

DEPARTMENT OF ELECTRONICS AGH UST

LABORATORY  
OF  
**ELECTRONIC ELEMENTS**

**RC CIRCUITS**

REV. 1.0

## 1. THE GOAL OF THE EXERCISE

- practical verification of the theoretical properties of sinusoidal excited RC circuits
- practical verification of the theoretical properties of rectangular wave excited RC circuits

## 2. THE UTILIZED MODELS AND ELEMENTS

During the exercise following components will be used:

- NI ELVIS Prototyping Board (ELVIS) connected with PC,
- Virtual measurement devices:
  - Virtual Instruments (VI):
  - Bode Analyzer (BA),
  - Impedance Analyzer (IA),
  - Digital Multimeter (DMM),
  - Function Generator (FGEN),
  - Oscilloscope (OSC)
- Set of electronic elements listed in Table 1.

Table 1. Values of electronic elements required to perform the exercise

Resistors	2x51 $\Omega$ , 2x2k $\Omega$ , 2x6.8k $\Omega$ , 2x18k $\Omega$ , 2x43k $\Omega$ , 2x91k $\Omega$ , 2x300k $\Omega$ , 2x510k $\Omega$ , 2x1M $\Omega$
Capacitors	2x1nF, 2x22nF, 2x100nF, 2x1 $\mu$ F, 2x2.2 $\mu$ F, 2x10 $\mu$ F

## 3. PREPARING THE DRAFT

3.1. For the series RC two-port network from Fig. 3.1 and values of elements chosen by teacher from Table 1 (for example  $R=510\text{k}\Omega$ ,  $C=1\text{nF}$ ) determine the following values: the real part of the impedance (resistance) and the imaginary part of the impedance (reactance), the impedance  $Z$  and the angle of the phase shift for the frequencies, which fulfill the following relations: a).  $f=1/(2\pi RC)$ , b).  $f=10/(2\pi RC)$ , c).  $f=1/(20\pi RC)$ .

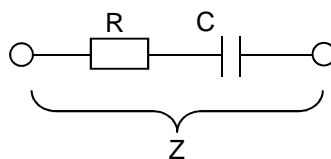


Fig. 3.1. Series RC two-port network.

- 3.2. For the parallel RC two-port network from Fig. 3.2 and values of elements chosen by teacher from Table 1 (for example  $R=510\text{k}\Omega$ ,  $C=1\text{nF}$ ) determine the following values: the real part of the impedance (resistance) and the imaginary part of the impedance (reactance), the impedance  $Z$  and the angle of the phase shift for the frequencies, which fulfill the following relations: a).  $f=1/(2\pi RC)$ , b).  $f=10/(2\pi RC)$ , c).  $f=1/(20\pi RC)$ .

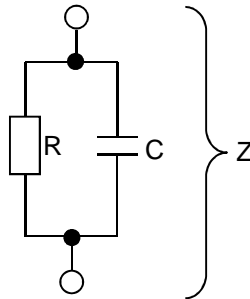


Fig. 3.2. Parallel RC two-port network.

- 3.3. Design and draw the schematic of the passive integrator circuit having time constant chosen by the teacher based on the elements from Table 2 (for example  $\tau=510\mu\text{s}$ ,  $R=510\text{k}\Omega$ ,  $C=1\text{nF}$ ).
- 3.3.1. Estimate a voltage amplitude at the output of the circuit in steady state by applying sinusoidal excitation having amplitude  $U_{p-p}$  ( $0\text{V}\div 5\text{V}$ ) and period  $T$ , which fulfills following relations: a).  $T=2\pi\tau$ , b).  $T=20\pi\tau$ , c).  $T=(1/5)\pi\tau$ .
- 3.3.2. Draw a voltage waveform at the output of the circuit in a steady state by applying rectangular wave excitation having amplitude  $U_{p-p}$  ( $0\text{V}\div 5\text{V}$ ) and period  $T$ , which fulfills following relations: a).  $T=\tau$ , b).  $T=10\tau$ , c).  $T=(1/10)\tau$ . How will the above mentioned waveform look like when the duty cycle of the input voltage is changed from 50% to 80%?
- 3.4. Design and draw the schematic of the basic differentiator having time constant chosen by the teacher based on the elements from Table 2 (for example  $\tau=510\mu\text{s}$ ,  $R=510\text{k}\Omega$ ,  $C=1\text{nF}$ ).
- 3.4.1. Estimate a voltage amplitude at the end of the circuit being in a steady state by applying sinusoidal excitation having amplitude  $U_{p-p}$  ( $0\text{V}\div 5\text{V}$ ) and period  $T$ , which fulfills following relations: a).  $T=2\pi\tau$ , b).  $T=20\pi\tau$ , c).  $T=(1/5)\pi\tau$ .
- 3.4.2. Draw a voltage waveform at the output of the circuit being in a steady state by applying rectangular wave excitation having amplitude  $U_{p-p}$  ( $0\text{V}\div 5\text{V}$ ) and period  $T$ , which fulfills following relations: a).  $T=\tau$ , b).  $T=10\tau$ , c).  $T=(1/10)\tau$ . How will the above mentioned waveform look like when the duty cycle of the input voltage is changed from 50% to 80%?

Table 2. Time constants

Set	A	B	C	D	E	F	G	H	I	J
$\tau$	$510\mu\text{s}$	$2\mu\text{s}$	$18\mu\text{s}$	$5.1\text{ms}$	$20\text{ms}$	$0.946\mu\text{s}$	$200\mu\text{s}$	$2\text{ms}$	$6.8\text{ms}$	$680\mu\text{s}$

3.5. For two chosen schematics from Fig. 3.3 and the values of elements selected from Table 1, draw the waveform of the output voltage in the steady state by applying rectangular wave excitation having amplitude  $U_{p-p}$  (0V÷5V). Chose the period of the input voltage in such a manner, that characteristic (significant) parts of the output waveform will be possible to observe.

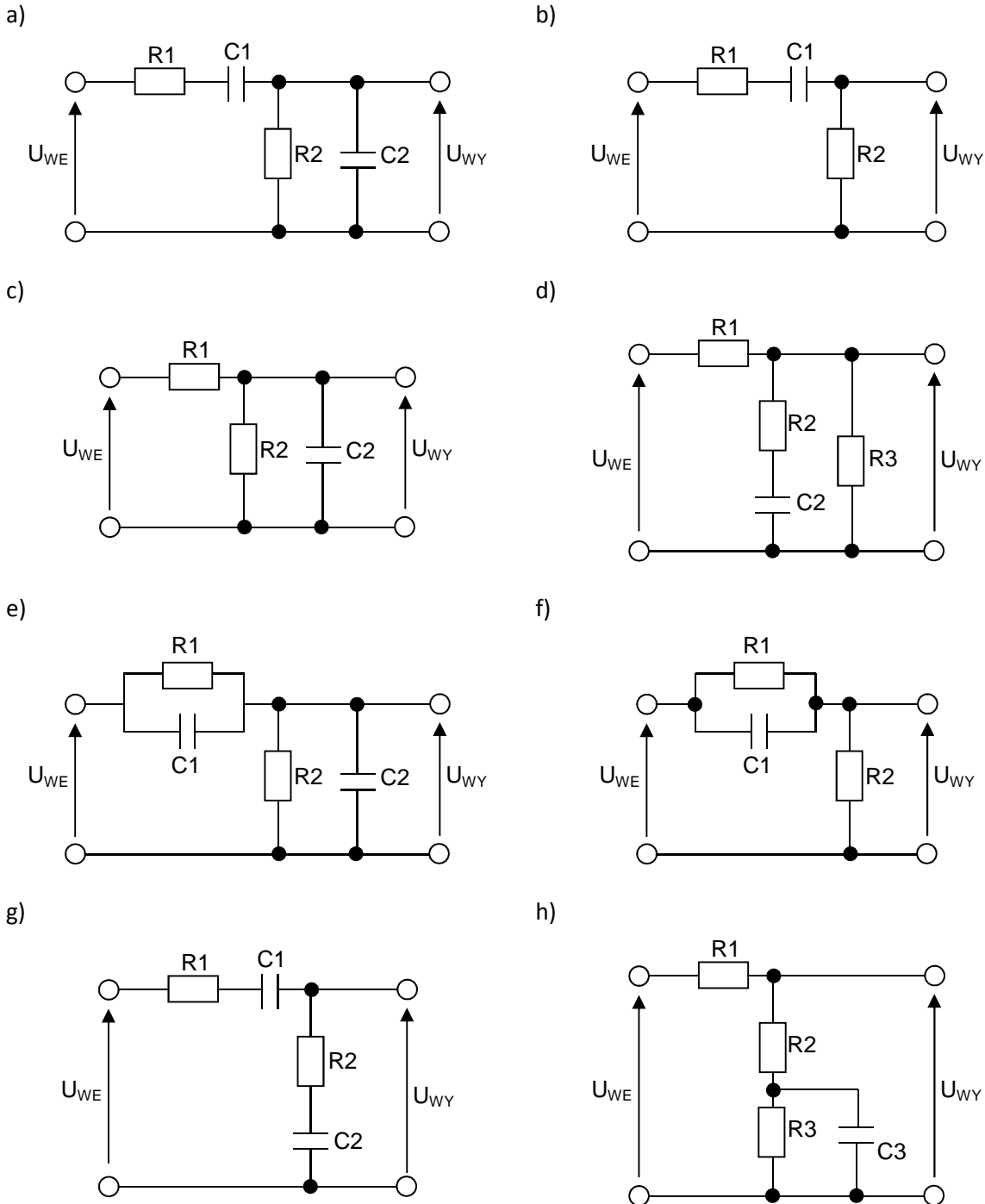


Fig. 3.3. Schematics of RC circuits for investigation by means of front&ridge method.

## 4. THE COURSE OF THE EXERCISE

- 4.1. Verify the experimental results from 3.1 with the use of IA.
- 4.2. Verify the experimental results from 3.2 with the use of IA.
- 4.3. Verify the experimental results from 3.3.1 with the use of FGEN and OSC. Draw frequency characteristic of the two-port network with the use of BA.
- 4.4. Verify the experimental results from 3.3.2 with the use of FGEN and OSC. Keeping the value of time constant  $\tau$ , change the values of R and C in such a manner, that R will be approximately equal to the output impedance of the generator  $50\Omega$  (for example  $R=51\Omega$ ,  $C=10\mu\text{F}$ ). Repeat observations for  $T=\tau$ . Comment the obtained results.
- 4.5. Verify the experimental results from 3.4.1 with the use of FGEN and OSC. Draw frequency characteristic of the two-port network with the use of BA.
- 4.6. Verify the experimental results from 3.4.2 with the use of FGEN and OSC. Keeping the value of time constant  $\tau$ , change the values of R and C in such a manner, that R will be approximately equal to the output impedance of the generator  $50\Omega$  (for example  $R=51\Omega$ ,  $C=10\mu\text{F}$ ). Repeat observations for  $T=\tau$ . Comment the obtained results.
- 4.7. Verify experimentally two chosen circuits from 3.5. Comment the obtained results.

## 5. LITERATURE

[1] Lecture (P. Dziurdzia)

[2] [http://layer.uci.agh.edu.pl/~maglay/wrona/pl/podstrony/dydaktyka/Technika\\_Cyfrowa/RLC\\_LD/RLC\\_NE555\\_teor.pdf](http://layer.uci.agh.edu.pl/~maglay/wrona/pl/podstrony/dydaktyka/Technika_Cyfrowa/RLC_LD/RLC_NE555_teor.pdf)