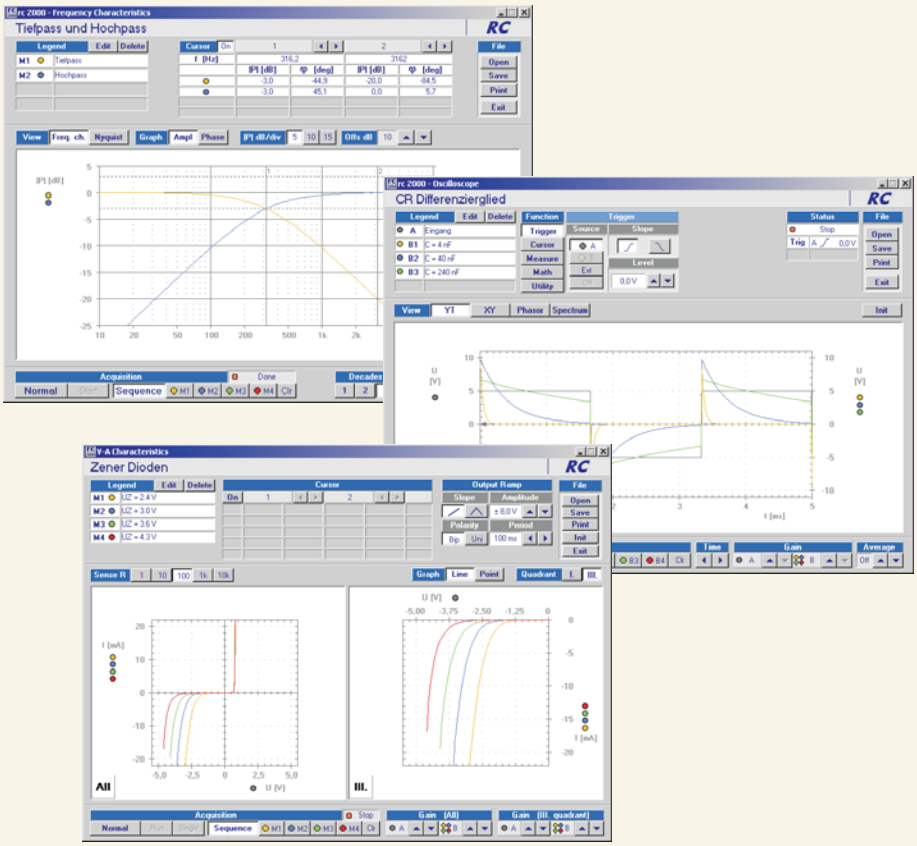
RC DIDACTIC SYSTEMS

System rc2000 - µLAB

Inspiration



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E-mail: info@rcdidactic.cz

Contents

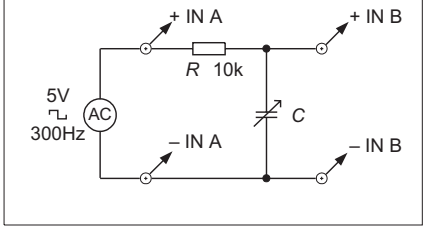
RC Integrator and CR Differentiator

Exercise

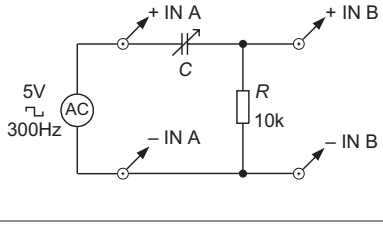
Square waves are applied to the input of the RC circuit (integrator) and the CR circuit (differentiator). Display the output of both circuits at different settings of the time constant.

Schematics

RC Intergrator 1



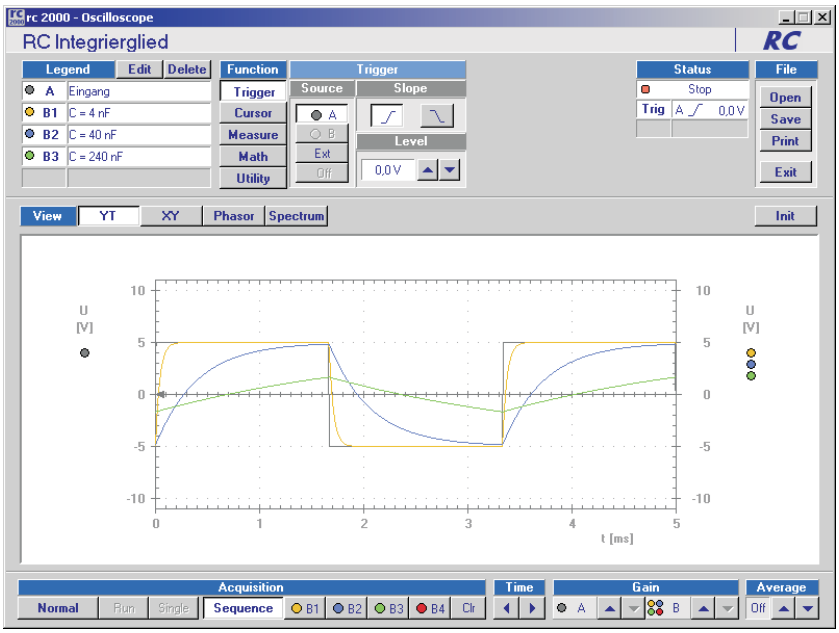
CR Differentiator 2



Time constant:

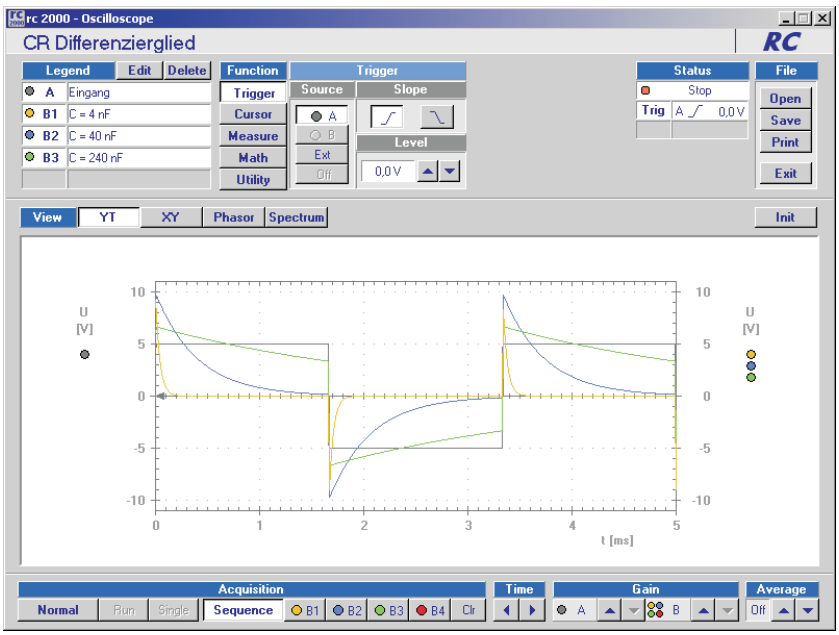
$$\tau = R \cdot C$$

Result



Integrator - Time constant

- τ = 0,04 ms (*C* = 4 nF)
- τ = 0,4 ms (*C* = 40 nF)
- τ = 2,4 ms (*C* = 240 nF)
  Integration



Differentiator - Time constant:

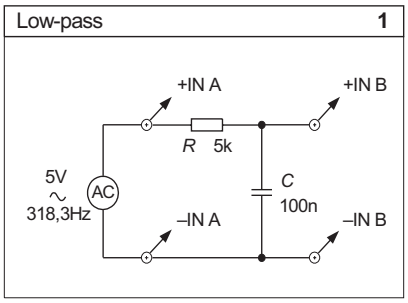
- τ = 0,04 ms (*C* = 4 nF)
  Differentiation
- τ = 0,4 ms (*C* = 40 nF)
- τ = 2,4 ms (*C* = 240 nF)

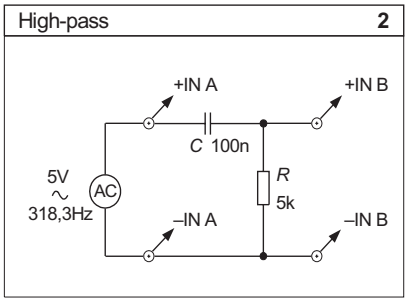
Low- and High-Pass Filter - Time Domain

Exercise

Display the voltage curves and phasors of the low-pass and high-pass filter at an equal cutoff frequency.

Schematics





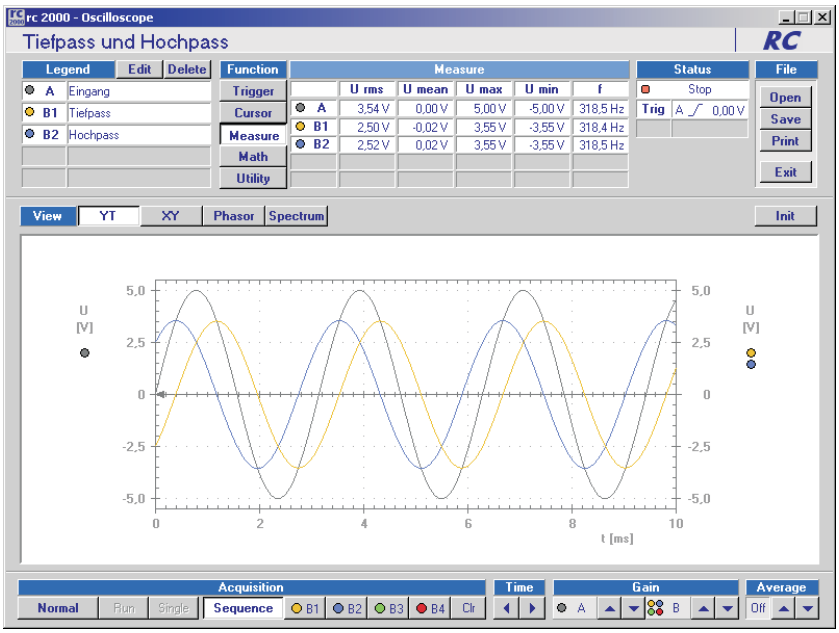
Cutoff frequency (-3dB):

$$f_G = \frac{1}{2\pi RC}$$

Phase shift:

$$\varphi = \pm 45°$$

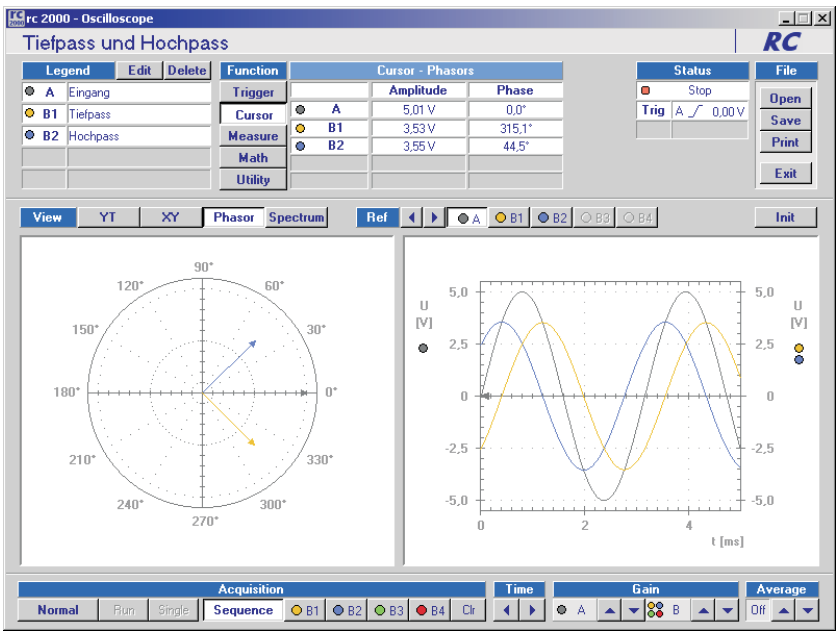
Result



Time curves:

- Low-pass
- High-pass

f_G = 318,3 Hz



Phasor and time diagram:

- Low-pass
- High-pass

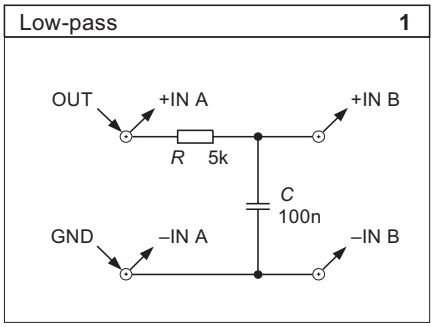
f_G = 318,3 Hz

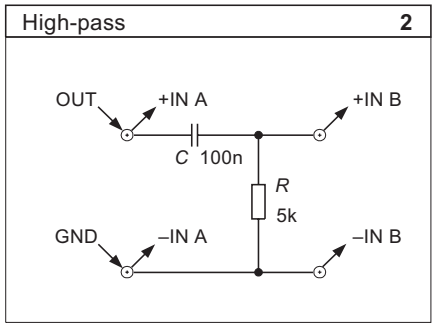
Low- and High-Pass Filter - Frequency Domain

Exercise

Measure the amplitude and phase frequency characteristics at an equal cuttoff frequency.

Schematics





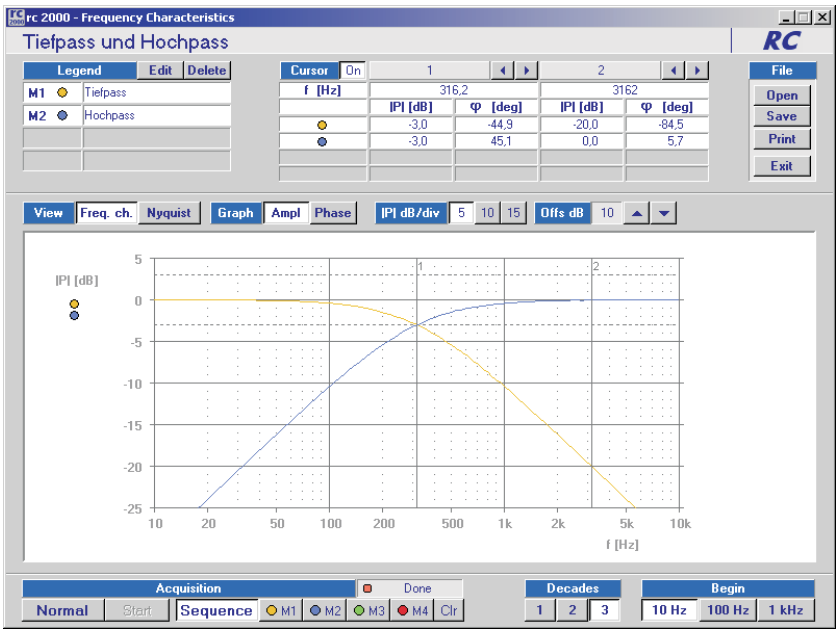
Cutoff frequency (-3dB):

$$f_G = \frac{1}{2\pi RC}$$

Phase shift:

$$\varphi = \pm 45°$$

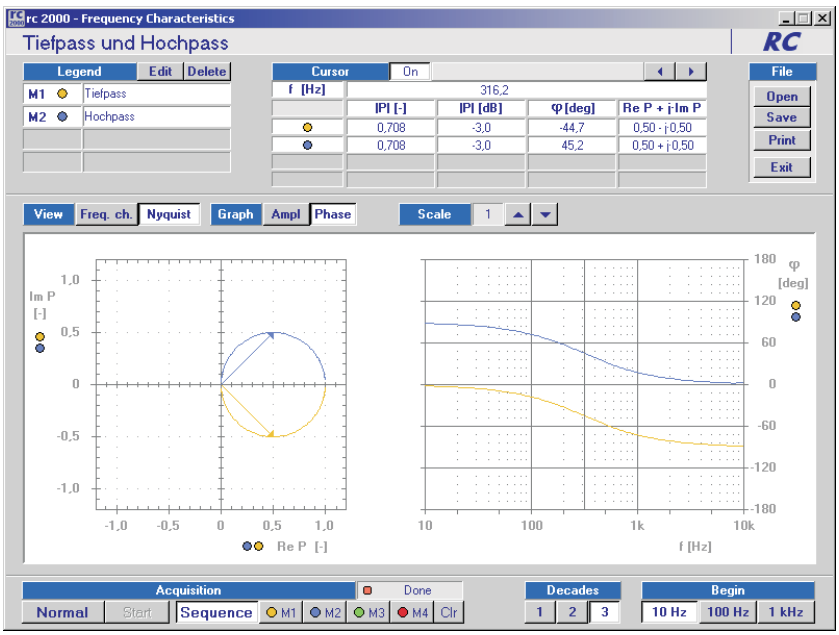
Result



Amplitude characteristics:

- Low-pass
- High-pass

f_G = 318,3 Hz



Nyquist + Freq. characteristics:

- Low-pass
- High-pass

f_G = 318,3 Hz

Series RLC Resonant Circuit

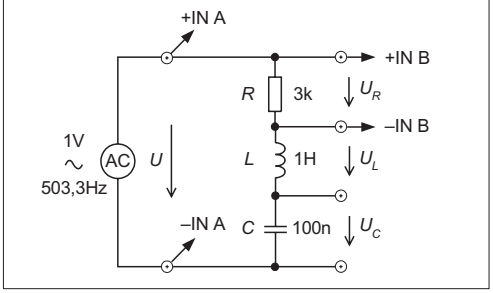
Exercise

Display the voltage curves across the R,L,C of the series circuit for two cases:

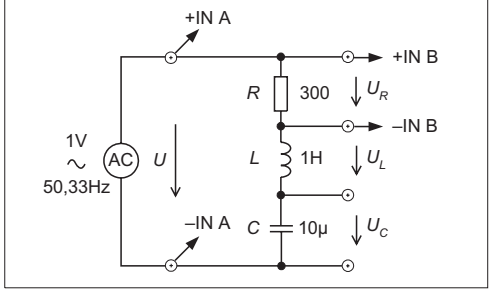
1) C - ideal, L - ideal
2) C - ideal, L - real

Schematics

Series RLC Resonant Circuit- C ideal, L ideal **1**



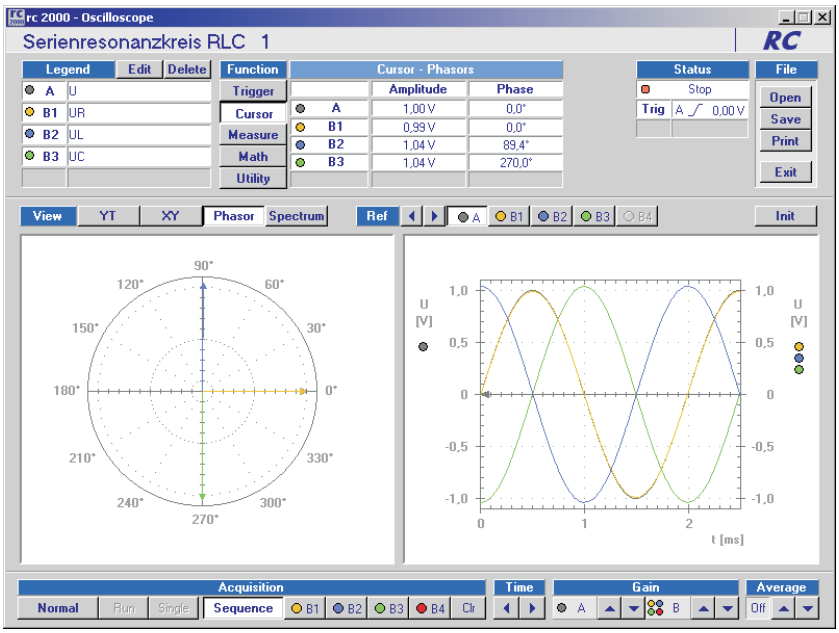
Series RLC Resonant Circuit- C ideal, L real **2**



Resonant frequency:

$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

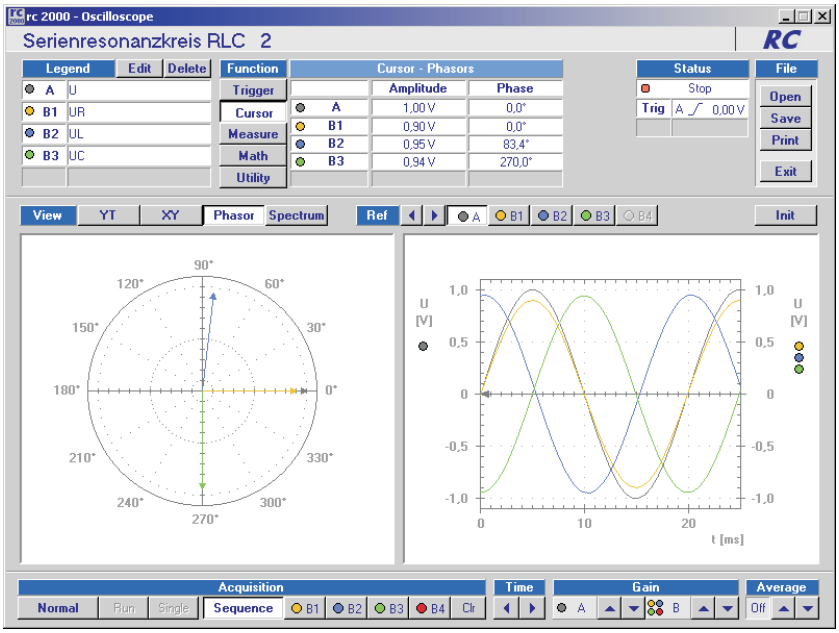
Result



Circuit 1 - C ideal, L ideal:

- U_R
- U_L
- U_C

f_R = 503,3 Hz Q ≅ 90



Circuit 2 - C ideal, L real:

- U_R
- U_L
- U_C

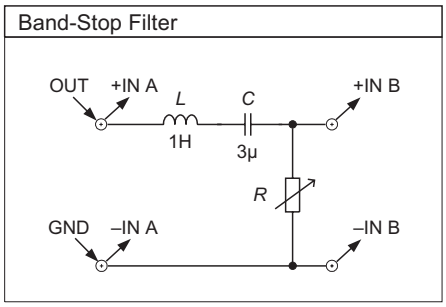
f_R = 50,33 Hz Q ≅ 9

Series RLC Band-Stop Filter

Exercise

Measure the amplitude and phase frequency characteristics of the series band-stop filter at different damping resistors.

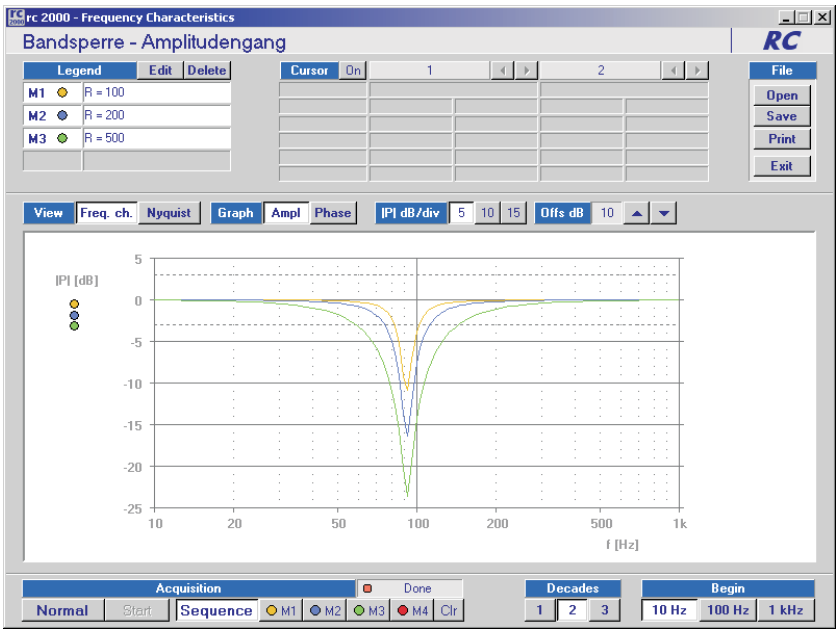
Schematics



Resonant frequency:

$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

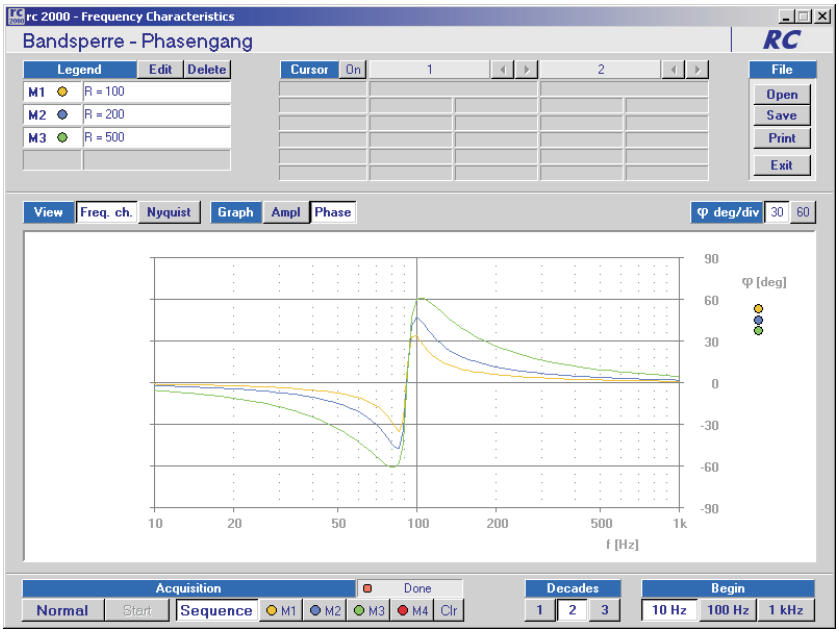
Result



Amplitude characteristics:

- R = 100 Ω
- R = 200 Ω
- R = 500 Ω

f_R = 91,9 Hz



Phase characteristics:

- R = 100 Ω
- R = 200 Ω
- R = 500 Ω

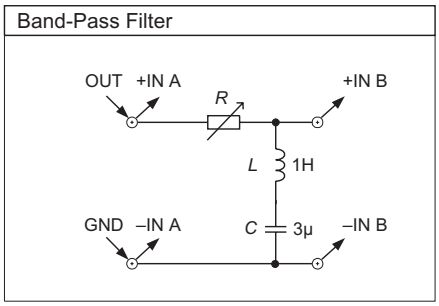
f_R = 91,9 Hz

Series RLC Band-Pass Filter

Exercise

Measure the amplitude and phase frequency characteristics of the series RLC band-pass filter for different damping resistors.

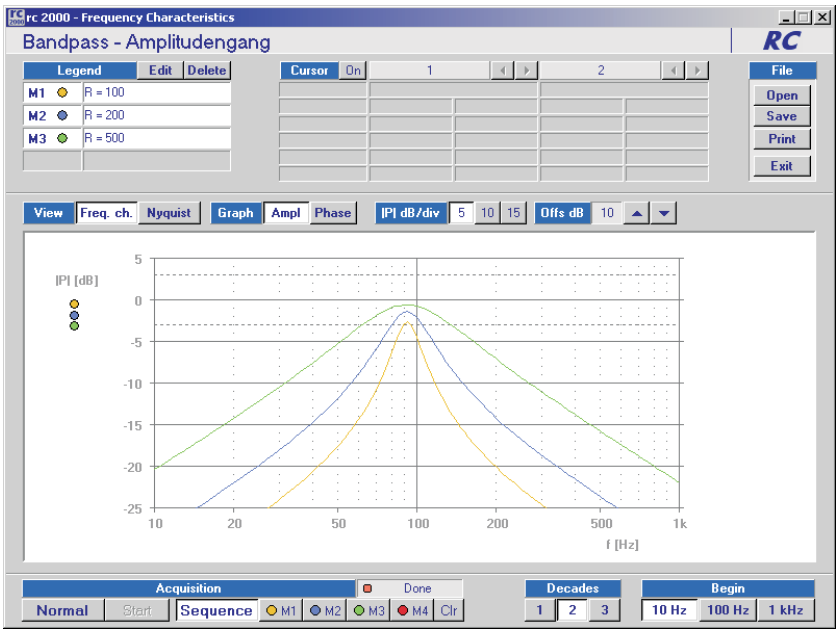
Schematics



Resonant frequency:

$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

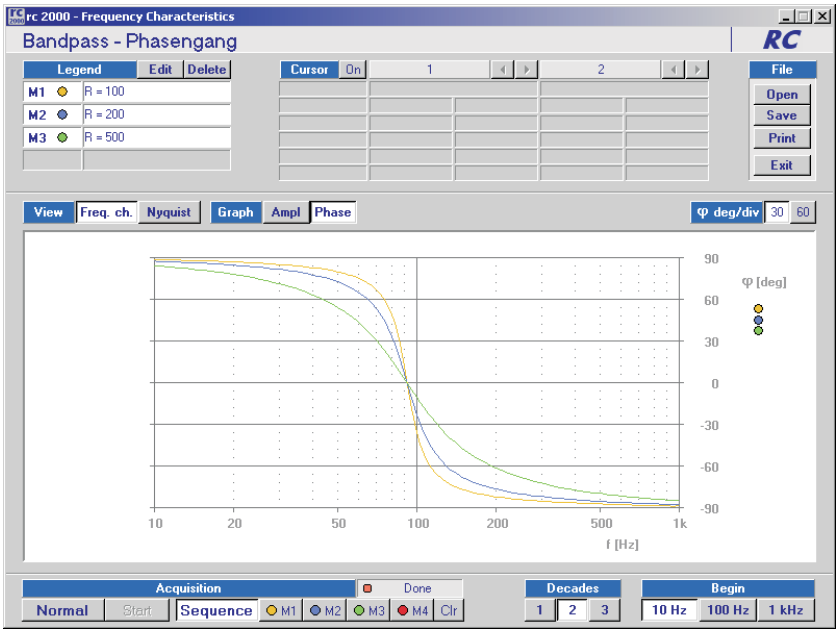
Result



Amplitude characteristics:

- R = 100 Ω
- R = 200 Ω
- R = 500 Ω

f_R = 91,9 Hz



Phase characteristics:

- R = 100 Ω
- R = 200 Ω
- R = 500 Ω

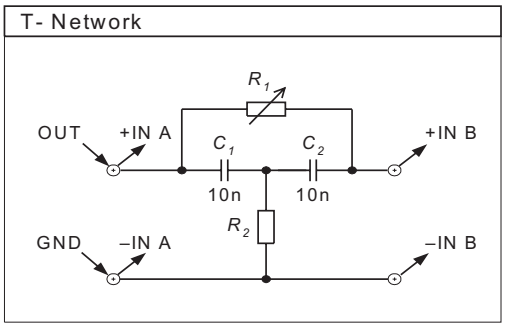
f_R = 91,9 Hz

T - Network

Exercise

Measure the amplitude and phase characteristics of the T-network at different resistor combinations using the equation:

Schematics

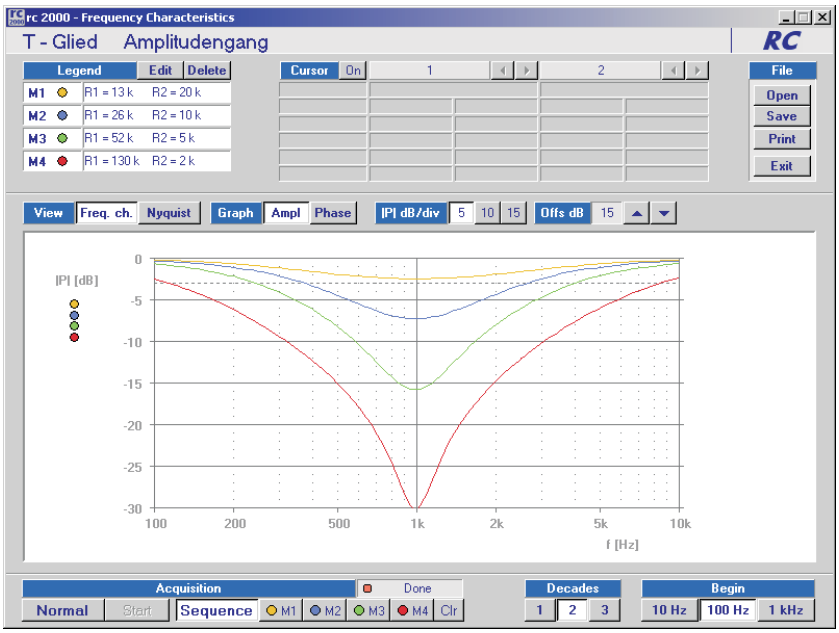


Equation:

$R_1 \cdot R_2 = konst$

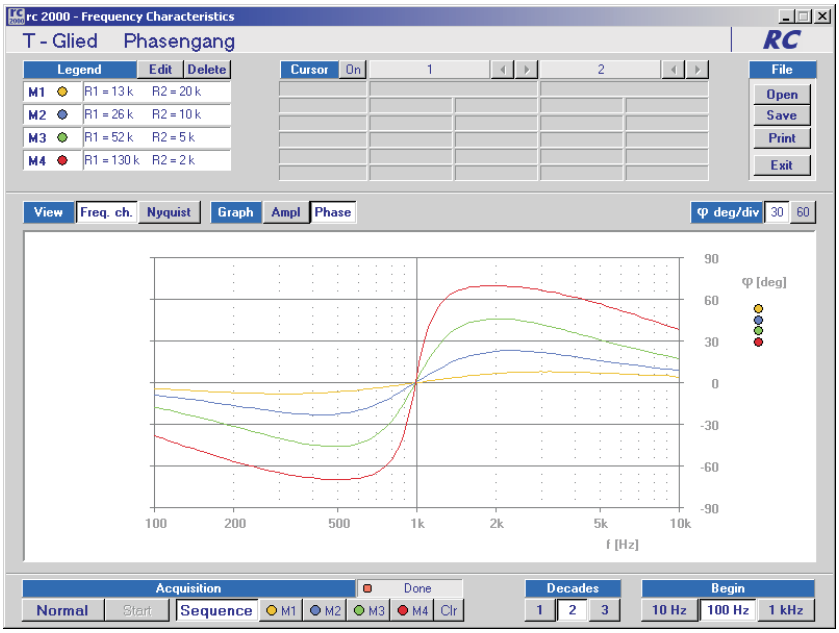
$f_R = konst$

Result



Amplitude characteristics:

- R_1 = 13 kΩ R_2 = 20 kΩ
- R_1 = 26 kΩ R_2 = 10 kΩ
- R_1 = 52 kΩ R_2 = 5 kΩ
- R_1 = 130 kΩ R_2 = 2 kΩ



Phase characteristics:

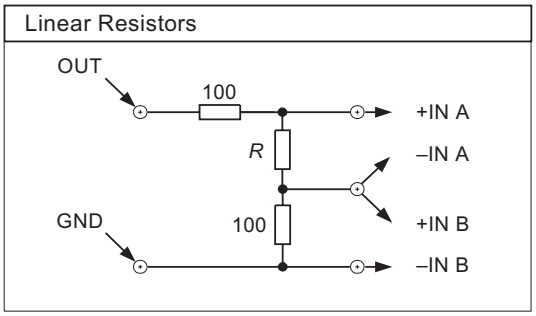
- R_1 = 13 kΩ R_2 = 20 kΩ
- R_1 = 26 kΩ R_2 = 10 kΩ
- R_1 = 52 kΩ R_2 = 5 kΩ
- R_1 = 130 kΩ R_2 = 2 kΩ

Linear Resistors

Exercise

Display the V/A characteristics of different linear resistors.
Using cursors determine the resistor values.

Schematics



Result

Linear Resistors:

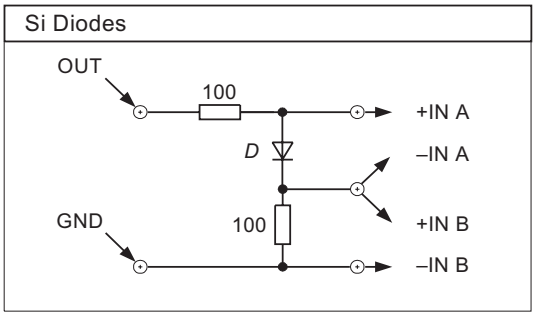
- R = 100 Ω
- R = 200 Ω
- R = 300 Ω

Si Diodes

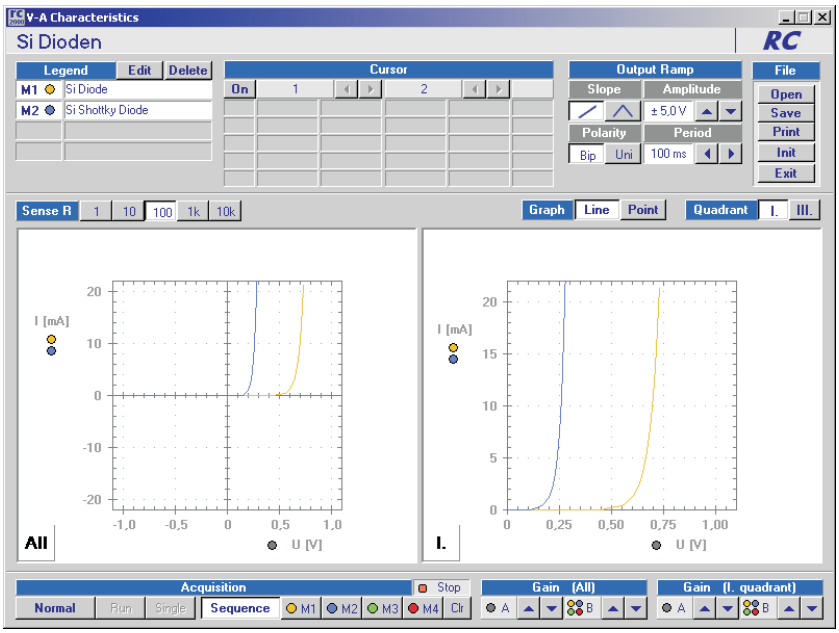
Exercise

Display the V/A characteristics of two diode types ("normal" and Shottky).

Schematics



Result



Si Diodes:

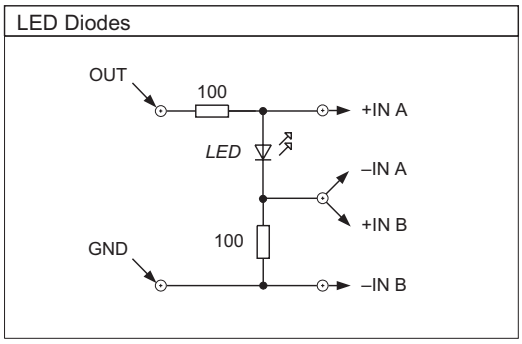
- Si Diode
- Si Shottky Diode

LED Diodes

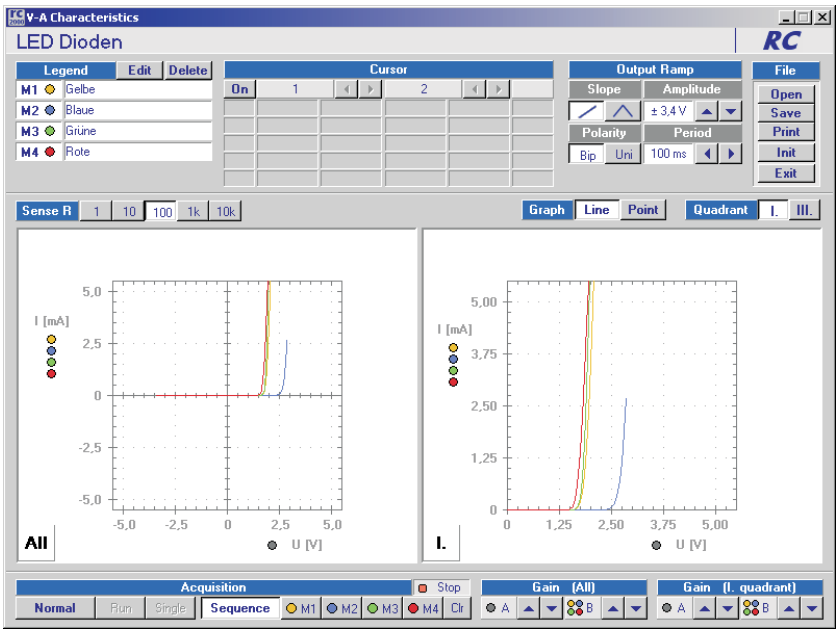
Exercise

Measure the V/A characteristics of the LED diodes (yellow, blue, green, red).

Schematics



Result



LED Diodes:

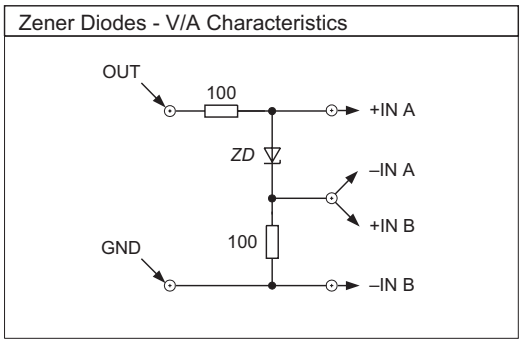
- yellow LED
- blue LED
- green LED
- red LED

Zener Diodes

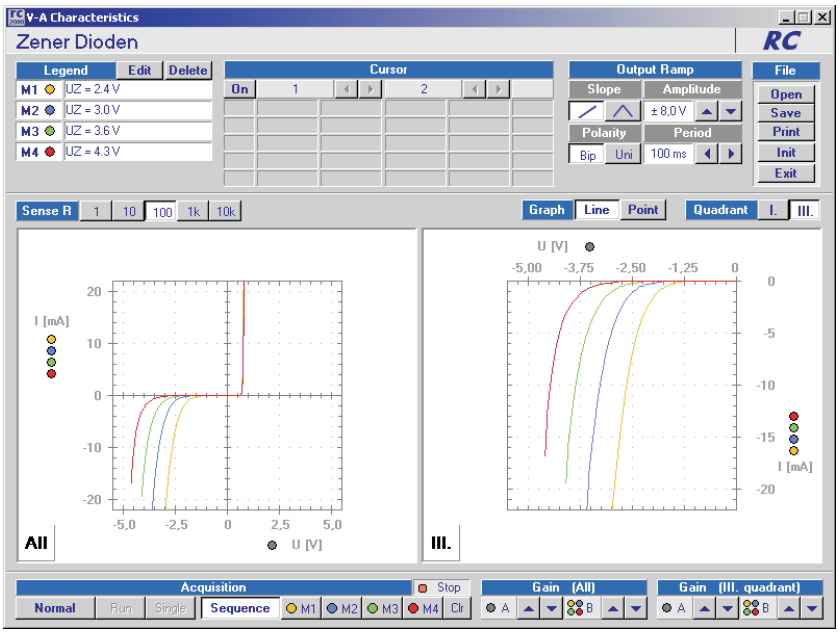
Exercise

Measure the V/A characteristics of the Zener diodes with different Zener voltage U_z.

Schematics



Result



Zener Diodes:

- U_z = 2.4 V
- U_z = 3 V
- U_z = 3.6 V
- U_z = 4.3 V

Diode Limiter

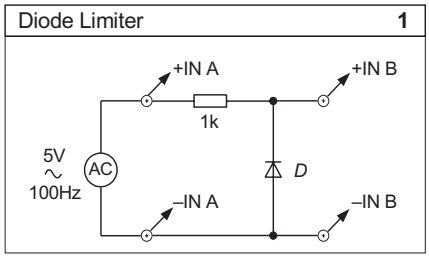
Exercise

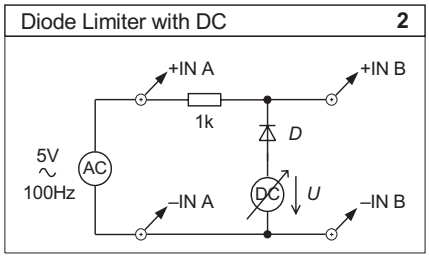
Display the input and output voltage curves of the half-wave diode limiter.

Circuit 1 - limiter without DC

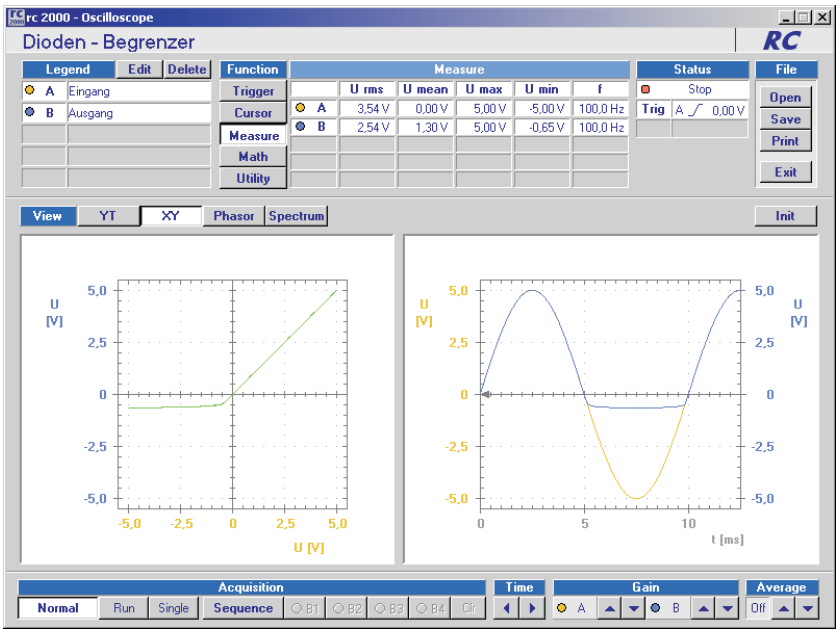
Circuit 2 - limiter with DC

Schematics



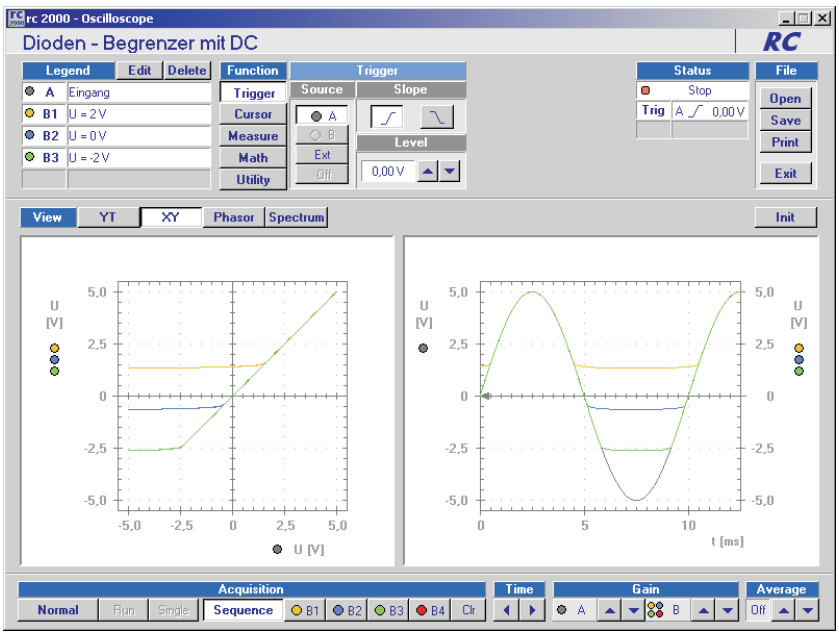


Result



Diode limiter:

- Input
- Output



Diode limiter with DC:

- U = 2 V
- U = 0 V
- U = -2 V

Comparator with Hysteresis

Exercise

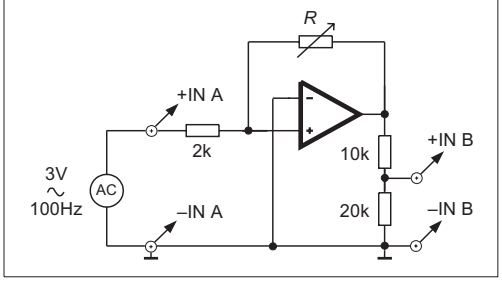
Display the input and output voltege curves of the comparator with hysteresis.

Circuit 1 - Zero level detector

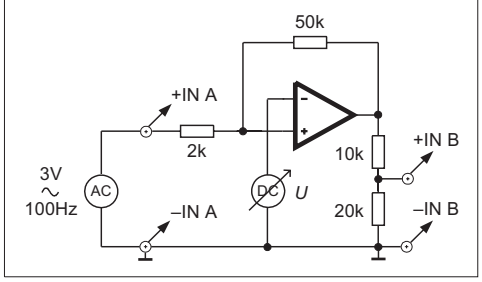
Circuit 2 - Reference level comparator

Schematics

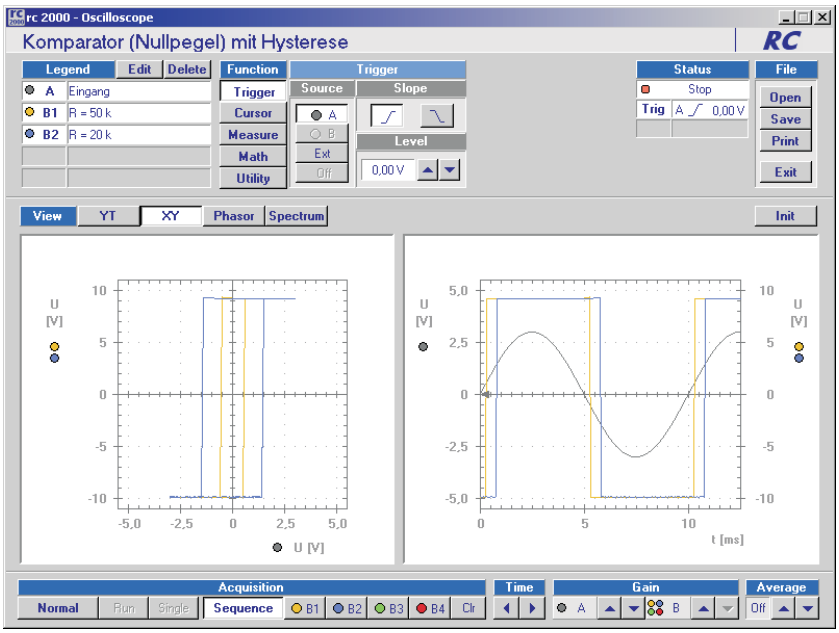
Comparator (Zero level) with Hysteresis 1



Comparator (Ref. level) with Hysteresis 2

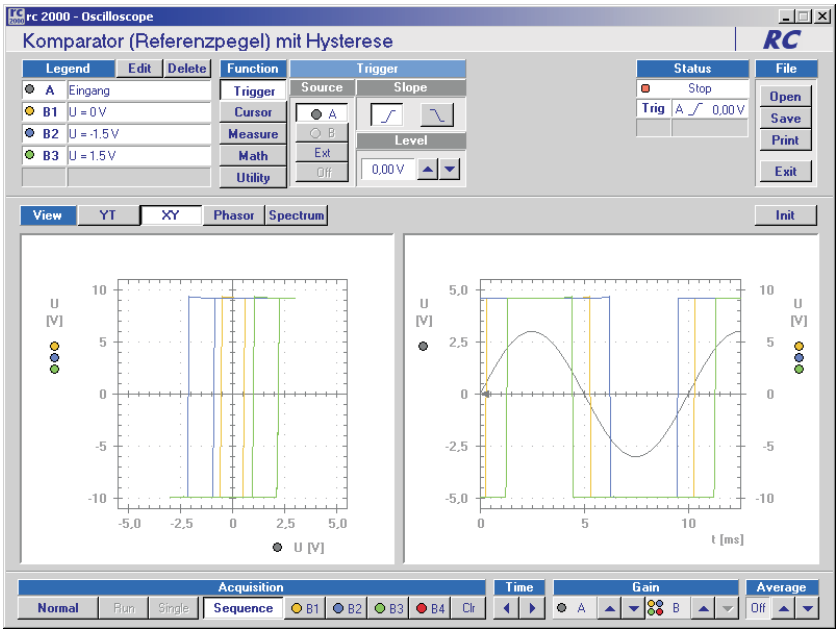


Result



Variable hysteresis:

- R = 50 kΩ
- R = 20 kΩ



Variable reference voltage:

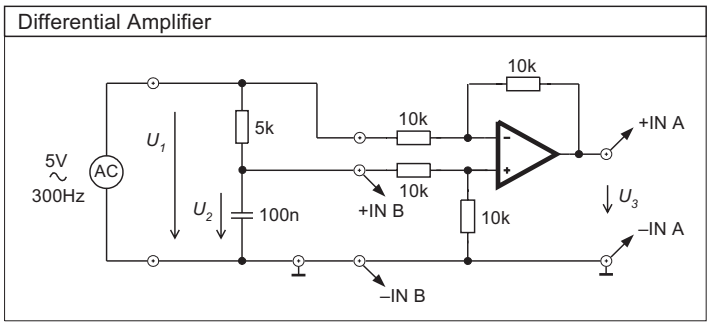
- U = 0 V
- U = -1.5 V
- U = 1.5 V

Differential Amplifier

Exercise

Display the U_1, U_2 and U_3 voltage curves.
Using the cursor prove the validity of the equation:

Schematics

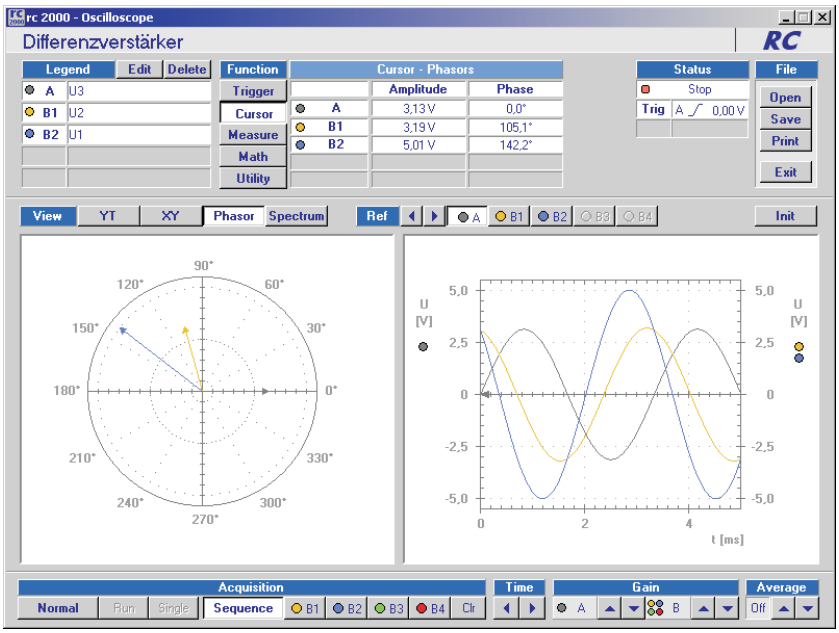


Equation:

$$U_3 = -(U_1 - U_2)$$

$$U_2 = U_3 + U_1$$

Result



Differential amplifier:

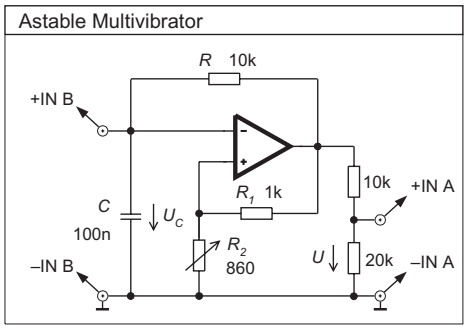
- Output voltage U_3
- Input voltage U_2
- Input voltage U_1

Astable Multivibrator

Exercise

Display the output voltage and voltage across the capacitor *C*.
The output frequency is given by the equation:

Schematics

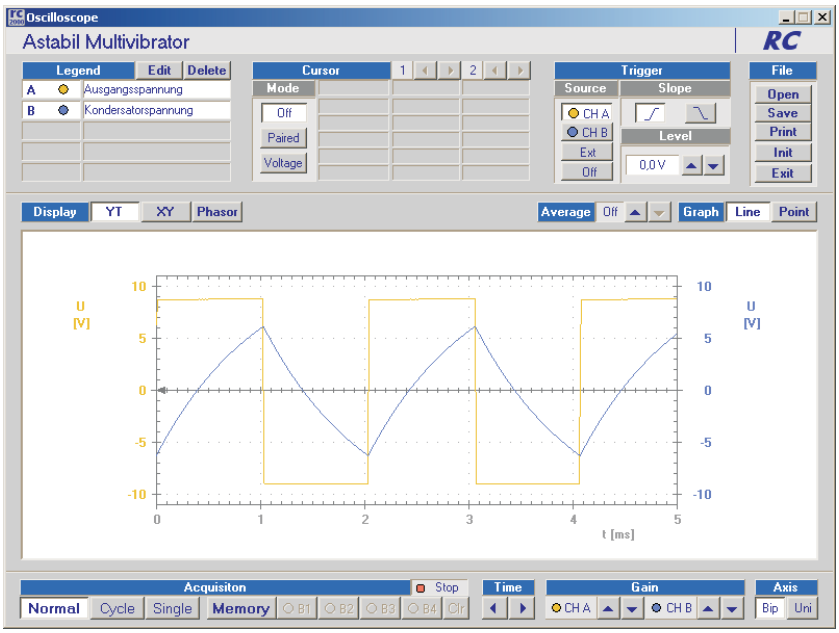


Equation:

$$R_2 = 0{,}86 \cdot R_1$$

$$f \cong \frac{1}{2\,R\,C}$$

Result



Astable multivibrator:

- Output voltage
- Capacitor voltage

$f \cong 500$ Hz

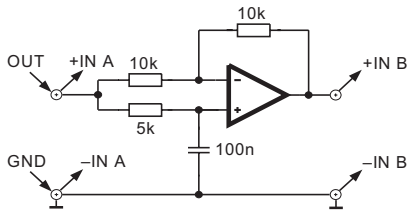
Phase - Shift Circuits

Exercise

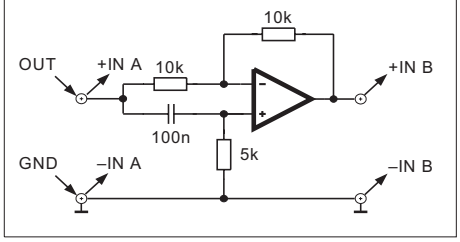
Display the amplitude and phase frequency characteristics for both circuits (all-pass filters).

Schematics

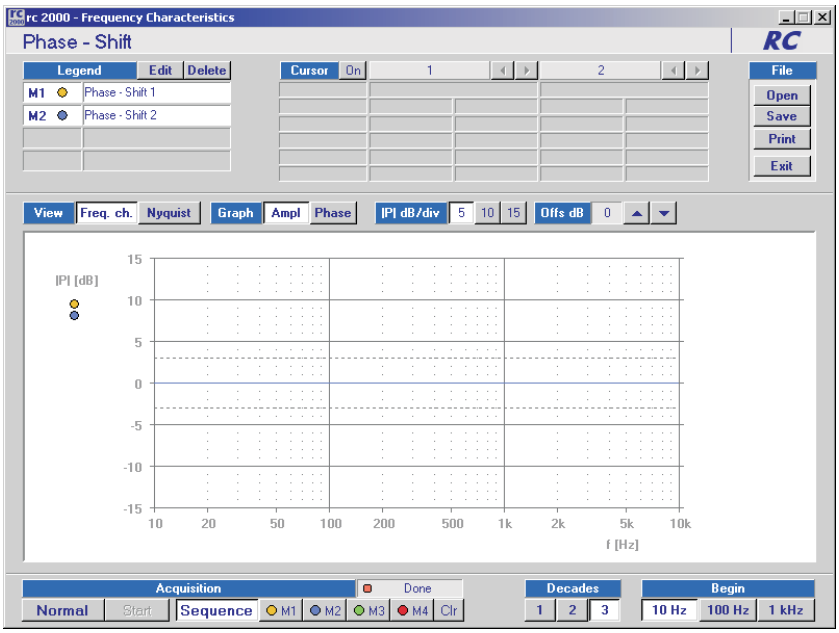
Phase - Shift 1



Phase - Shift 2

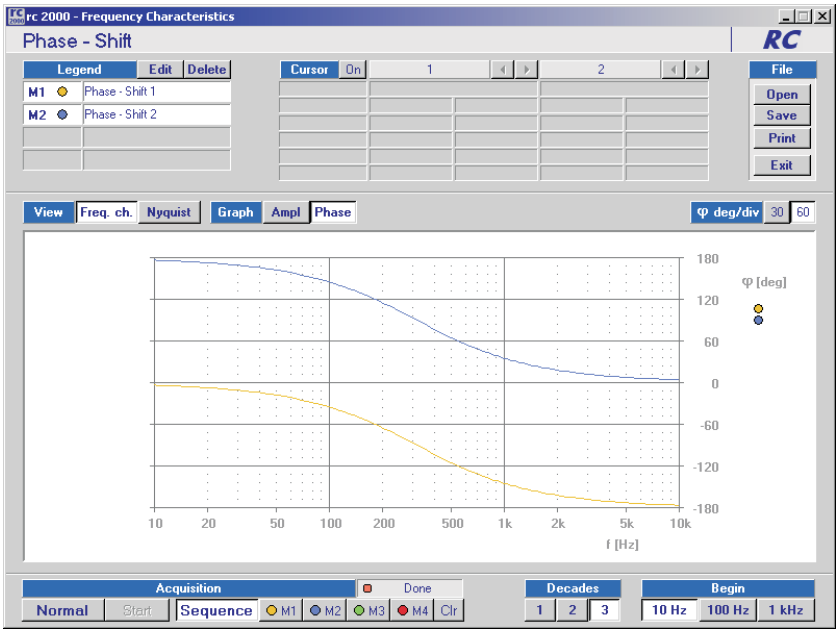


Result



Amplitude characteristics:

- Phase-Shift 1
- Phase-Shift 2



Phase characteristics:

- Phase-Shift 1
- Phase-Shift 2

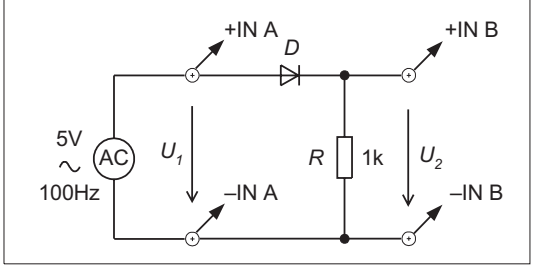
Half-Wave Rectifier

Exercise

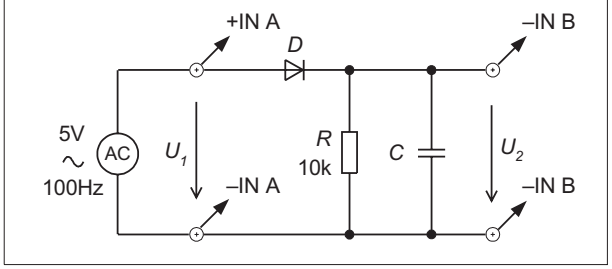
Display the input and output voltage of the half-wave rectifier (schematics 1).
Using schematics 2 display the input and output voltage of the rectifier with a capacitor filter.

Schematics

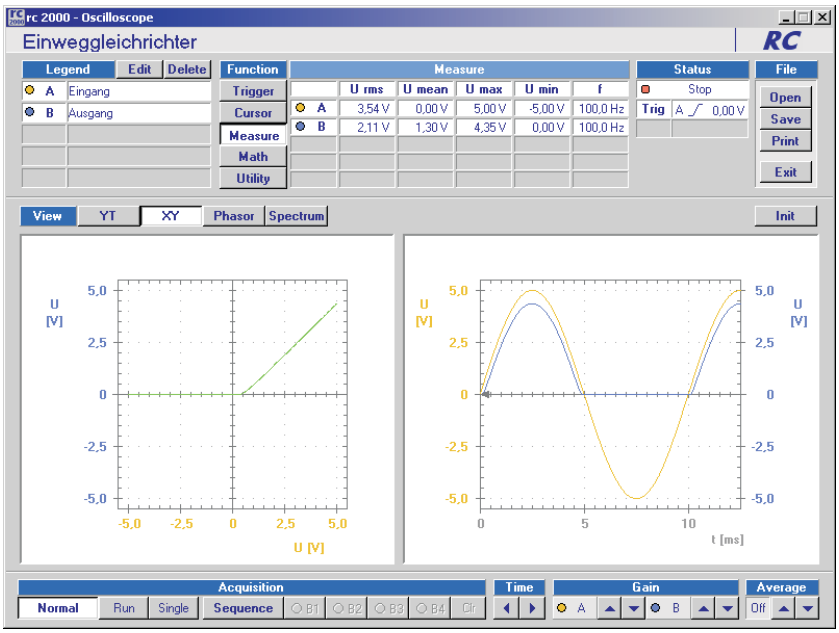
Half-Wave Rectifier 1



Half-Wave Rectifier - C Filter 2

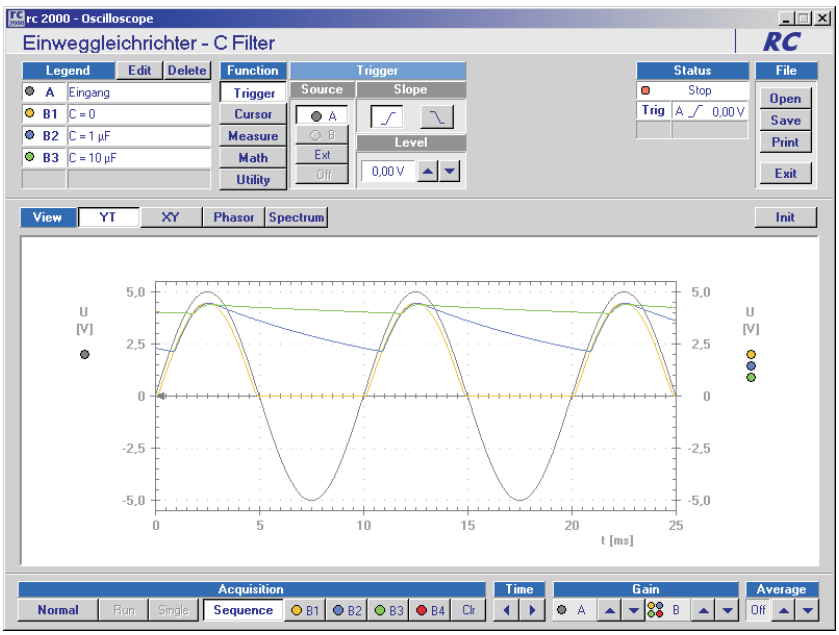


Result



Half-wave rectifier:

- Input
- Output



Filter:

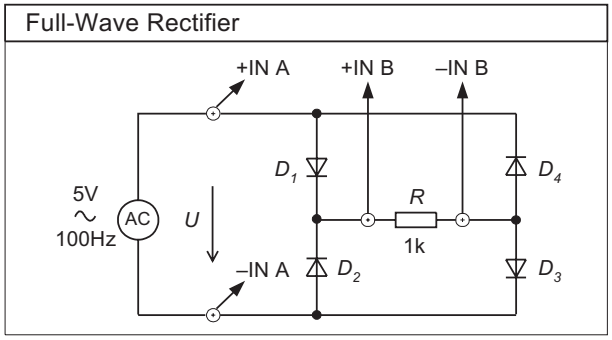
- C = 0
- C = 1 µF
- C = 10 µF

Full-Wave Rectifier

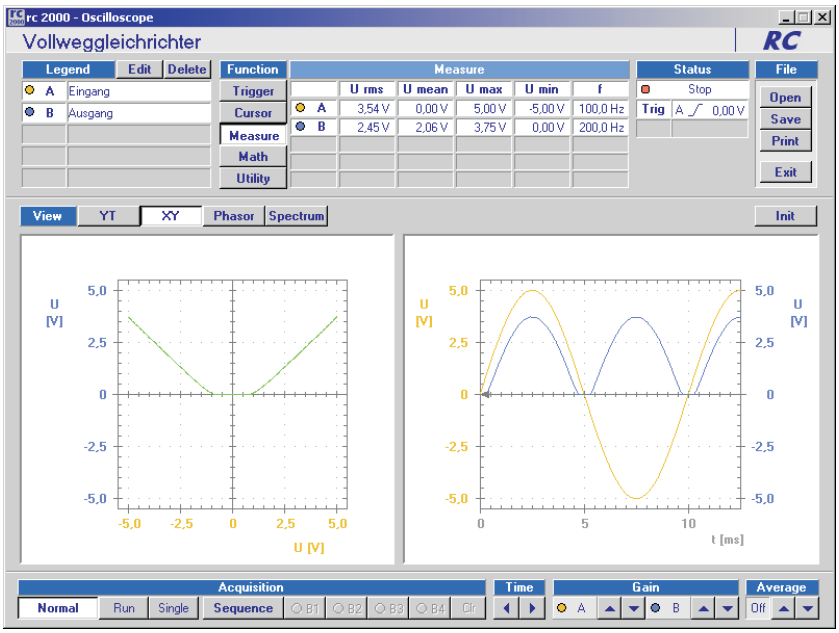
Exercise

Display the input and output voltage curve of the full-wave rectifier.

Schematics

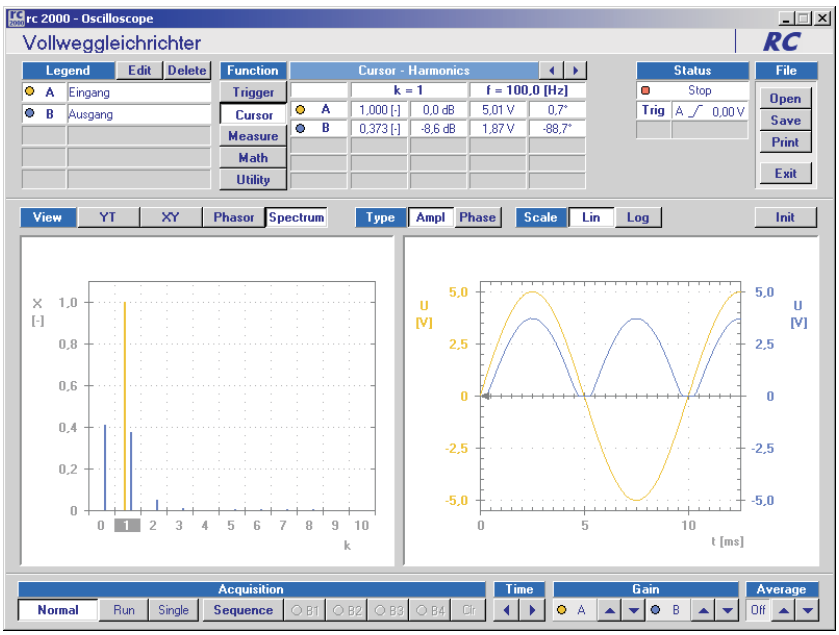


Result



XY Diagram:

- Input
- Output



Spectrum (Harmonics):

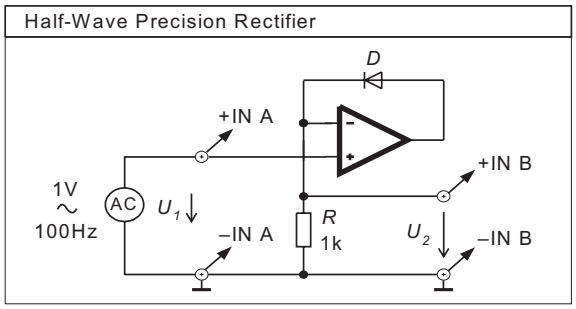
- Input
- Output

Half-Wave Precision Rectifier

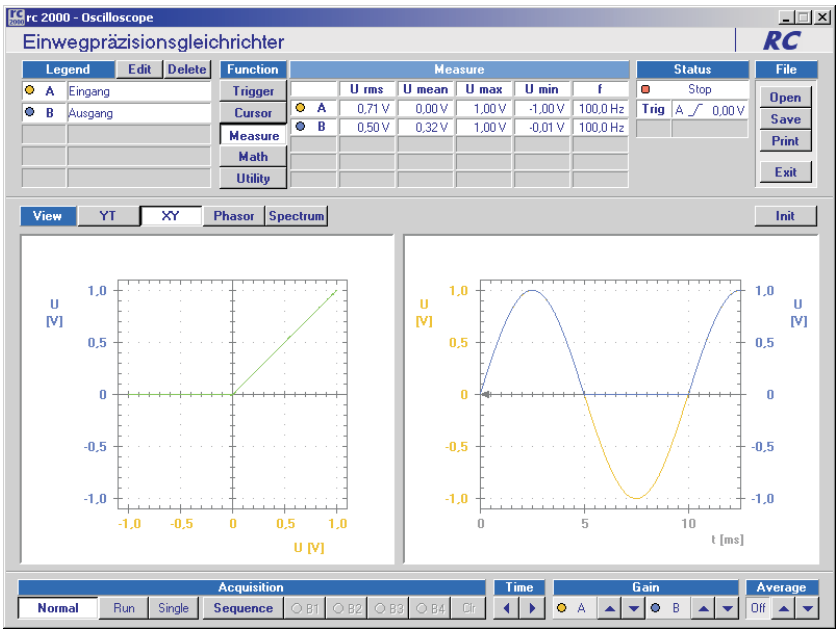
Exercise

Display the input and output voltage of the OPAMP precision half-wave rectifier.

Schematics



Result



Half-wave precision rectifier

- Input
- Output