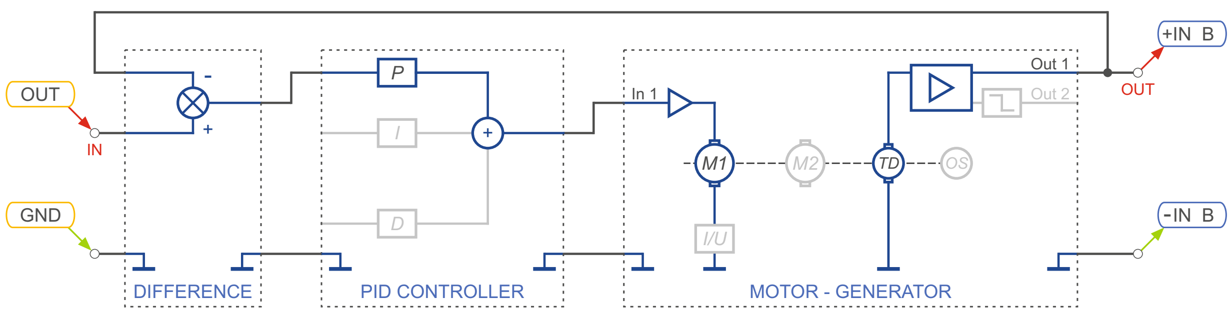
Exercise

Check the P-controller function. Measure the transition characteristic of the system with P-controller for the resistance values R_2 = 20 kΩ; 50 kΩ; 140 kΩ. Compare the waveforms with the characteristics of the system without regulation.

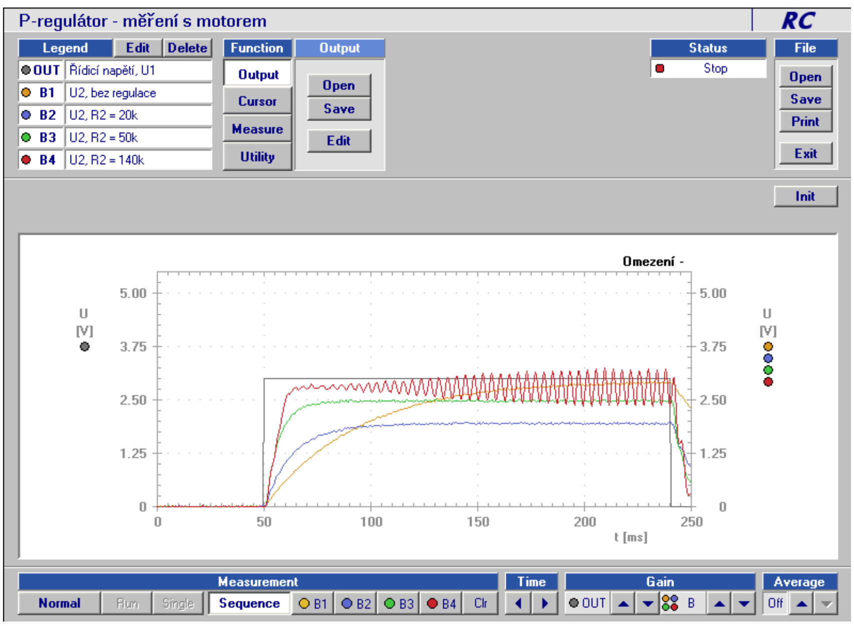
Schema



Circuit



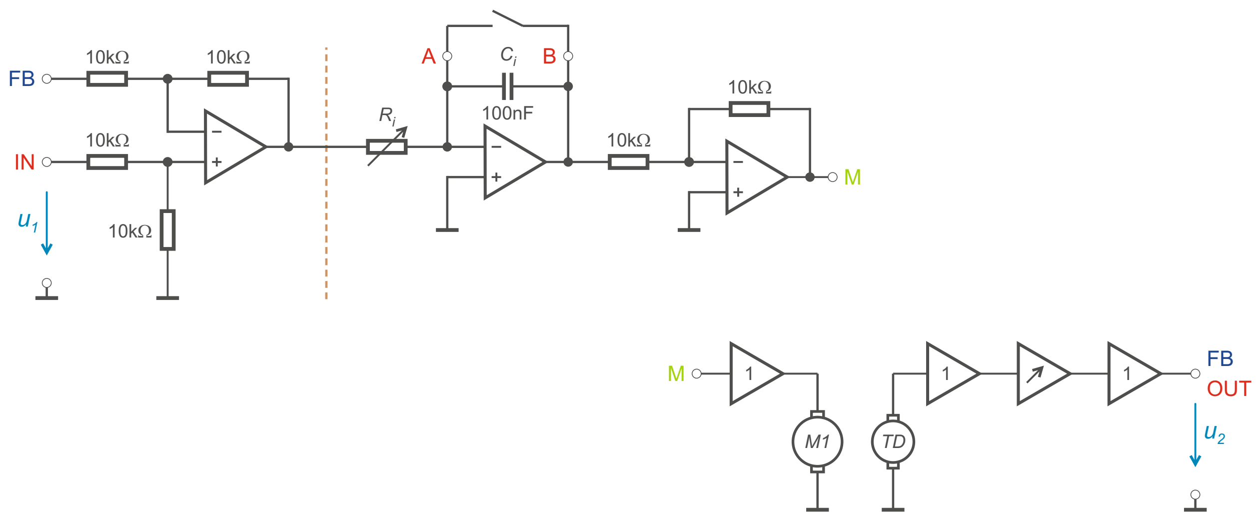
Measurement



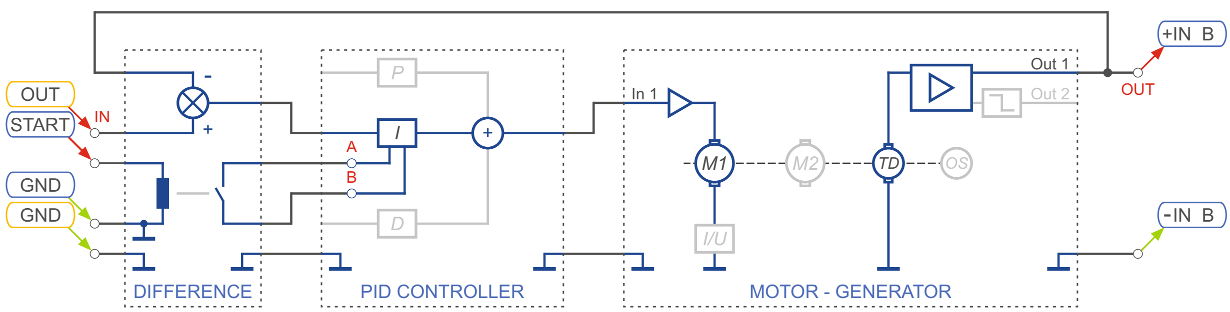
Exercise

Check the function of the I-controller. Measure the transition characteristic of the system with I controller for the resistance values R_i = 20 kΩ; 90 kΩ; 190 kΩ. Compare the waveforms with the characteristics of the system without control.

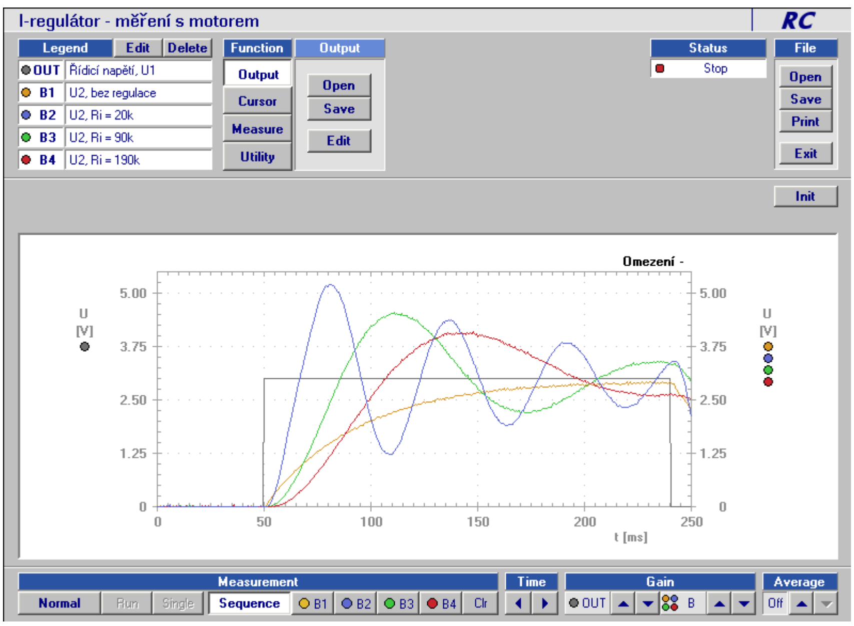
Schema



Circuit



Measurement

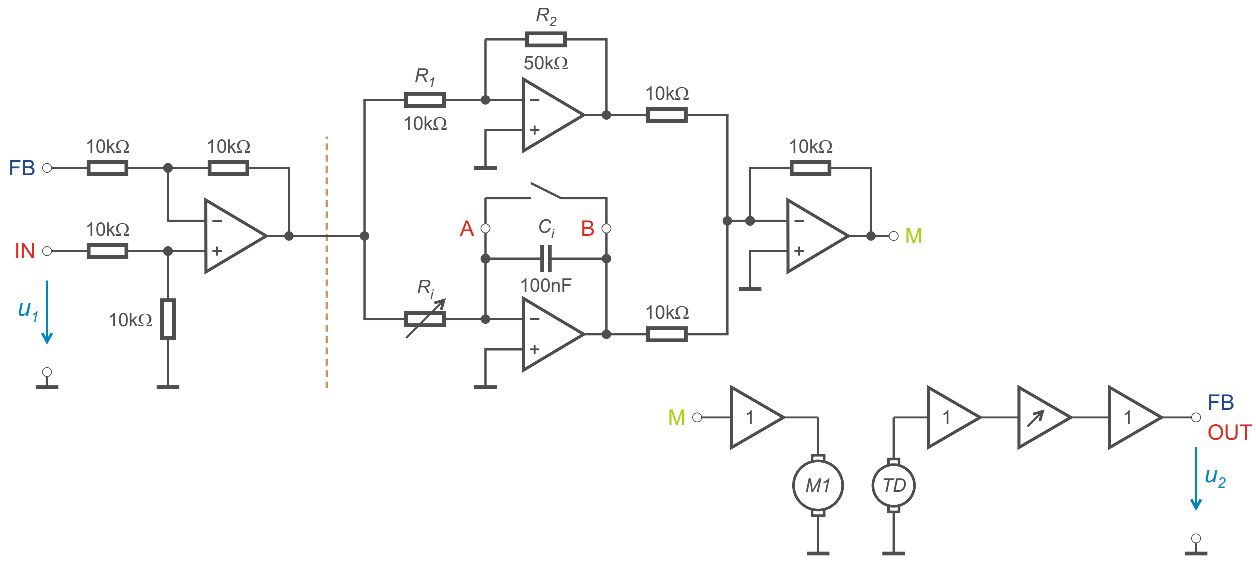


PI-Controller - Measurement with motor

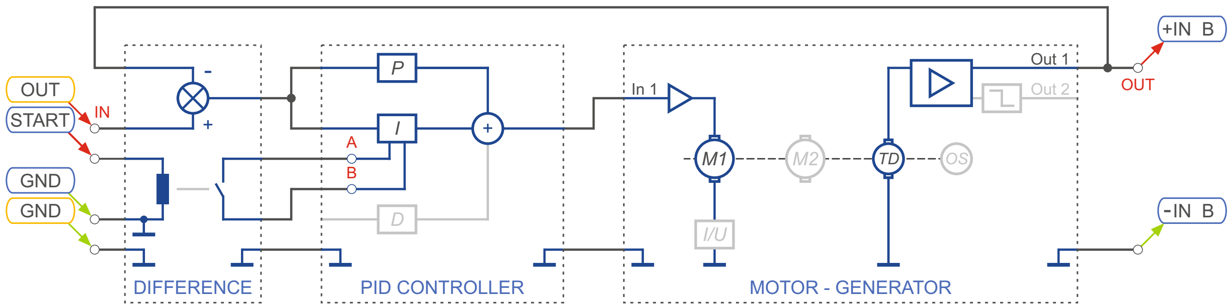
Exercise

Check the function of the PI controller. Measure the transition characteristic of the system in the case of the aperiodic control (R_i = 20 kΩ) and in the case of a control with overshoot (R_i = 90 kΩ). Compare the waveforms with the characteristics of the system without control.

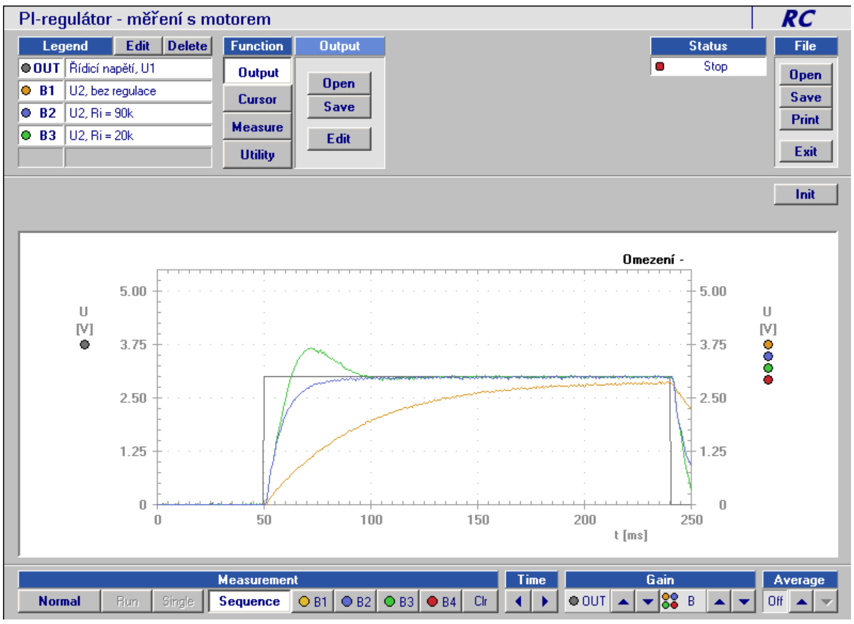
Schema



Circuit



Measurement

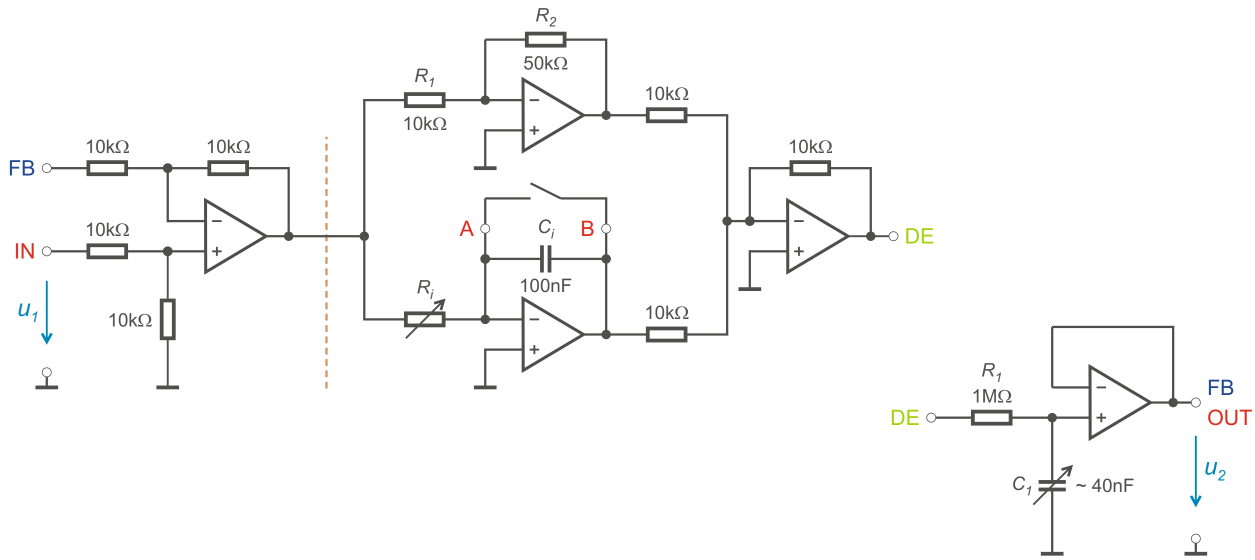


8.8 PI controller - Measurement with delay element

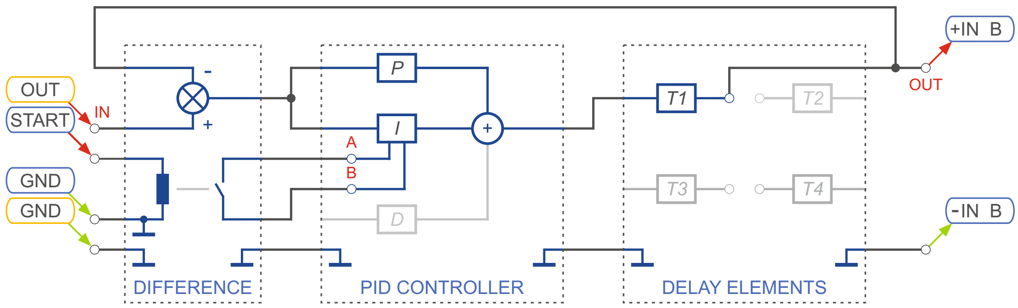
Exercise

Check the function of the PI controller. Measure the transition characteristics of the system during an aperiodic regulation (R_i = 20 kΩ) and during a regulation with overshoot (R_i = 90 kΩ). Compare the curves with characteristics of the system without regulation.

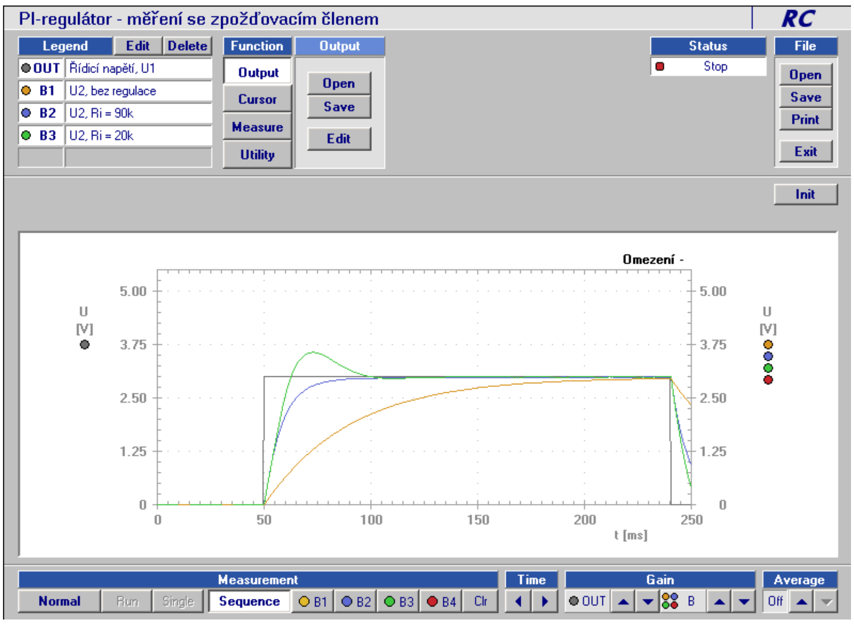
Schema



Circuit



Measurement

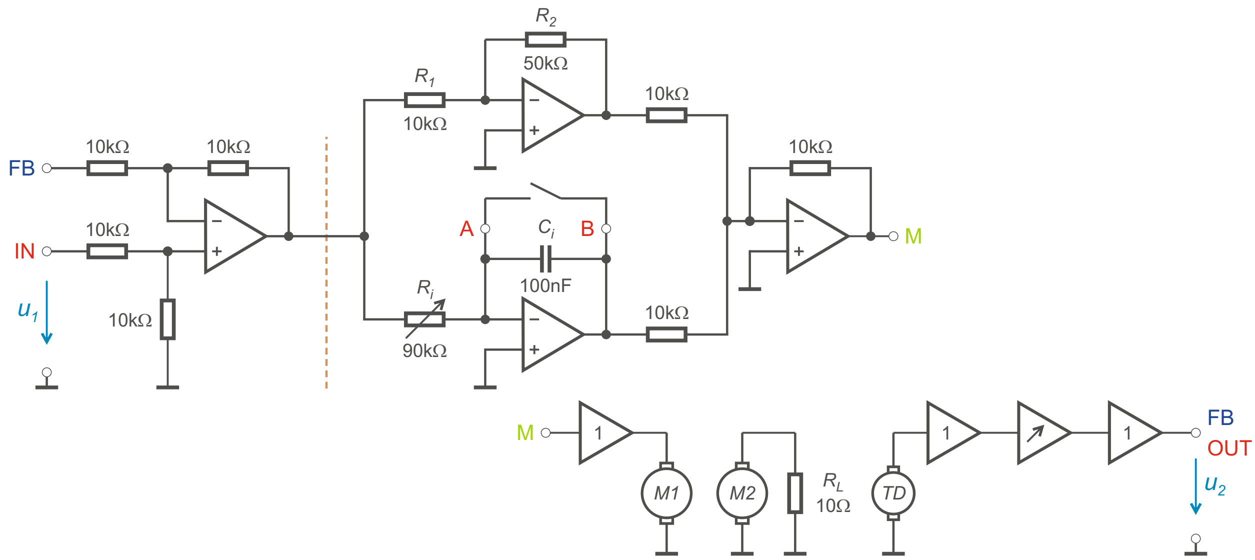


Loaded Motor - without and with PI-Controller

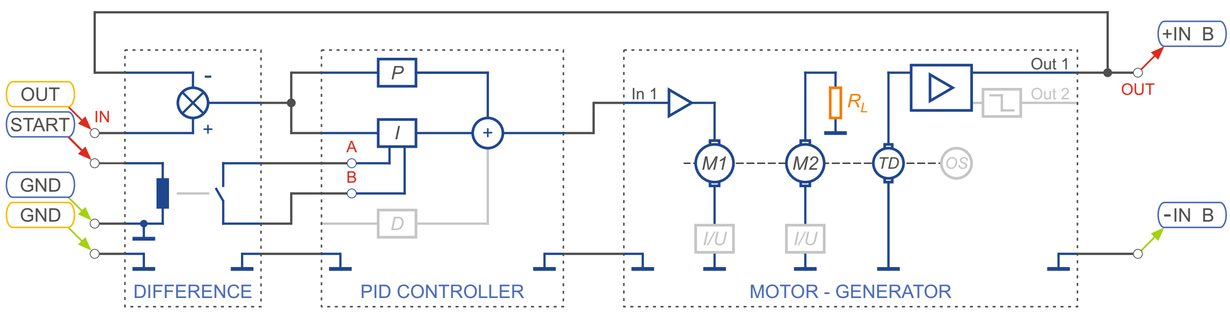
Exercise

Compare the transition characteristics of the unloaded and loaded system without regulation. Then compare the transition characteristic of the unloaded and loaded system with PI regulation.

Schema



Circuit



Measurement