Billich Stevon

Lucrarea 1
Circuite Liniare RC trece-jos

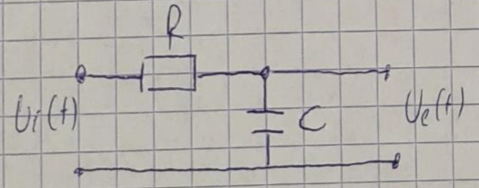
1) Scopul Lucrării: Studiul experimental al semnalelor sinusoidale, rectangulare, exponențiale prin circuite RC-trece-jos

2) Considerații teoretice:
- Semnal sinusoidal aplicat circuit liniar => formă sinusoidală
- Semnal nesinusoidal aplicat circuit liniar => suferă distorsiuni

„Transformarea liniară"

Circuite liniare:
→ circuite cu elem pasive RC, LC, RLC
→ transformatoare de impulsuri
→ linii de întârzieri
etc

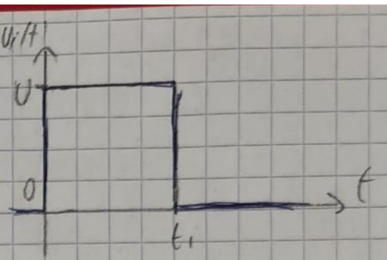
2.1 Circuite RC trece-jos:
→ proprietatea de a avea atenuarea A în funcție de frecvența intrare
→ semnal nesinusoidal → comp. fr. jos apar cu atenuare mai mică decât cele cu fr. înaltă

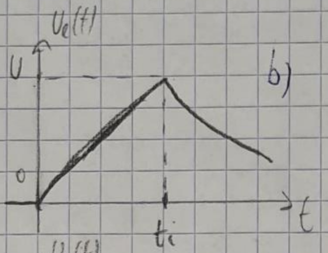


2.1.1 Atenuarea dată de $A(\omega) = \frac{1}{\sqrt{1+(\omega RC)^2}}$ $\quad A = \frac{U_e}{U_i}$ $\quad$ unde

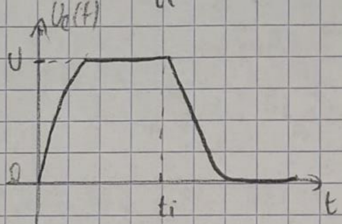
$\varphi(\omega) = -\operatorname{arctg}(\omega RC)$ $\quad \omega = 2\pi f$ $\quad \varphi = \frac{t \cdot 360}{T}$

2.1.2 Semnalul de intrare impuls



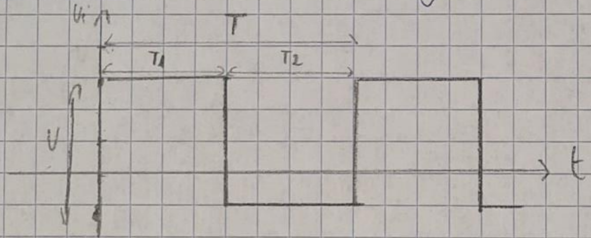


$RC < t_i$

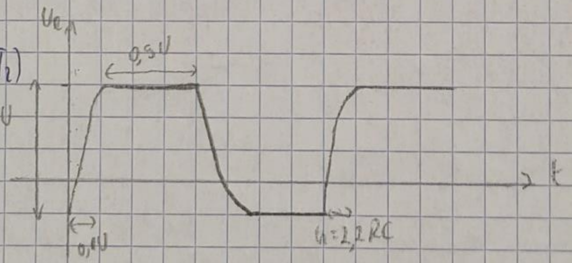


$RC << t_i$

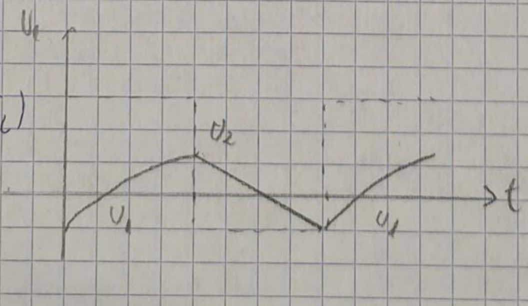
2.1.3 Semnal de intrare rectangular



$RC << \min(T_1, T_2)$



$RC \ll \max(T_1, T_2)$



Dacă timpul de ridicare tr este mai mic decât T_1, T_2 răspunsul său va reproduce aprox forma semnalului de intrare

Pentru $T_1 = T_2 = \frac{T}{2}$

$\Downarrow$

$$U_1 = -\frac{U}{2} * \frac{1-e^{-x}}{1+e^{-x}} \quad //\left(-\frac{U}{2}\right)$$

$$U_2 = \frac{U}{2} * \frac{1-e^{-x}}{1+e^{-x}} \quad //\left(+\frac{U}{2}\right)$$

$$x = \frac{T}{2RC}$$

Circuitele RC trece jos → filtre care permit trecerea semnalelor de frecvența joasă și atenuarea puternică a celor cu frecvență înaltă

Ex) frec. mari ⇒ practic semnal ieșire egal cu 0

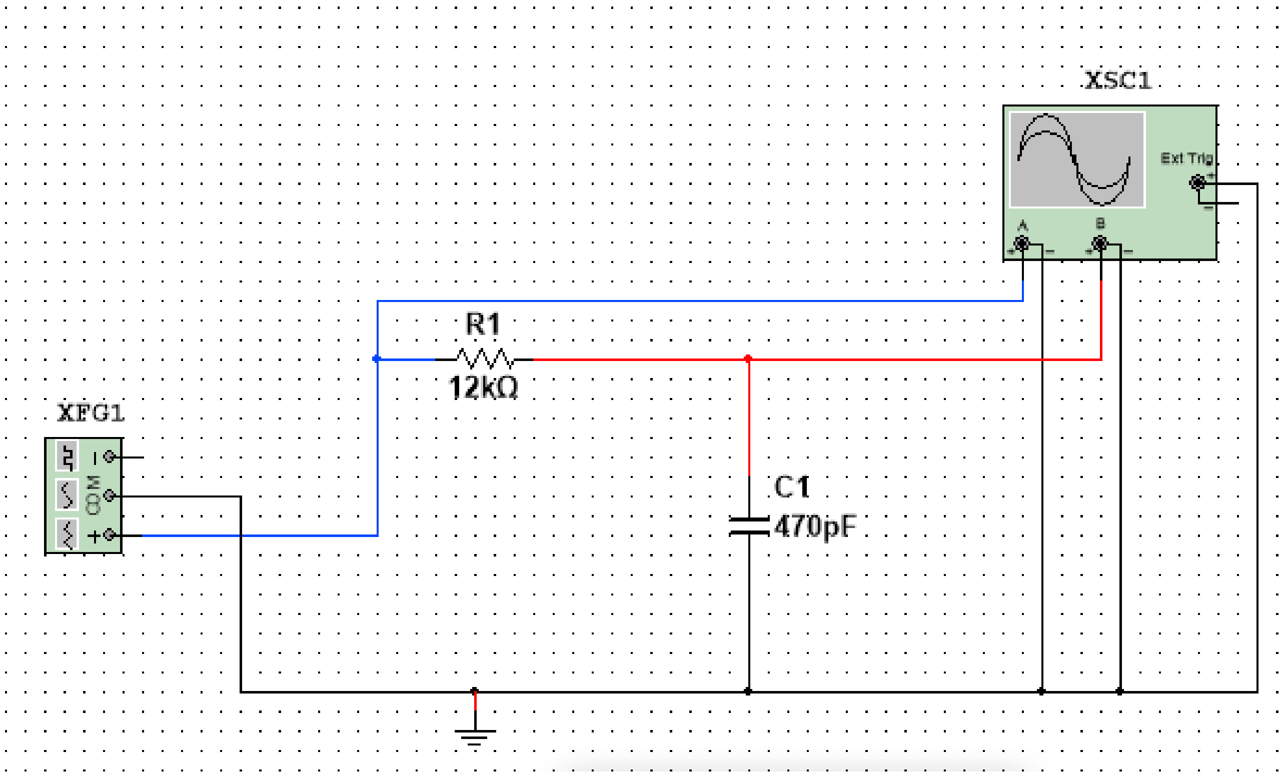
frec. mică ⇒ semnal aproximativ la fel cu cel de intrare

Orice circuit integrat poate poate fi reprezentat practic prin RC trece jos.

Permit analiza comportamentului zgomotelor de pe barele de alimentare și luarea unor măsuri pt ~~ele~~ eliminarea efectelor negative

Aceste zgomote pot influența negativ nivelul "1" logic în sensul apropierii de nivelul logic inferior ⇒ disfuncționalitate

3.Mersul Lucrarii



3.1.1 $R = 12\,k\Omega$ $C = 470\,pF$ amplitudine $= 5V$ $R = 10^3 \cdot 12\,\Omega$ $C = 470 \cdot 10^{-12}\,F$

a) <u>Rezultat teoretic</u>: $\omega = 2\pi f_1 \Rightarrow \omega = 2\pi \cdot 4 \cdot 10^3$

$\omega = 8 \cdot \pi \cdot 10^3\ rad/sec$

$$\Rightarrow A(\omega) = \frac{1}{\sqrt{1+(8\pi \cdot 10^3 \cdot 12 \cdot 10^3 \cdot 470 \cdot 10^{-12})^2}} = \frac{1}{\sqrt{1+(96 \cdot 47 \cdot \pi \cdot 10^{-6})^2}}$$

$$A(\omega) = \frac{1}{\sqrt{1+(0{,}14174866)^2}} \Rightarrow A(\omega) = \frac{1}{\sqrt{1+0{,}021}} = \frac{1}{\sqrt{1{,}021}}$$

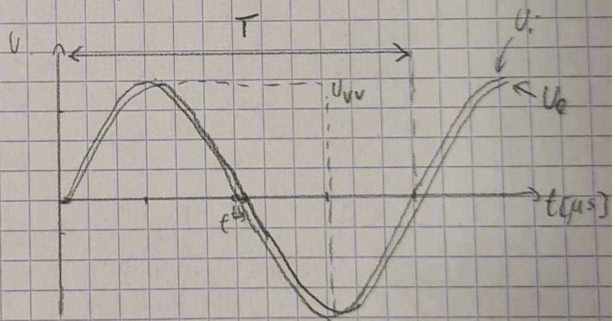
$$\Rightarrow A(\omega) = \frac{1}{1{,}01} \Rightarrow A(\omega) = 0{,}99 \simeq 1$$

$T = \frac{1}{f}$ $\quad \varphi(\omega) = +arctg(\omega RC) \Rightarrow \varphi(\omega) = +arctg(8 \cdot \pi \cdot 10^3 \cdot 12 \cdot 10^3 \cdot 470 \cdot 10^{-12})$

$\varphi(\omega) = +arctg(0{,}14174866)$

$\varphi(\omega) = 8.07^\circ$

<u>Rezultat experimental</u>



$T = 5$ diviziuni $\Rightarrow T = 5 \cdot 50\,\mu s = 250\,\mu s$

sau $T = 374 - 124 = 250\,\mu s$ (folosind indicii)

iar $f = \frac{1}{T} = \frac{1}{250 \cdot 10^{-6}} = 4000\,Hz = 4\,kHz$

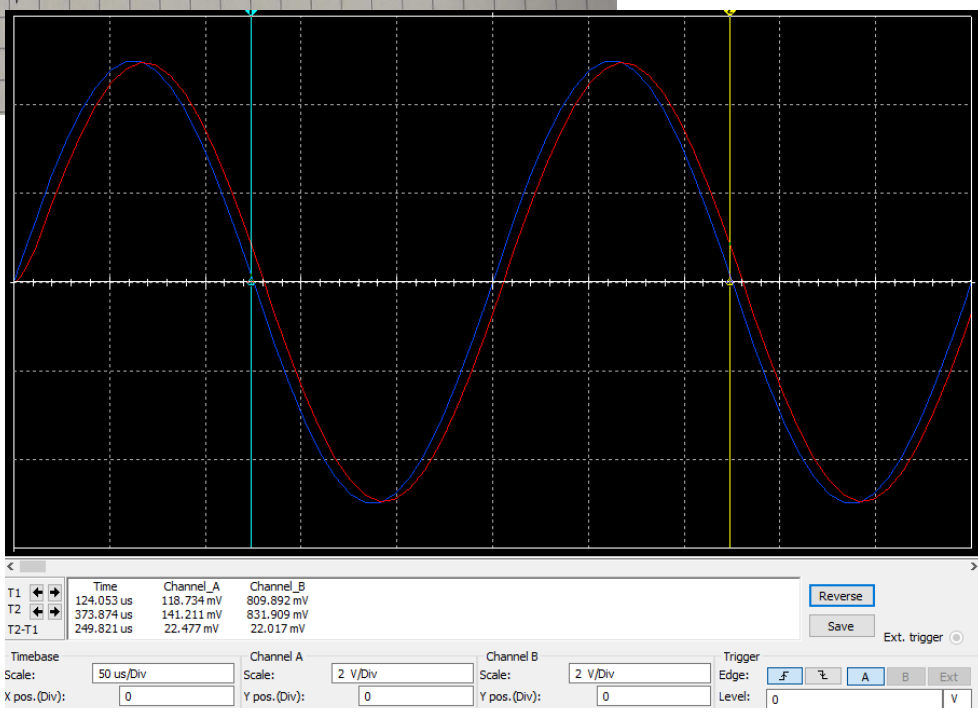
$U_{ivv} = 0{,}5\,div + 4\,div + 0{,}5\,div \Rightarrow U_{ivv} = 5 \cdot 2 = 10\,V$

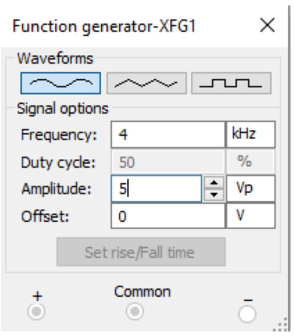
$U_{evv} = 0{,}5\,div + 4\,div + 0{,}5\,div \Rightarrow U_{evv} = 5 \cdot 2 = 10\,V$

$\Rightarrow A = \frac{U_e}{U_i} = \frac{10}{10} = 1$

$t = 0{,}15\,div = 0{,}15 \cdot 50\,\mu s = 7{,}5\,\mu s$

$$\Rightarrow \varphi = \frac{7{,}5\,\mu s \cdot 360}{250\,\mu s} \simeq 10{,}7^\circ$$





b) $f_2 = 4\cdot10^4\,Hz = 40\,kHz$

Rezultat teoretic: $\omega = 2\pi f_2 \Rightarrow \omega = 2\cdot\pi\cdot40\cdot10^3$

$\omega = 80\cdot\pi\cdot10^3$ rad/sec

$$A(\omega) = \frac{1}{\sqrt{1+(\omega RC)^2}} \Rightarrow A(\omega) = \frac{1}{\sqrt{1+(80\cdot\pi\cdot10^3\cdot12\cdot10^3\cdot470\cdot10^{-12})^2}} = \frac{1}{\sqrt{1+(960\,\pi\cdot10^{-6}\cdot470)}}$$

$$A(\omega) = \frac{1}{\sqrt{1+(1,4174)^2}} =$$

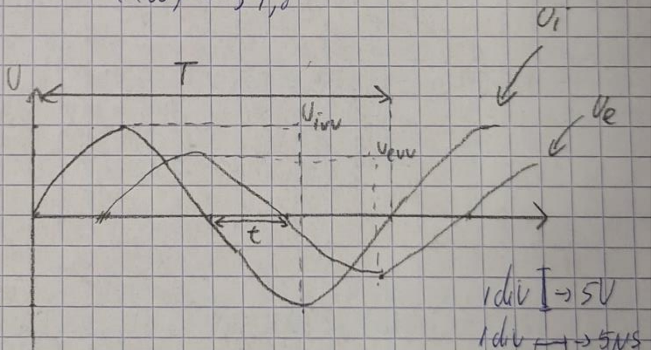
$$A(\omega) = \frac{1}{\sqrt{1+2,009}} = \frac{1}{1,734} \Rightarrow A(\omega) = 0,578$$

$$\Rightarrow \varphi(\omega) = arctg(\omega RC) \Rightarrow \varphi(\omega) = arctg(80\cdot\pi\cdot10^3\cdot12\cdot10^3\cdot470\cdot10^{-12})$$

$$\varphi(\omega) = arctg(1,4174)$$

$$\varphi(\omega) = 54,8^\circ$$

Rezultat experimental



$T = 5div \Rightarrow T = 5\cdot5\mu s = 25\mu s$

far $f = \frac{1}{T} = \frac{1}{25\cdot10^{-6}} = 40000Hz = 40kHz$

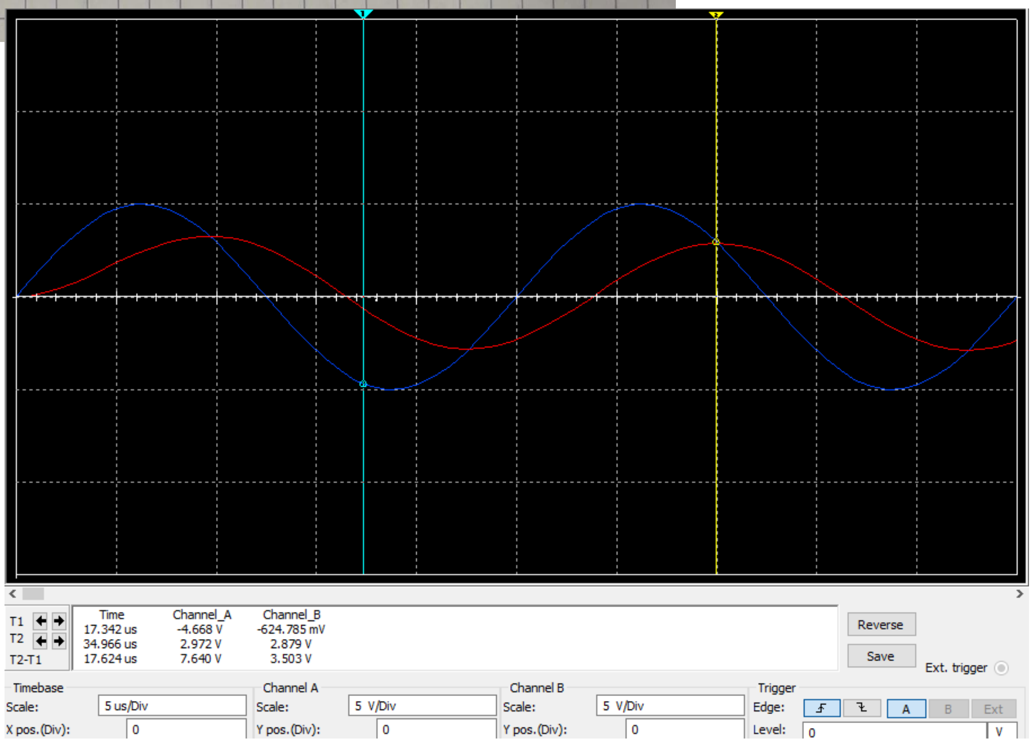
$U_{ivv} = 1div + 1div = 2div = 2\cdot5V \Rightarrow U_{ivv} = 10V$

$U_{evv} = 0,6div + 0,6div = 1,2div \Rightarrow U_{evv} = 1,2\cdot5V = 6V$

$\Rightarrow A = \frac{U_e}{U_i} = \frac{6}{10} = 0,6$

$t = 0,8div \Rightarrow t = 0,8\cdot5\mu s \Rightarrow t = 4\mu s$

$$\varphi = \frac{4\mu s\cdot360}{25\mu s} \Rightarrow \varphi = 57,6^\circ$$



c) $f_3 = 4\cdot 10^5 Hz = 400 kHz$

Rezultat teoretic: $\omega = 2\pi \cdot f_3 \Rightarrow \omega = 2\pi \cdot 400 \cdot 10^3$

$\omega = 800\pi \cdot 10^3 \, rad/sec$

$$A(\omega) = \frac{1}{\sqrt{1+(800\pi\cdot 10^3 \cdot 12 \cdot 10^3 \cdot 470 \cdot 10^{-12})^2}} = \frac{1}{\sqrt{1+(14,1748)^2}} = \frac{1}{\sqrt{201,927}}$$

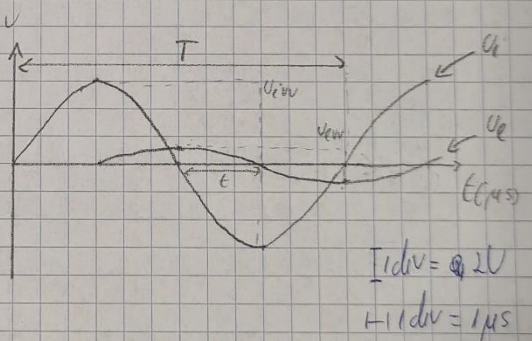
$\Rightarrow A(\omega) = 0,07$

$\varphi(\omega) = arctg(\omega RC) \Rightarrow \varphi(\omega) = arctg(800\pi \cdot 10^3 \cdot 12 \cdot 10^3 \cdot 470 \cdot 10^{-12})$

$= arctg(14,1748)$

$\Rightarrow \varphi(\omega) = 85,96^\circ$

Rezultat Experimental



$T = 2,5 div \Rightarrow T = 2,5 \cdot 1\mu s = 2,5\mu s$

iar $f = \frac{1}{T} = \frac{1}{2,5\cdot 10^{-6}} = 400000 Hz = 400 kHz$

$U_{ivv} = 2,5div + 2,5div = 5div \Rightarrow U_{ivv} = 5 \cdot 2 = 10V$

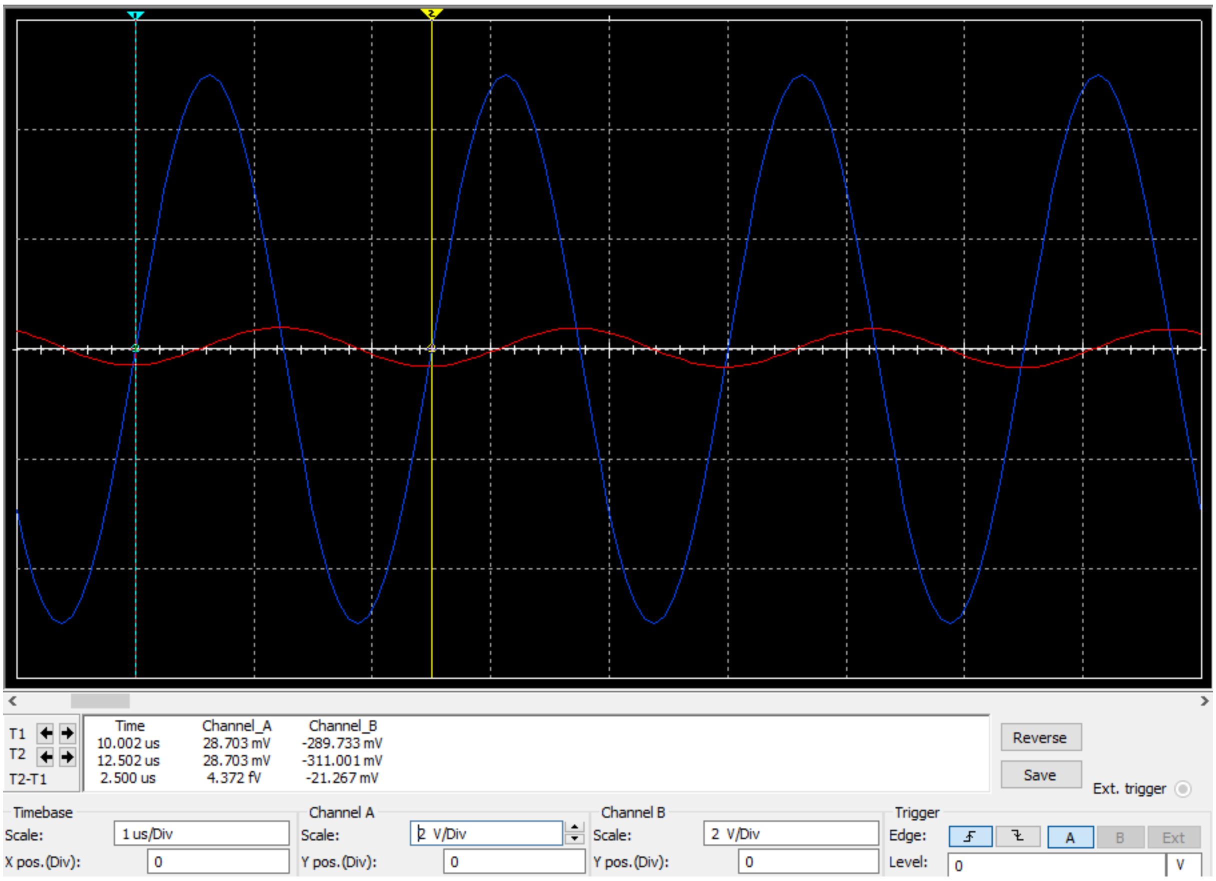
$U_{evv} = 0,2div + 0,2div = 0,4div \Rightarrow U_{evv} = 0,4 \cdot 2V = 0,8V$

$\Rightarrow A = \frac{U_e}{U_i} = \frac{0,8}{10} = 0,08$

~~t = 1,2 div => t = 1,2 · 1µs => t = 1,2µs~~ $t = 0,6 div = 0,6 \cdot 1\mu s \Rightarrow t = 0,6\mu s$

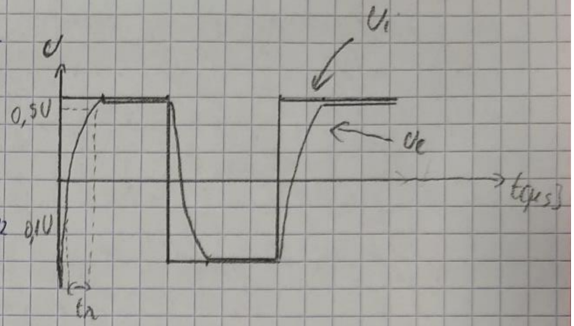
$\cancel{\Rightarrow \varphi = \frac{1,2\mu s \cdot 360}{2,5\mu s}}$ $\Rightarrow \varphi = \frac{0,6\mu s \cdot 360^\circ}{2,5\mu s}$

$\Rightarrow \varphi = 86,4^\circ$



3.1.2 Semnal intrare rectangular

a) $f_1 = 4\cdot10^3 Hz = 4kHz$



Rezultatul teoretic:

$t_r = 2,2\cdot R\cdot C \Rightarrow t_r = 2,2\cdot 10\cdot 10^3\cdot 470\cdot 10^{-12}$

$\Rightarrow t_r = 10,34\mu s$

Rezultat experimental:

Măsurăm timpul între 0,1U și 0,9U :

$\Rightarrow t_r = 0,5div = 0,5\cdot 20\mu s = 10\mu s$

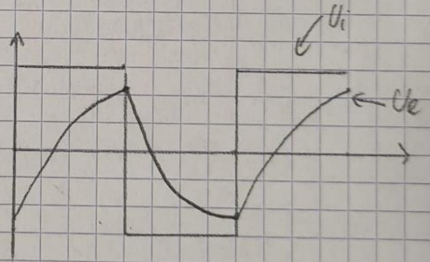
(Măsurarea de la ~~...~~ -5 la 5: $t_r' = 25\mu s$)

⇓

Oscilare mai lentă după ce Ue atinge valoarea de 4V

Observăm că timpul de ridicare ~~exte~~ este aproximativ la fel (cel teoretic și cel experimental)

b) $f_2 = 4\cdot10^4 Hz = 40kHz$



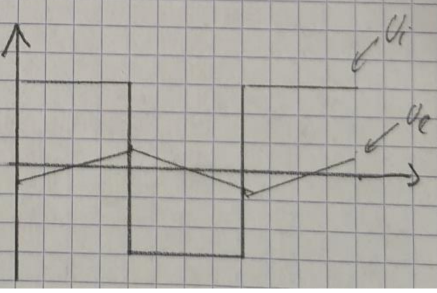
Ue: Val max = 4,3V

Ue: Val min = -4,3V

Timpul între val max și val min (t)

$t = 12,571\mu s$

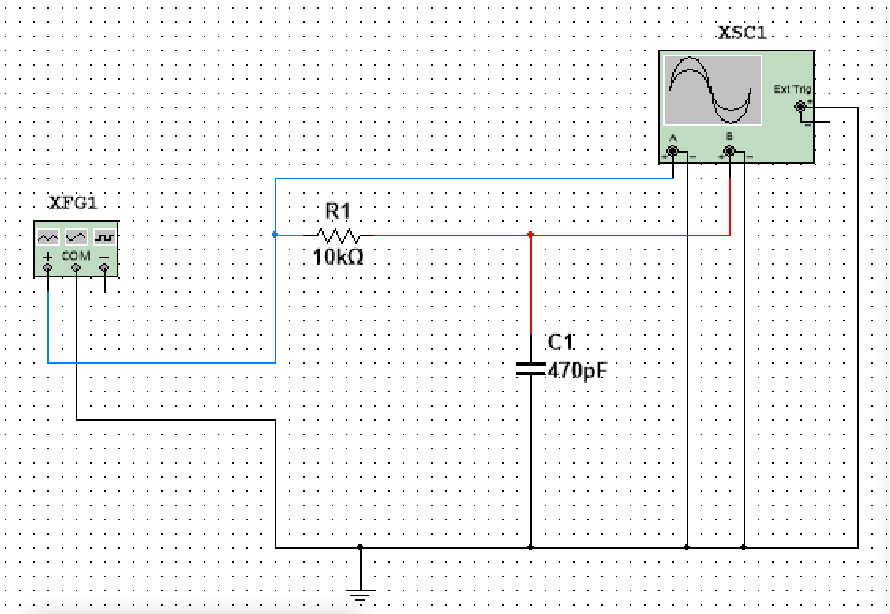
c) $f_3 = 4\cdot10^5 Hz = 400kHz$



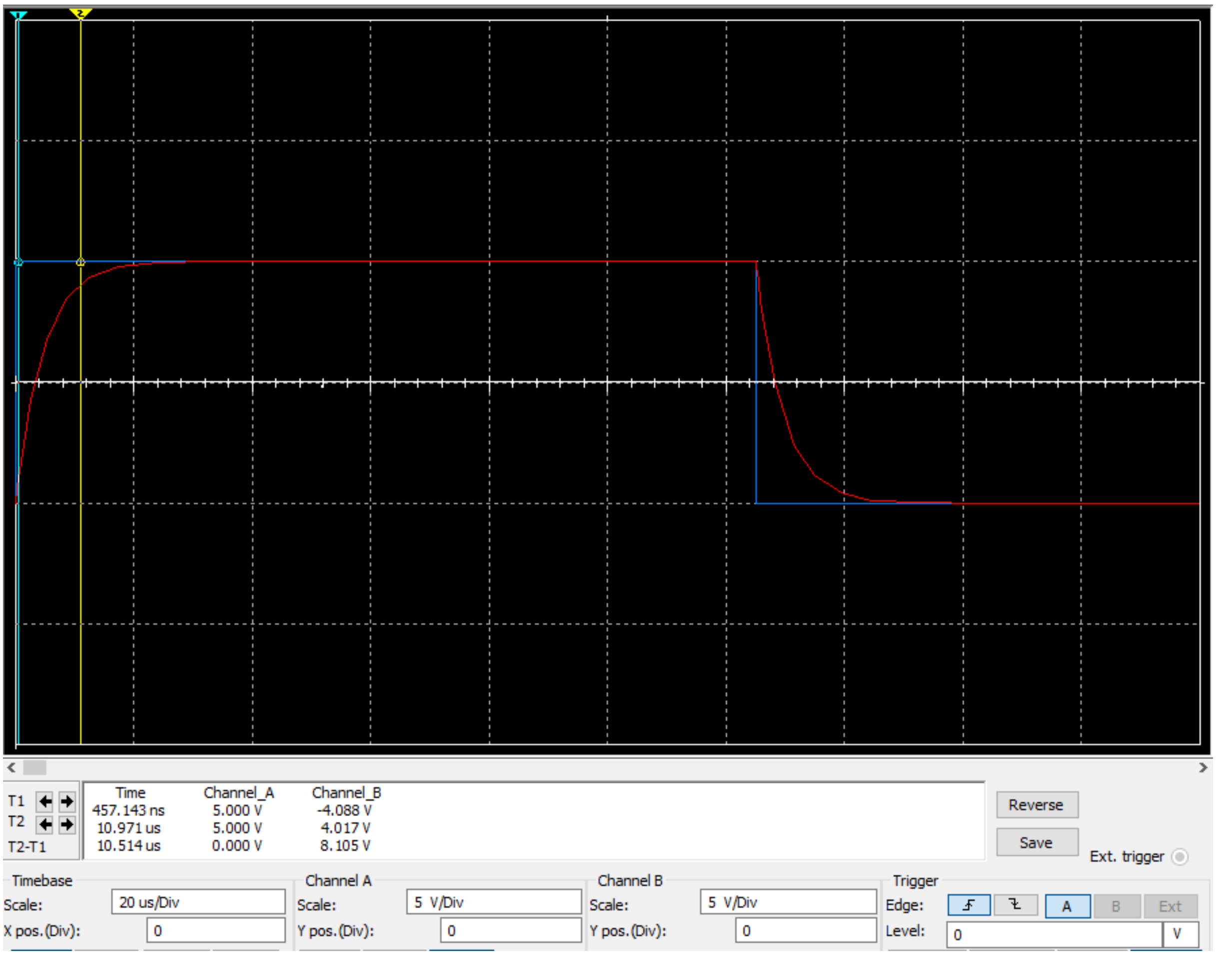
Ue : Val max = +660mV

Ue : Val min = -660mV

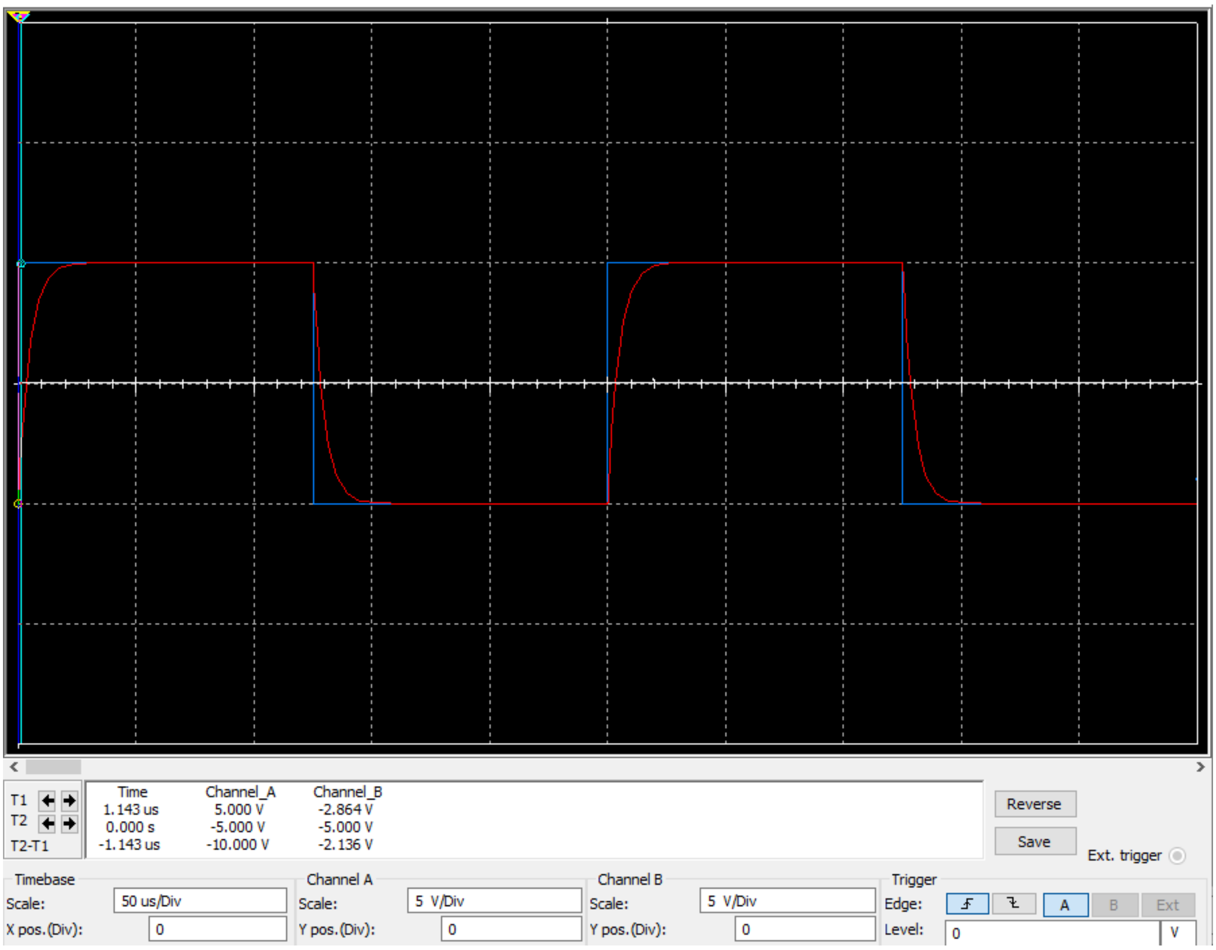
$t = 1,26\mu s$



311 a)

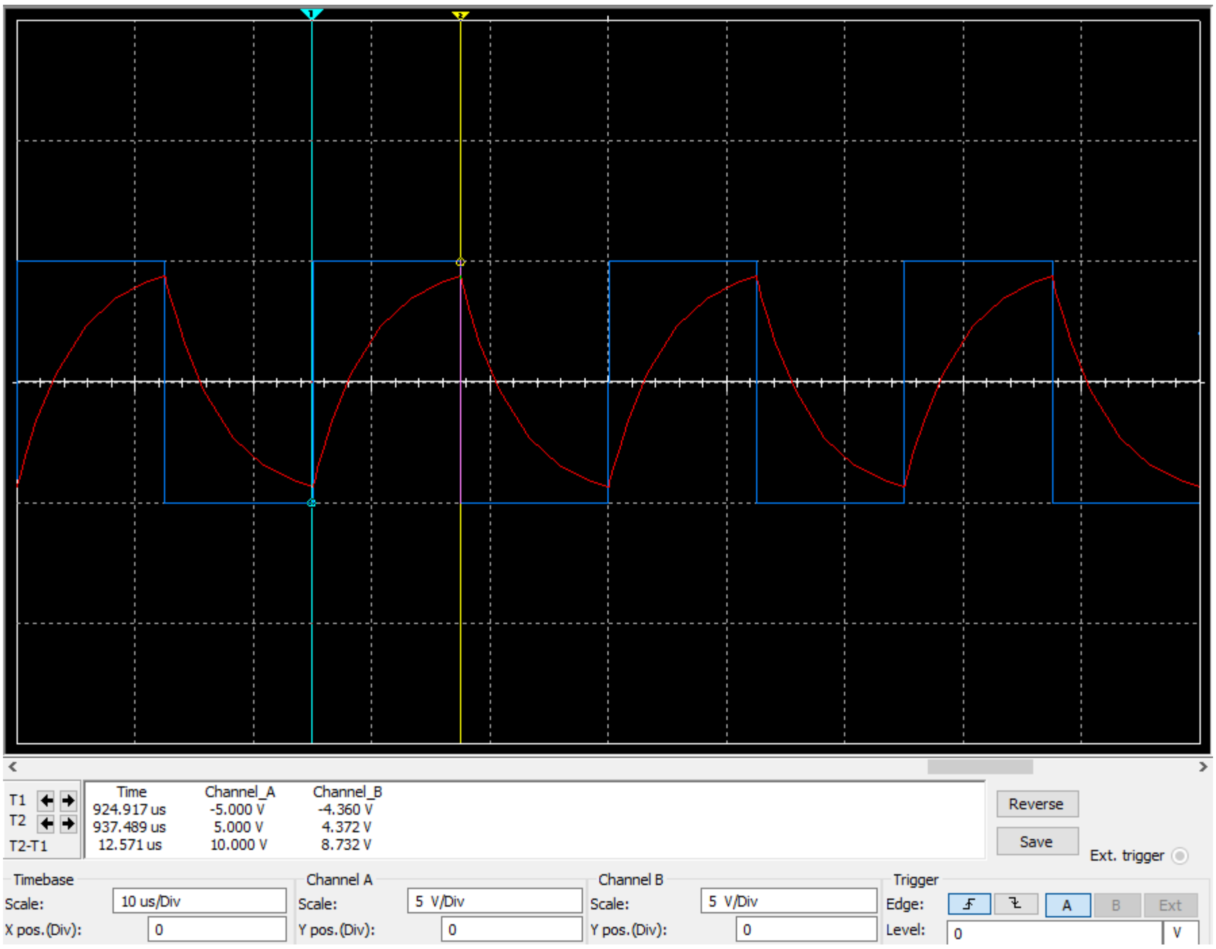


T1
T2
T2-T1
Time
457.143 ns
10.971 us
10.514 us
Channel_A
5.000 V
5.000 V
0.000 V
Channel_B
-4.088 V
4.017 V
8.105 V
Reverse
Save
Ext. trigger
Timebase
Scale: 20 us/Div
X pos.(Div): 0
Channel A
Scale: 5 V/Div
Y pos.(Div): 0
Channel B
Scale: 5 V/Div
Y pos.(Div): 0
Trigger
Edge:
A
B
Ext
Level: 0 V



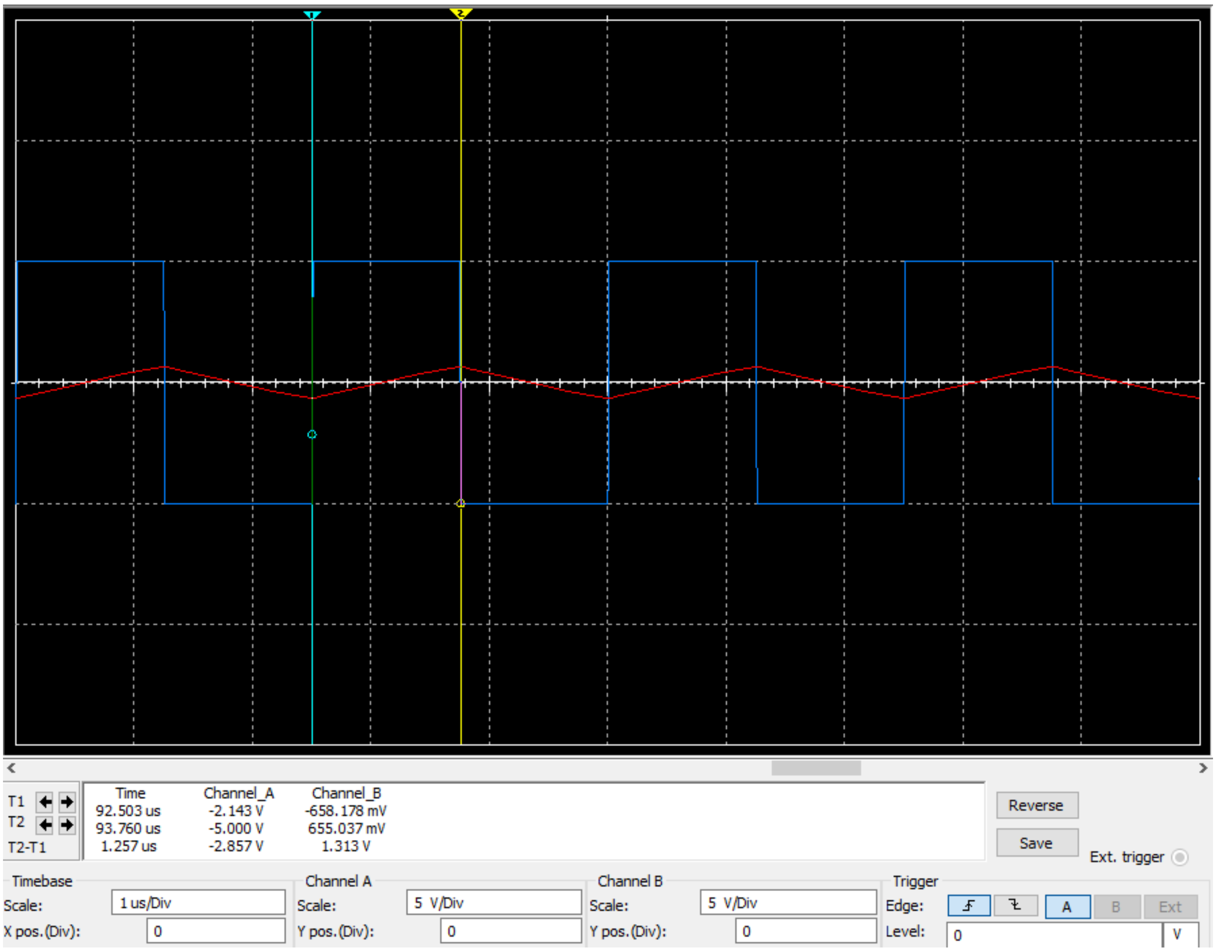
T1
T2
T2-T1
Time
1.143 us
0.000 s
-1.143 us
Channel_A
5.000 V
-5.000 V
-10.000 V
Channel_B
-2.864 V
-5.000 V
-2.136 V
Reverse
Save
Ext. trigger
Timebase
Scale: 50 us/Div
X pos.(Div): 0
Channel A
Scale: 5 V/Div
Y pos.(Div): 0
Channel B
Scale: 5 V/Div
Y pos.(Div): 0
Trigger
Edge:
A
B
Ext
Level: 0 V

311 b)



T1
T2
T2-T1
Time
924.917 us
937.489 us
12.571 us
Channel_A
-5.000 V
5.000 V
10.000 V
Channel_B
-4.360 V
4.372 V
8.732 V
Reverse
Save
Ext. trigger
Timebase
Scale:
10 us/Div
X pos.(Div):
0
Channel A
Scale:
5 V/Div
Y pos.(Div):
0
Channel B
Scale:
5 V/Div
Y pos.(Div):
0
Trigger
Edge:
A
B
Ext
Level:
0
V

312 c)



T1
T2
T2-T1
Time
92.503 us
93.760 us
1.257 us
Channel_A
-2.143 V
-5.000 V
-2.857 V
Channel_B
-658.178 mV
655.037 mV
1.313 V
Reverse
Save
Ext. trigger
Timebase
Scale:
1 us/Div
X pos.(Div):
0
Channel A
Scale:
5 V/Div
Y pos.(Div):
0
Channel B
Scale:
5 V/Div
Y pos.(Div):
0
Trigger
Edge:
A
B
Ext
Level:
0
V