Test Report

Document No.	C1004957	Copy No.	1	Number of pages	92
Apparatus	Polymer-housed surge arrester section				
Designation	PBP-V				
Serial Number	---				
Manufacturer	Industria Eletromecânica Balestro Ltda				
Client	Industria Eletromecânica Balestro Ltda Rua Santa Cruz, 1550 13800-911 Mogi Mirim (Brazil)				
Tested for	---				
Date(s) of tests	March 18 ÷ 30, 2021				
Tested by	CESI S.p.A. Via Rubattino, 54 20134 Milano – Italy				
Test performed	Power-frequency voltage-versus-time				

PAD C1004957 (2878581) - CONFIDENTIAL USE

The apparatus, constructed in accordance with the description, drawings and photographs incorporated in this document has been subjected to the series of proving tests in accordance with:

IEC 60099-4 – Edition 3.0 (2014-06)

The results are shown in the record of proving tests and the oscillograms attached hereto. The ratings assigned by the Manufacturer are listed on the ratings page.
The document applies only to the apparatus tested. The responsibility for conformity of any apparatus having the same designations with that tested rests with the Manufacturer.

May 28, 2021

Date	Gregori Marco C1004957 3059 AUT Test Engineer in charge	The Manager - Verhoeven Bas C1004957 3482248 APP Approved By Document Digitally Signed

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测思 Centro Elettrotecnico Sperimentale Italiano

CESI

Shaping a Better Energy Future

Notes

STL-Member

CESI Group members are founder members of the SHORT-CIRCUIT TESTING LIAISON (STL) which has been established in 1969. STL is a forum for voluntary international cooperation of testing organizations.

CESI Group Test Documents description

STL Type Test Certificate of .....

Issued for type tests of high voltage products (> 1 kV_{ac}; > 1,5 kV_{dc}), which have successfully been carried out in full compliance with the relevant specifications or standards and STL Guides valid at the time of the test. The STL Type Test Certificate consists of documents unequivocally identifying the test object and describes all conditions under which the tests were conducted. It gives evidence of the unobjectionable behavior of the test object during the tests in line with the normative documents applied as well as of the results of successful testing.

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Test Certificate of (complete / selected) Type Tests

Issued if type tests of low voltage products (< 1 kV_{ac}; < 1,5 kV_{dc}) requested by the relevant product standard were passed. For these tests the equipment under test must be clearly identified by technical description, drawings, and additional specifications.

Certificate of Design Verification

Issued for passed design verification tests according to IEC 61439. For these tests the equipment under test must be clearly identified by technical description, drawings, and additional specifications.

Type Test Report

Issued for high and low voltage products if parts of selected type tests have been passed; those shall be carried out in full compliance with the relevant standards but (for high voltage products) do not fulfill all STL requirements for issuing a Type Test Certificate. For these tests the equipment under test must be clearly identified by technical description, drawings, and additional specifications.

Test Report

Issued for all other tests on high and low voltage products which have been carried out according to specifications, standards and/or client instructions

On-Site Test Record

Issued as a record of results acquired during the on-site tests / measurements

Test Award

Can be additionally issued for all named types of test documents above if the tests to be referenced were passed

Tests witnessed by:

--- ---

Identification of the object: Not requested

Test evaluation

IEC/Sub-clause	Test	Test result
IEC 60099-4 (2014-06) – clause 10.8.8	Power-frequency voltage-versus-time test	Passed
The decision rule in conformity assessment is based on the simple acceptance method without considering the measuring uncertainties.		

The reported expanded uncertainties are determined in accordance with the Publication JCGM 100 "Evaluation of measurement data - Guide to the expression of uncertainty in measurement" and are based on a standard uncertainty multiplied by a coverage factor k = 2, which for a normal distribution provides a level of confidence of approximately 95 %.

Peak voltage (impulse tests)			± 3,0 %	
Voltage a.c., d.c. (dielectric tests)			± 3,0 %	
Peak current (impulse tests)			± 3,0 %	
Time parameters (impulse tests)			± 10 %	
Time parameters (a.c., d.c. dielectric tests)			± 3,5 %	
Partial discharge measurement			up to 10 pC: ± 1,0 pC	above 10 pC: ± 10 %
Atmospheric conditions:				
Temperature;	Pressure;	Relative Humidity (30 % to 95 % RH)	± 2,0 °C;	± 1,0 hPa; ± 5 %

Laboratory information *(CESI has not performed the sampling of the tested equipment)*

Receipt date of the sample March 2021

Test location CESI S.p.A. – Via Rubattino 54 – 20134 Milan - Italy

CESI testing team Mr L- Podavitte

Test laboratory P177 (Surge arrester laboratory)

ODV 70012718

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Test object characteristics

electrical characteristics (assigned by the client)

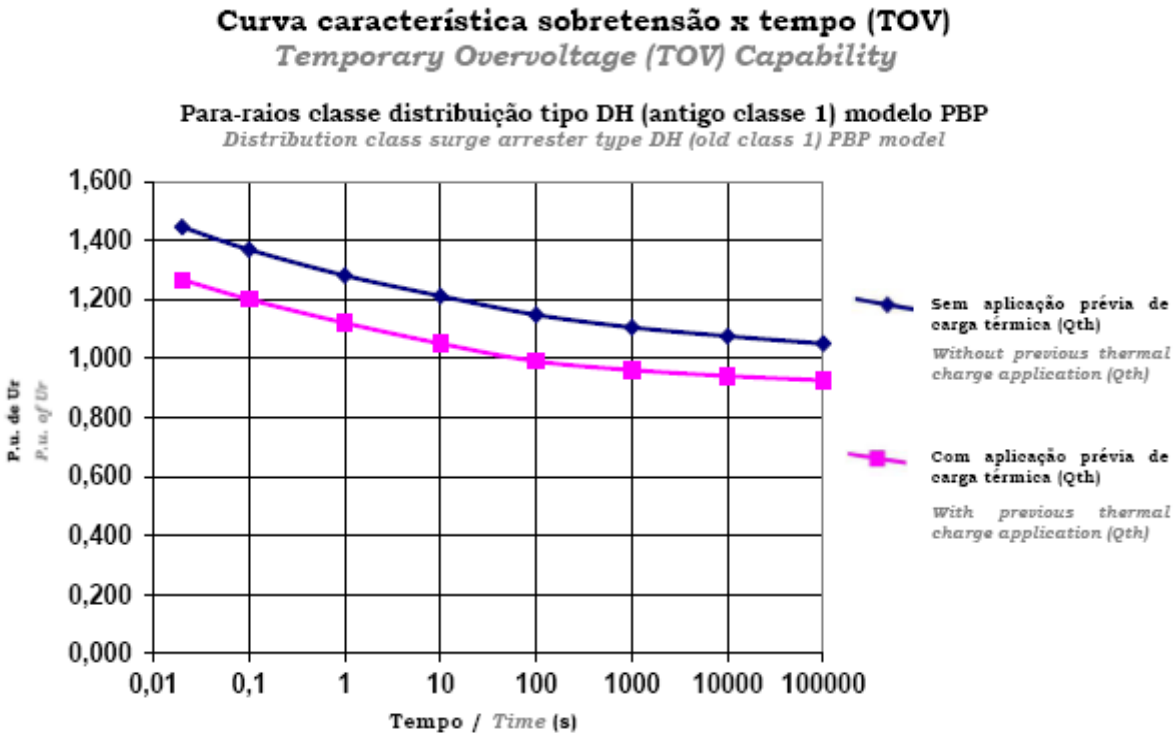
Manufacturer's name	Industria Eletromecânica Balestro Ltda
Arrester section type	PBP-V 06kV 10kA
Block's supplier	Industria Eletromecânica Balestro Ltda
Metal-oxide resistor type	P + 363610
Arrester class	Distribution
Designation	DH
Nominal discharge current - [kA]	10
Rated voltage – U_r [kV]	1,000 x $U_{ref.}$
Continuous operating voltage - U_c [kV]	0,850 x $U_{ref.}$
Repetitive charge transfer rating – Q_{rs} [C]	0,4
Thermal charge transfer rating - Q_{th} [kJ/kV]	1,1
Reference current - $I_{ref.}$ [mA]	1,7
Rated frequency - [Hz]	50÷60
Year of manufacture	2021

geometrical characteristics measured only on the metal-oxide resistor block

Total height [mm]	36,15
Diameter [mm]	36,35

Photographs of the test object

TOV curve in per unit of Ur



Reference Standard

IEC 60099-4 (20014/06) – Edition 3.0 - Clause 10.8.8
"Metal-oxide surge arresters without gaps for a.c. system"

Test carried out	Number of sample tested
Power-frequency voltage-versus-time	3

Test object identification

Test object name	Identification of the test sample (given by CESI)
Polymer-housed surge arrester section	TOV1
	TOV2
	TOV3
	TOV4
	TOV5
	TOV6

Test procedure

1. Test performed on Polymer-housed metal-oxide surge arrester section

The test procedure consisted of the following sequence:
Initial test

a) Measurement of the lightning impulse residual voltage at the nominal discharge current
b) Measurement of the power frequency reference voltage at the reference current

2. Test performed on Polymer-housed metal-oxide surge arrester section

Test with energy input (prior duty test)

c) The surge arrester sections were kept in an oven at the temperature of 78 °C till thermal equilibrium (not more than twenty hours)
d) Injection of two 8/20 lightning current impulses Q_{th} and at a time shorter than 100 ms after the application of the second 8/20 current impulse the sample was energized at U_r' for 10s and then at U_c' for 30 min. to verify the thermal stability.
   - intervals between 8/20 lightning current impulse: 55 seconds
   - nominal test frequency : 50 Hz

Four samples were tested as specified below:

Sample	U_{TOV}	Duration	Note
TOV1	1,120 x Ur'	1 s	prior duty test
TOV2	1,050 x Ur'	10 s	
TOV3	0,990 x Ur'	100 s	
TOV4	0,960 x Ur'	1000 s	

Test without energy input (no-prior duty test)

e) The surge arrester sections were kept in an oven at the temperature of 78°C till thermal equilibrium (not more than twenty hours)
f) Application of the overvoltage U_{TOV} (declared by the manufacturer) for a time t_{TOV} (declared by the manufacturer)and then at U_c' for 30 min. to verify the thermal stability.
   - nominal test frequency : 50 Hz

Two samples were tested as specified below:

Sample	U_{TOV}	Duration	Note
TOV5	1,211 x Ur'	10 s	without prior duty test
TOV6	1,105 x Ur'	1000 s	

3. Test performed on Polymer-housed metal-oxide surge arrester section in open air

g) Measurement of the lightning impulse residual voltage at nominal discharge current for comparison with initial value
h) After that the sample has cooled to ambient temperature and two current impulses 8/20 at 0,5 kA/cm^2 have been applied to check the integrity of the internal parts. The interval between impulses was 50-60 seconds.

Test result

The visual inspection of the sample after the test has revealed no sign of physical damage.
The variation of lightning impulse residual voltage before and after the test was less than 5% (maximum allowed variation according to reference standard is 5%). During the two last impulses the oscillograms not reveal any breakdown.
The thermal stability was achieved.

The acceptance criteria are fulfilled. The test result is positive.

Summary of test results

Variation of lightning impulse residual voltage at I_n

sample	before test		after test		Variation
	discharge current	residual voltage	discharge current	residual voltage	
	kA	kV	kA	kV	%
TOV1	10,14	18,56	10,04	18,80	+1,29
TOV2	10,18	18,47	10,20	18,70	+1,75
TOV3	10,16	18,47	10,16	18,68	+1,14
TOV4	10,16	18,55	10,01	18,79	+1,29
TOV5	10,07	18,62	10,12	18,68	+0,32
TOV6	10,14	18,58	10,05	18,73	+0,81

Visual inspection after the test

The visual inspection of the metal-oxide resistors after the test has revealed no sign of physical damage

Power frequency voltage versus time test.

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: March 18, 2021

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual Voltage
No.		kV	No.	µs	kA	kV
TOV1	I_n	29,4	1	8,3/18,0	10,14	18,56
TOV2		29,4	2		10,18	18,47
TOV3		29,4	3		10,16	18,47
TOV4		29,4	4		10,16	18,55
TOV5		29,4	5		10,07	18,62
TOV6		29,4	6		10,14	18,58

Notes:

Power frequency voltage versus time test.

Reference voltage test.

Test circuit: A019

Date: March 18, 2021

Sample No.TOV1						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
7	6,76	1,58	1,70	0,733	3,57	--

Sample No. TOV2						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
8	6,73	1,58	1,70	0,734	3,55	---

Sample No. TOV3						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
9	6,74	1,62	1,70	0,738	3,59	---

Sample No. TOV4						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
10	6,74	1,63	1,70	0,742	3,61	---

Sample No. TOV5						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
11	6,73	1,60	1,70	0,736	3,57	---

Sample No. TOV6						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
12	6,76	1,59	1,70	0,732	3,57	---

Power frequency voltage versus time test.

Voltage correction factor and thermal energy calculations

Date: March 25, 2021

Sample	U_{ref} [1]	KU_r [2]	KU_C [3]	U_r' [4]	U_c' [5]
No.	kV			kV	kV
TOV1	6,76	1,000	0,850	6,76	5,746
TOV2	6,73			6,73	5,721
TOV3	6,74			6,74	5,729
TOV4	6,74			6,74	5,729
TOV5	6,73			6,73	5,721
TOV6	6,76			6,76	5,746

[1] U_{ref} : measured reference voltage
[2] KU_r : maximum guaranteed factor for calculation of Ur' – $U_r/U_{ref.min.}$
[3] KU_C : maximum guaranteed factor for calculation of Uc' - $U_c/U_{ref.min.}$
[4] U_r' : corrected rated voltage [4] = [1] × [2]
[5] U_c' : corrected continuous operating voltage [5] = [1] × [3]

Sample	U_r'	Requested thermal charge transfer, Q_{th}	Requested Q_{th} per impulse
No.	kV	C	C
TOV1	6,76	1,1	0,55 (±10%)
TOV2	6,73		0,55 (±10%)
TOV3	6,74		0,55 (±10%)
TOV4	6,74		0,55 (±10%)

Power frequency voltage versus time test.

Application of the temporary overvoltage U_{TOV} and evaluation of thermal stability
(without prior duty test)

Test circuit: A0124-A0130-A0020

Sample No.: TOV5

Preheating temperature: 78 °C

Date: March 25, 2021

Temporary overvoltage application

Amplitude claimed by the manufacturer **Ur' x 1,211 = 6,730 x 1,211 = 8,150 kV**
Duration claimed by the manufacturer **10 sec.**

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA_{cr}	- mA_{cr}	W
13	0	8,15	287	253	---
14	10		227	201	

Corrected continuos operating voltage U_c' application to evaluate the thermal stability

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA_{cr}	- mA_{cr}	W
	1	5,721	1,63	1,84	3,90
15	5		1,52	1,56	2,70
	10		1,50	1,55	2,41
16	15		1,50	1,54	2,23
	20		1,49	1,53	2,12
	25		1,48	1,52	2,05
17	31		1,46	1,50	1,98

Note : Before the injection of the energy, the temperature of the test sample has been checked with instrument type FLUKE 52II thermometer CESI no.30889

continued

Sample No.: TOV6

Preheating temperature: 78 °C

Date: March 25, 2021

Temporary overvoltage application

Amplitude claimed by the manufacturer **Ur' x 1,105 = 6,750 x 1,105 = 7,459 kV**
Duration claimed by the manufacturer **1000 sec**.

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA_{cr}	- mA_{cr}	W
18	0	7,459	25,0	26,0	---
	300		24,3	23,7	
19	1000		27,0	27,0	

Corrected continuos operating voltage U_c' application to evaluate the thermal stability

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA_{cr}	- mA_{cr}	W
20	0	5,738	2,38	2,56	6,02
	5		1,55	1,60	3,30
	10		1,53	1,57	2,76
21	15		1,51	1,56	2,43
	20		1,50	1,55	2,27
	25		1,49	1,54	2,14
22	30		1,48	1,53	2,00

Note : Before the injection of the energy, the temperature of the test sample has been checked with instrument type FLUKE 52II thermometer CESI no.30889

continued

Power frequency voltage versus time test.

Application of two lightning current impulses 8/20µs, corrected rated voltage U_r' and corrected continuous operating U_c' for evaluation of the thermal stability.

Test circuit: A0124-A0020-A0130

Sample No.: TOV 1

Ambient temperature: 23 °C
Preheating temperature: 78 °C

Date: March 29, 2021

Lightning current impulses 8/20 µs application

Oscillogram	Impulse	Charging voltage	Residual voltage	Discharge current	Q_{th}	Applicable range for Q_{th}
No.	No.	kV	kV	kA	C	C
23	1	68,0 x 2	---	38,30	0,56	0,495÷0,605
24	2	68,0 x 2	---	37,80	0,55	0,495÷0,605

Current impulse waveshape (µs)
8,9 /18,5

Temporary overvoltage application

Amplitude claimed by the manufacturer **Ur' x 1,120 = 6,760 x 1,120 = 7,571 kV**
Duration claimed by the manufacturer **1 sec**.

Oscillogram	Time	U_r'	Current	Current
No.	s	kV	+ mA_{cr}	- mA_{cr}
---	0	7,571	208	250
---	1		195	210

Corrected continuous operating voltage U_c' application to evaluate the thermal stability

Oscillogram	Time	U_c'	Current	Current	Power	Temperature
No.	min	kV	+ mA_{cr}	- mA_{cr}	W	°C
27	1	5,746	3,70	4,06	8,71	---
	5		2,00	2,26	4,75	---
	10		1,30	1,38	2,83	---
28	15		1,07	1,16	2,30	---
	20		0,89	0,93	1,91	---
	25		0,80	0,81	1,60	---
29	31		0,77	0,79	1,36	---

Note : Before the injection of the energy, the temperature of the test sample has been checked with instrument type FLUKE 52II thermometer CESI no.30889

continued

Continued

Sample No.: TOV2

Ambient temperature: 23 °C
Preheating temperature: 79 °C

Date: March 29, 2021

Lightning current impulses 8/20 μs application

Oscillogram	Impulse	Charging voltage	Residual voltage	Discharge current	Q_{th}	Applicable range for Q_{th}
No.	No.	kV	kV	kA	C	C
30	1	68,0 x 2	---	38,0	0,56	0,495÷0,605
31	2	68,0 x 2	---	38,0	0,56	0,495÷0,605

Current impulse waveshape (μs)
8,9 /18,5

Temporary overvoltage application

Amplitude claimed by the manufacturer **Ur' x 1,050 = 6,730 x 1,050 = 7,067 kV**
Duration claimed by the manufacturer **10 sec**.

Oscillogram	Time	U_r'	Current	Current
No.	s	kV	+ mA_{cr}	- mA_{cr}
32	0	7,067	152	162
33	10		134	150

Corrected continuous operating voltage U_c' application to evaluate the thermal stability

Oscillogram	Time	U_c'	Current	Current	Power	Temperature
No.	min	kV	+ mA_{cr}	- mA_{cr}	W	°C
34	1	5,721	6,20	6,98	15,8	---
	5		1,52	1,69	3,90	---
	10		1,00	1,15	2,50	---
35	15		0,99	1,05	2,20	---
	20		0,86	0,89	1,87	---
	25		0,80	0,80	1,60	---
36	31		0,78	0,79	1,40	---

Note : Before the injection of the energy, the temperature of the test sample has been checked with instrument type FLUKE 52II thermometer CESI no.30889

continued

Continued

Sample No.: TOV3

Ambient temperature: 23 °C
Preheating temperature: 81 °C

Date: March 30, 2021

Lightning current impulses 8/20 µs application

Oscillogram	Impulse	Charging voltage	Residual voltage	Discharge current	Q_{th}	Applicable range for Q_{th}
No.	No.	kV	kV	kA	C	C
37	1	68,0 x 2	---	38,90	0,57	0,495÷0,605
38	2	68,0 x 2	---	38,40	0,56	

Current impulse waveshape (µs)
8,9 /18,5

Temporary overvoltage application

Amplitude claimed by the manufacturer **Ur' x 0,990= 6,740 x 0,990 = 6,673 kV**
Duration claimed by the manufacturer **100 sec**.

Oscillogram	Time	U_r'	Current	Current
No.	s	kV	+ mA_{cr}	- mA_{cr}
39	0	6,673	72,0	89,0
40	100		13,0	13,50

Corrected continuous operating voltage U_c' application to evaluate the thermal stability

Oscillogram	Time	U_c'	Current	Current	Power	Temperature
No.	min	kV	+ mA_{cr}	- mA_{cr}	W	°C
41	0	5,729	2,03	2,30	5,10	---
	5		1,34	1,50	3,21	---
	10		1,00	1,10	2,35	---
42	15		0,80	0,83	1,72	---
	20		0,77	0,75	1,44	---
	25		0,76	0,74	1,15	---
43	30		0,75	0,74	1,08	---

Note : Before the injection of the energy, the temperature of the test sample has been checked with instrument type FLUKE 52II thermometer CESI no.30889

continued

Continued

Sample No.: TOV4

Ambient temperature: 23 °C
Preheating temperature: 78 °C

Date: March 30, 2021

Lightning current impulses 8/20 µs application

Oscillogram	Impulse	Charging voltage	Residual voltage	Discharge current	Q_{th}	Applicable range for Q_{th}
No.	No.	kV	kV	kA	C	C
47	1	68,0 x 2	---	38,7	0,57	0,495÷0,605
48	2	68,0 x 2	---	38,6	0,57	

Current impulse waveshape (µs)
8,9 /18,5

Temporary overvoltage application

Amplitude claimed by the manufacturer **Ur' x 0,960 = 6,6,74 x 0,960 = 6,470 kV**
Duration claimed by the manufacturer **1000 sec**.

Oscillogram	Time	U_r'	Current	Current
No.	s	kV	+ mA_{cr}	- mA_{cr}
49	0	6,470	62,0	69,0
50	1000		2,40	2,50

Corrected continuous operating voltage U_c' application to evaluate the thermal stability

Oscillogram	Time	U_c'	Current	Current	Power	Temperature
No.	min	kV	+ mA_{cr}	- mA_{cr}	W	°C
51	0	5,729	0,87	0,88	1,85	---
	5		0,75	0,76	1,48	---
	10		0,74	0,74	1,31	---
52	15		0,72	0,74	1,20	---
	20		0,72	0,73	1,05	---
	25		0,71	0,72	0,97	---
53	30		0,70	0,71	0,87	---

Note : Before the injection of the energy, the temperature of the test sample has been checked with instrument type FLUKE 52II thermometer CESI no.30889

continued

Power frequency voltage versus time test.

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

Date: March 30, 2021

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual Voltage
No.		kV	No.	µs	kA	kV
TOV1	I_n	29,8	54	8,4/18,1	10,04	18,80
TOV2		29,8	55		10,20	18,70
TOV3		29,8	56		10,16	18,68
TOV4		29,8	57		10,01	18,79
TOV5		29,8	58		10,12	18,68
TOV6		29,8	59		10,05	18,73

Notes:

Power frequency voltage versus time test.

Final application of a current impulse 8/20 µs (withstand capability)

Test circuit: A0120

Date: March 30, 2021

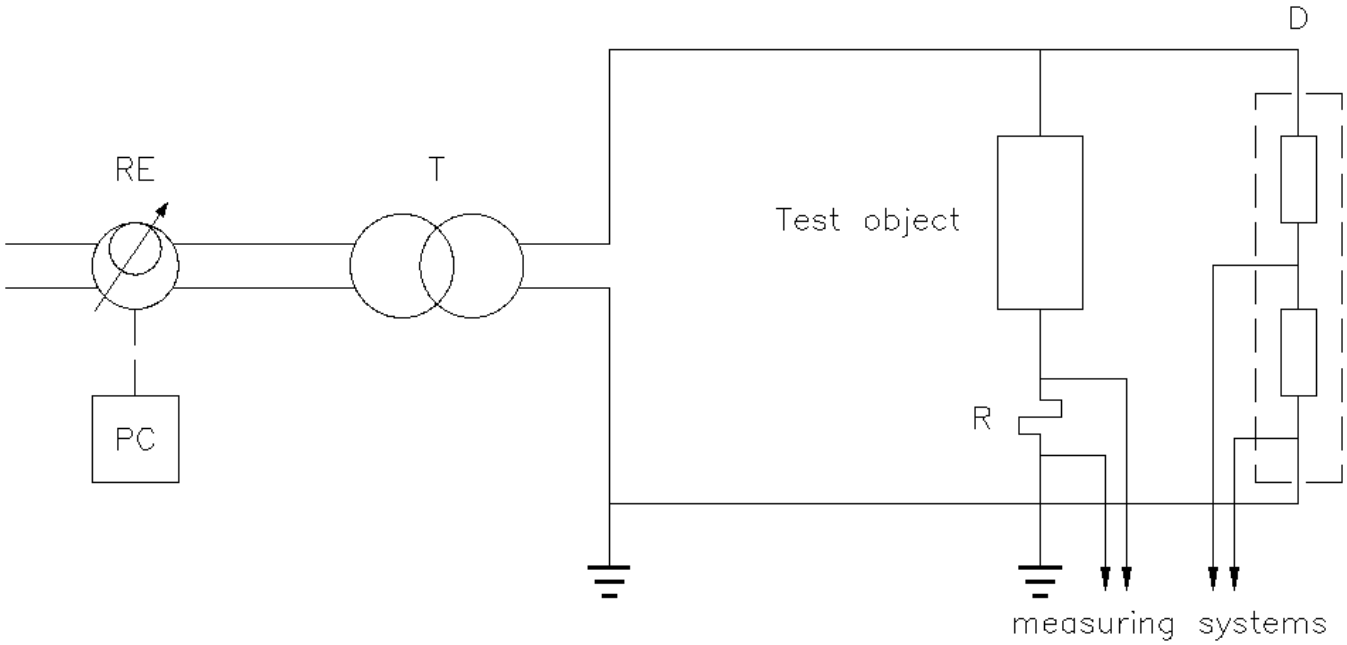
Sample	Requested current	Charging Voltage	Oscillogram	Current waveshape	Discharge current	Discharge voltage
No.	kA	kV	No.	µs	kA	kV
TOV1	5,11 (*)	24,2	60	8,8/18,6	5,56	17,61
TOV1		24,2	61		5,57	17,60
TOV2		24,2	62		5,78	17,44
TOV2		24,2	63		5,72	17,48
TOV3		24,2	64		5,68	17,49
TOV3		24,2	65		5,67	17,56
TOV4		24,2	66		5,71	17,61
TOV4		24,2	67		5,65	17,56
TOV5		24,2	68		5,71	17,54
TOV5		24,2	69		5,68	17,55
TOV1		24,2	70		5,79	17,50
TOV1		24,2	71		5,72	17,54

Notes:

(*) Requested current = 0,5 kA/cm^2 x 10,23 cm^2 = 5,11 kA

- where 0,5 kA/cm^2 is peak current density
- where 10,23 cm^2 is surface area on the metal-oxide resistor used for this test declared by the manufacturer

Circuit A0019



Power frequency supply

RE - programmable supply type PACIFIC A.C. Power Source 140 ASX.; CESI no. 0560408
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system HBM No.57987/57986

OSC
- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 056226 (on channel No.1)

Voltage measuring system

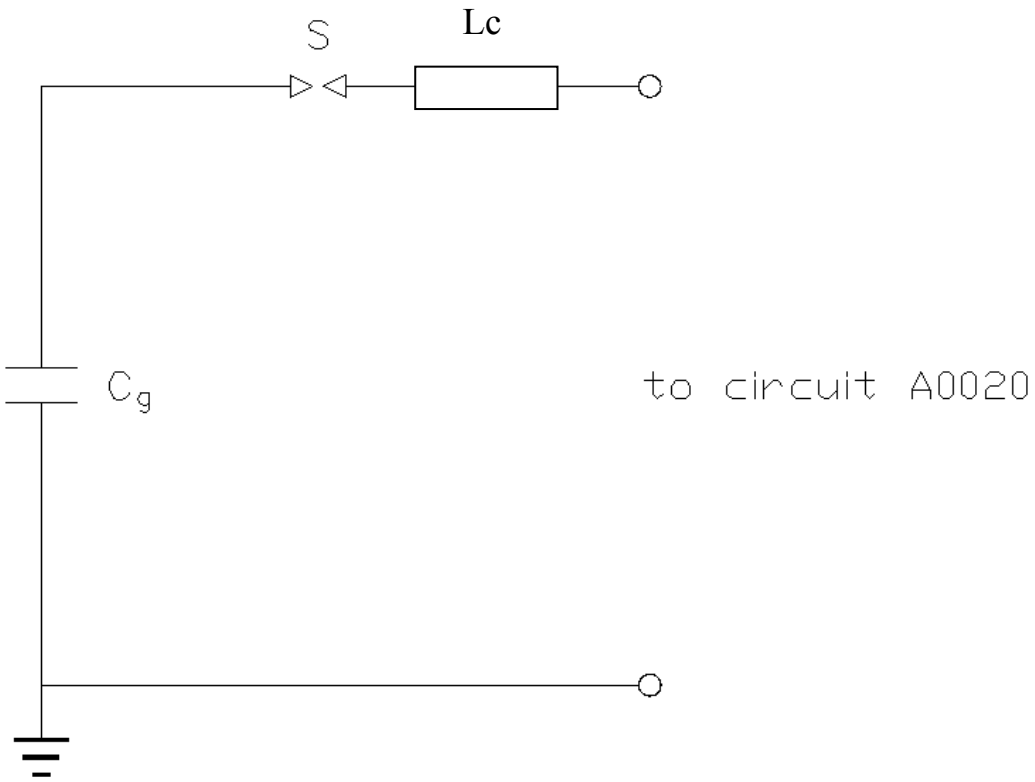
D - Voltage divider SAGI; CESI No.13027
- Electro optical system HBM No.57991/57986

OSC
- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.2)

Software system:

SW - S.A.D. Surge arrester version 2.0

Circuit A0123

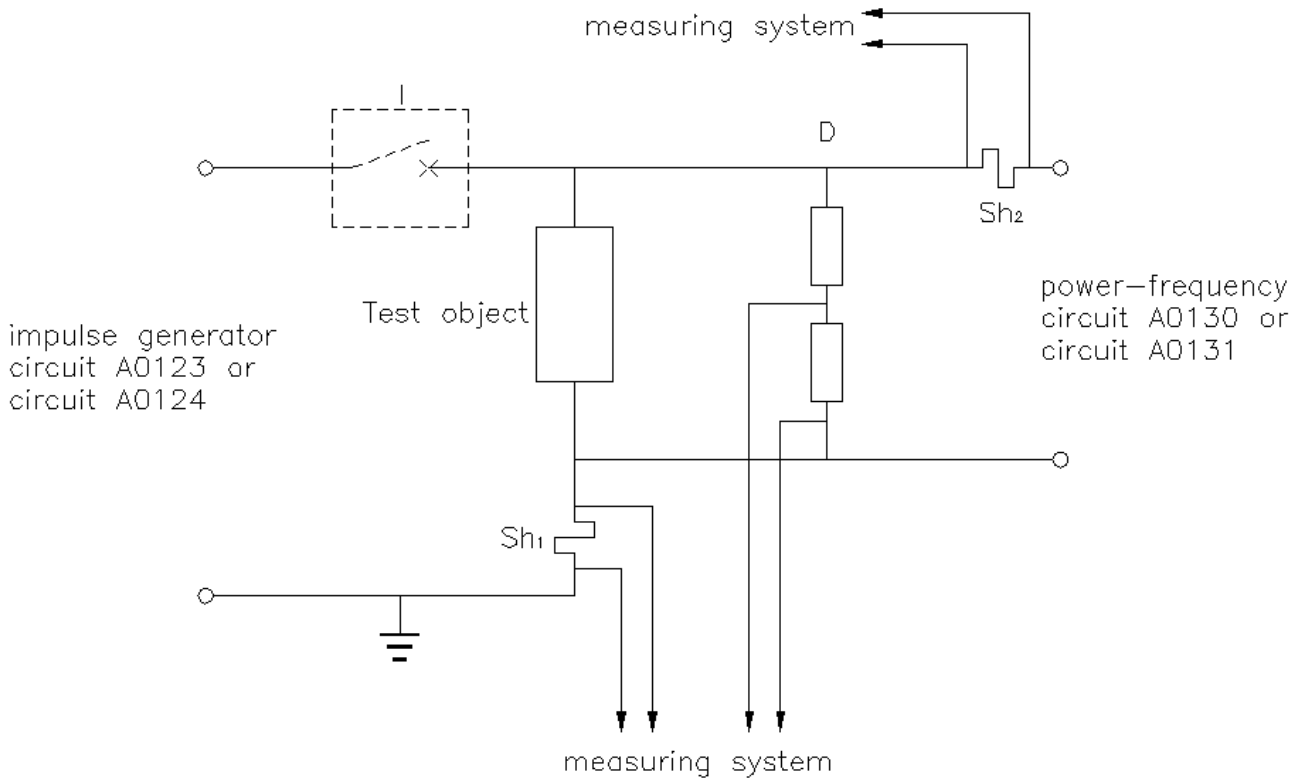


Impulse generator circuit

No. of stages	2
Cg	3,32 µF
Lc	16 µH
S	- Spark-gap

Note : additional MO resistors have been added

Circuit A0020



Impulse generator circuit A0124

I - Circuit-breaker

Power frequency circuit A0130

Voltage measuring system.

D - Voltage divider SAGI; CESI No.13027
- Electro optical system HBM No.57991/57986

$OSC_{2,3}$ - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122
- CESI No 056227- 0562226 (on channel No.2)

Current measuring system

Sh_2 (TOV) - Current shunt CESI No 058315/15; R= 200 Ω - Electro optical system HBM No.58295/57986

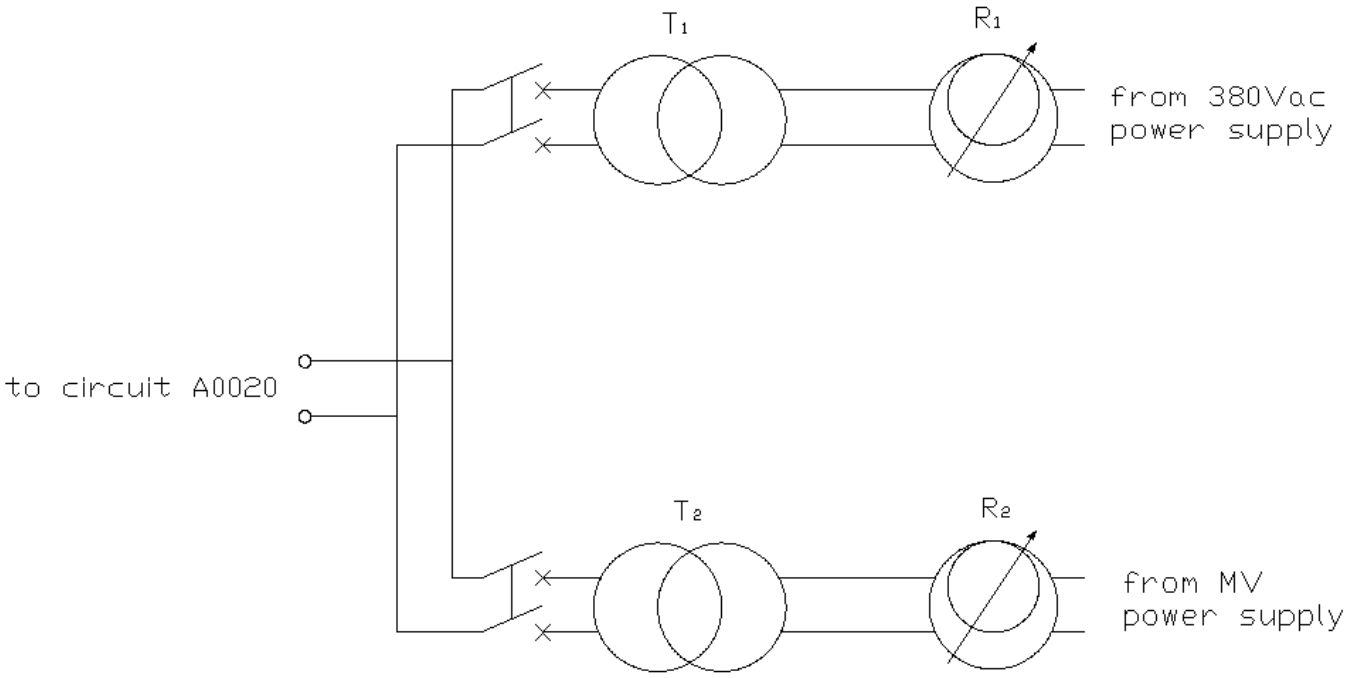
Sh_2 (MCOV) - Current shunt type CESI No. 05831/17; R= 1000 Ω - Electro optical system HBM No.58294/57986

$OSC_{2,3}$ - Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 056226 (on channel No.1)

Software system:

SW - S.A.D. Surge arrester version 2.0

Circuit A0130

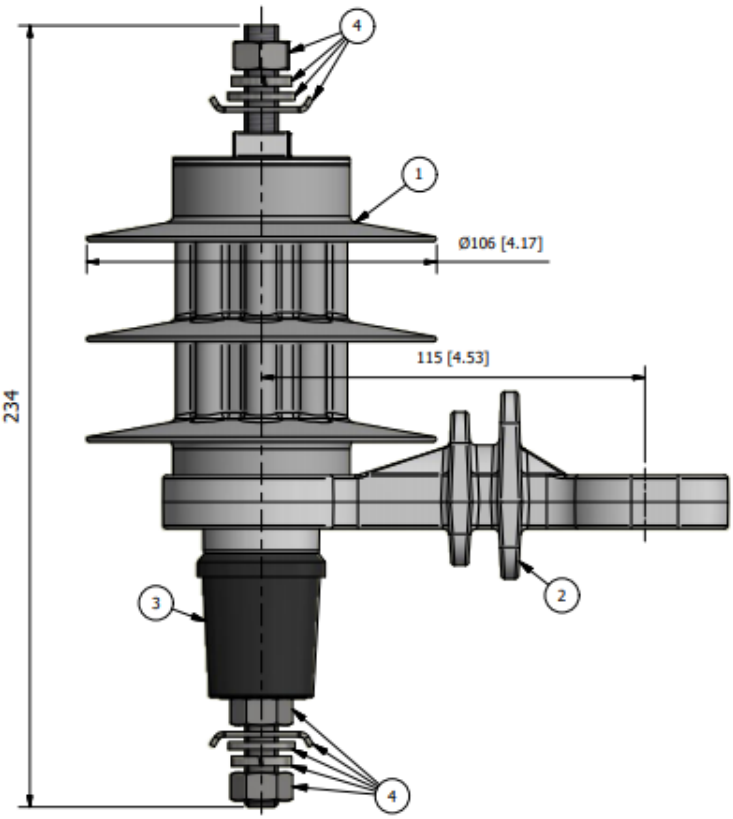


Power-frequency circuit

from 380Vac power supply
R_1 - programmable supply type PACIFIC A.C. Power Source 140 ASX.; CESI no. 0560408
T_1 - voltage transformer type PIVI; power 20 kVA; voltage 220 V/50 kV

from Medium Voltage (MV) power supply
R_2-T_2 - voltage regulator group BONNEFOND; power 3x350 kVA; voltage 23 kV/0 ÷ 6*√3 kV

Client's drawing



CÓPIA NÃO CONTROLADA / *NOT CONTROLLED COPY*

NOTA:
- MEDIDAS EM MILÍMETROS E [POLEGADAS].
- GRAVAÇÃO NO CORPO.
- DISTANCIA DE ARCO: 185mm
- DISTANCIA DE ESCOAMENTO: 321mm

NOTE:
- *MEASURES IN MILLIMETERS AND [INCHES];*
- ENGRAVING IN THE BODY:
- *ARC DISTANCE: [7.28]in;*
- *CREEPAGE DISTANCE: [12.64]in:*

POS.	DESCRIÇÃO / *DESCRIPTION*	MATERIAL / *MATERIAL*
4	TERMINAL / *FITTING*	AÇO INOX / *STAINLESS STEEL*
3	DESLIGADOR AUTOMÁTICO / *AUTOMATIC DISCONNECTOR*	POLÍMERO / *POLYMER*
2	SUPORTE ISOLANTE / *INSULATING BRACKET*	POLÍMERO / *POLYMER*
1	INVÓLUCRO / *HOUSING*	SILICONE / *SILICONE RUBBER*

BALESTRO

CONJUNTO DE MONTAGEM
PARA-RAIOS POLIMÉRICO
PBP-V

MOUNTING KIT POLYMERIC SURGE ARRESTER PBP-V

FOLHA / *SHEET*: 1 / 1

REV. | MODIFICAÇÃO / *MODIFICATION* | DES. | APR. | DATA / *DATE*

CLIENTE / *CUSTOMER*

DES.:MOREIRA 05/05/21
VER.: 05/05/21
APR.: 05/05/21

DES. NÚMERO / *DWG. NUMBER*: 5K506071/4
FORMATO FOLHA / *SHEET SIZE*: A4

EDIÇÃO / *EDITION*: 01
ESCALA / *SCALE*: 1 : 2
TOL. GERAL / *TOLERANCE*: ± 5 [± 0.20]

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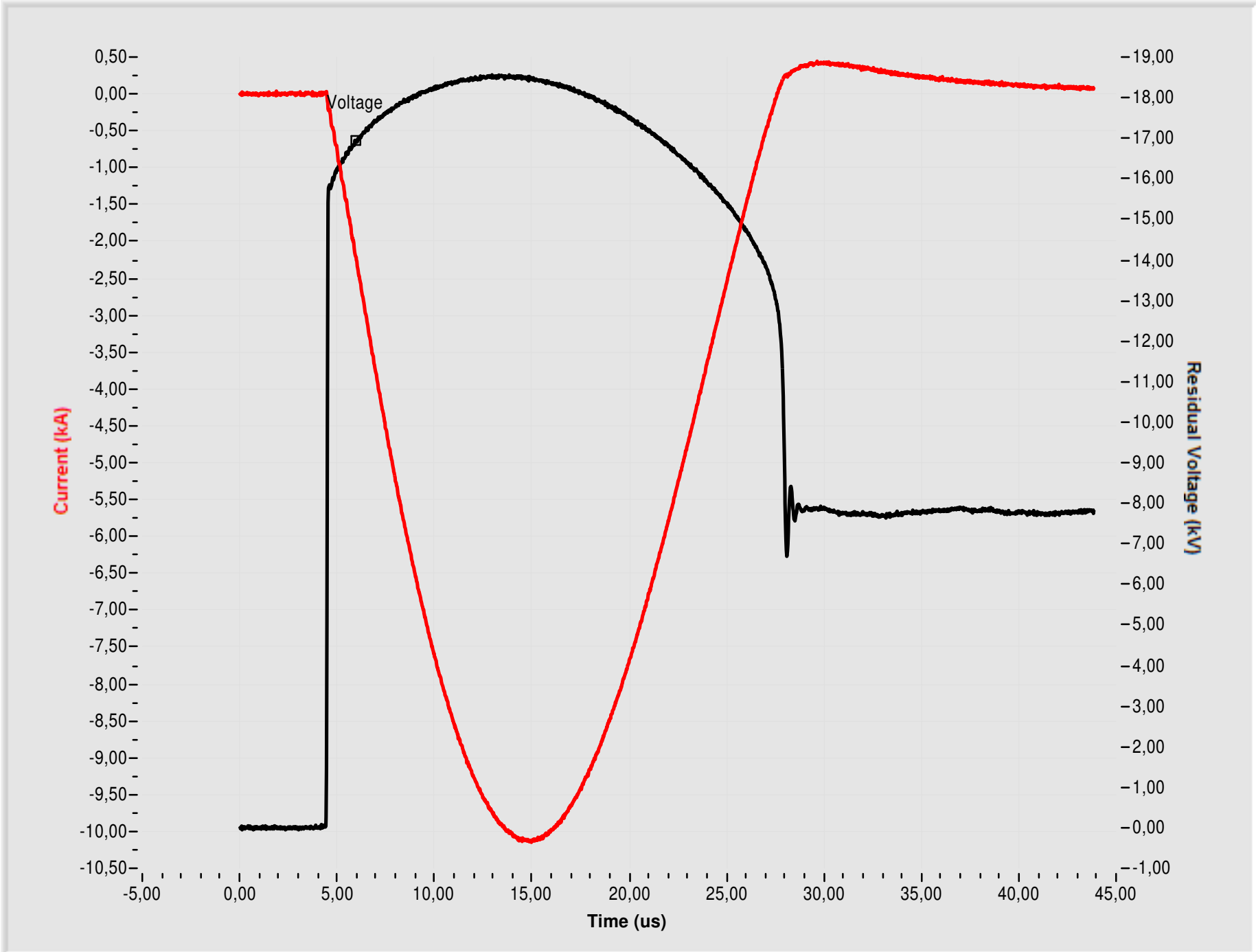
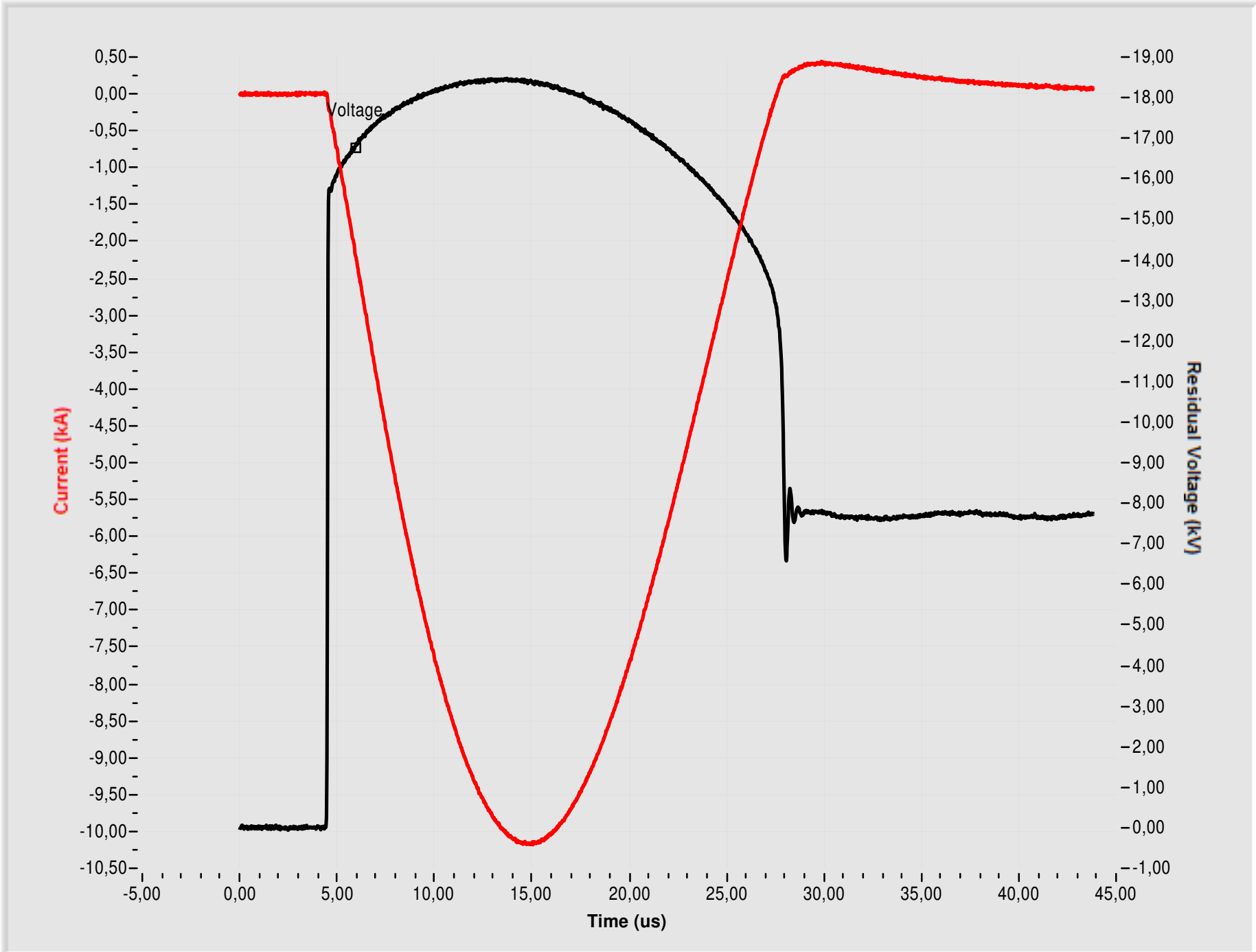
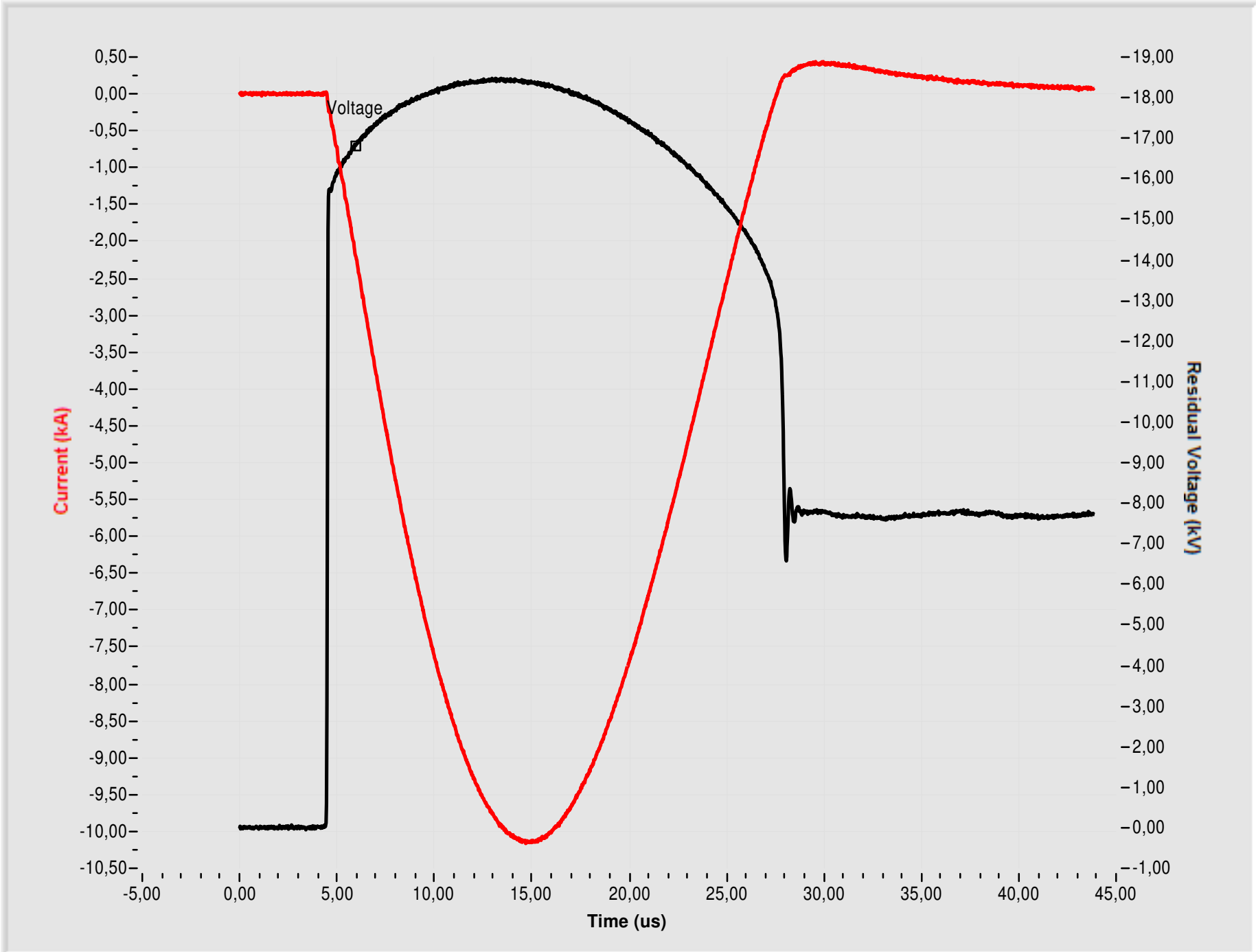
CESI C1004957 Oscillogram n. 1



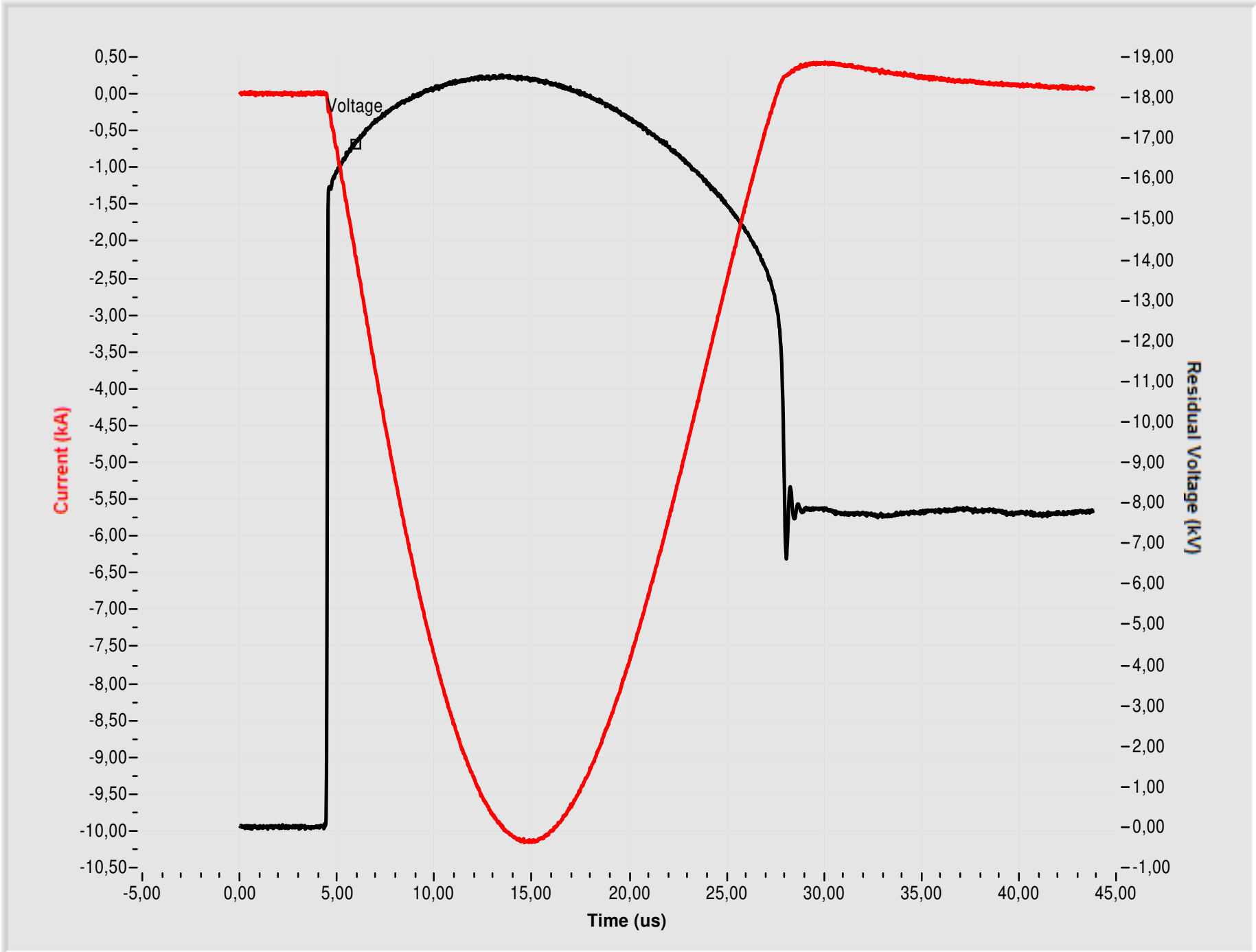
CESI C1004957 Oscillogram n. 2



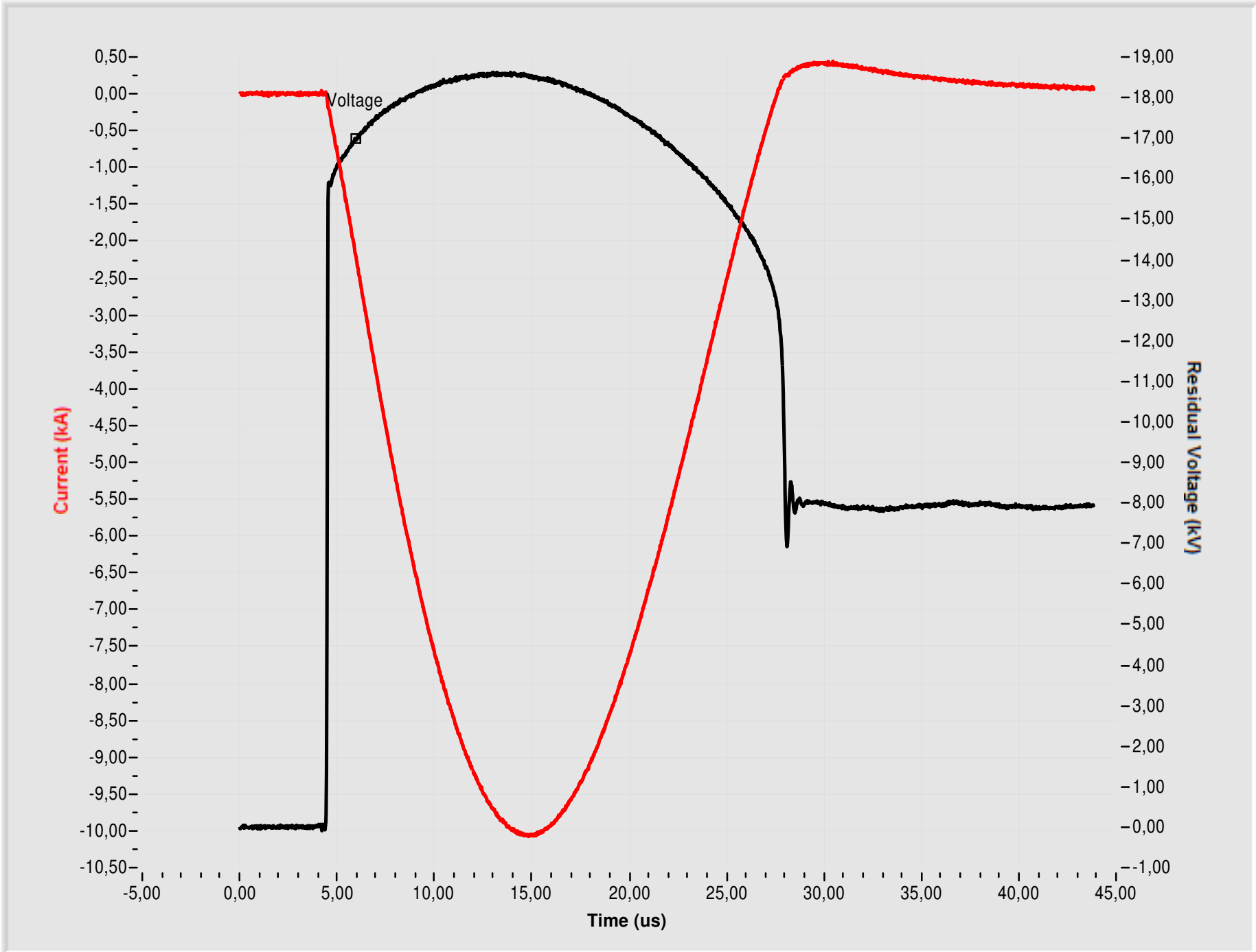
CESI C1004957 Oscillogram n. 3



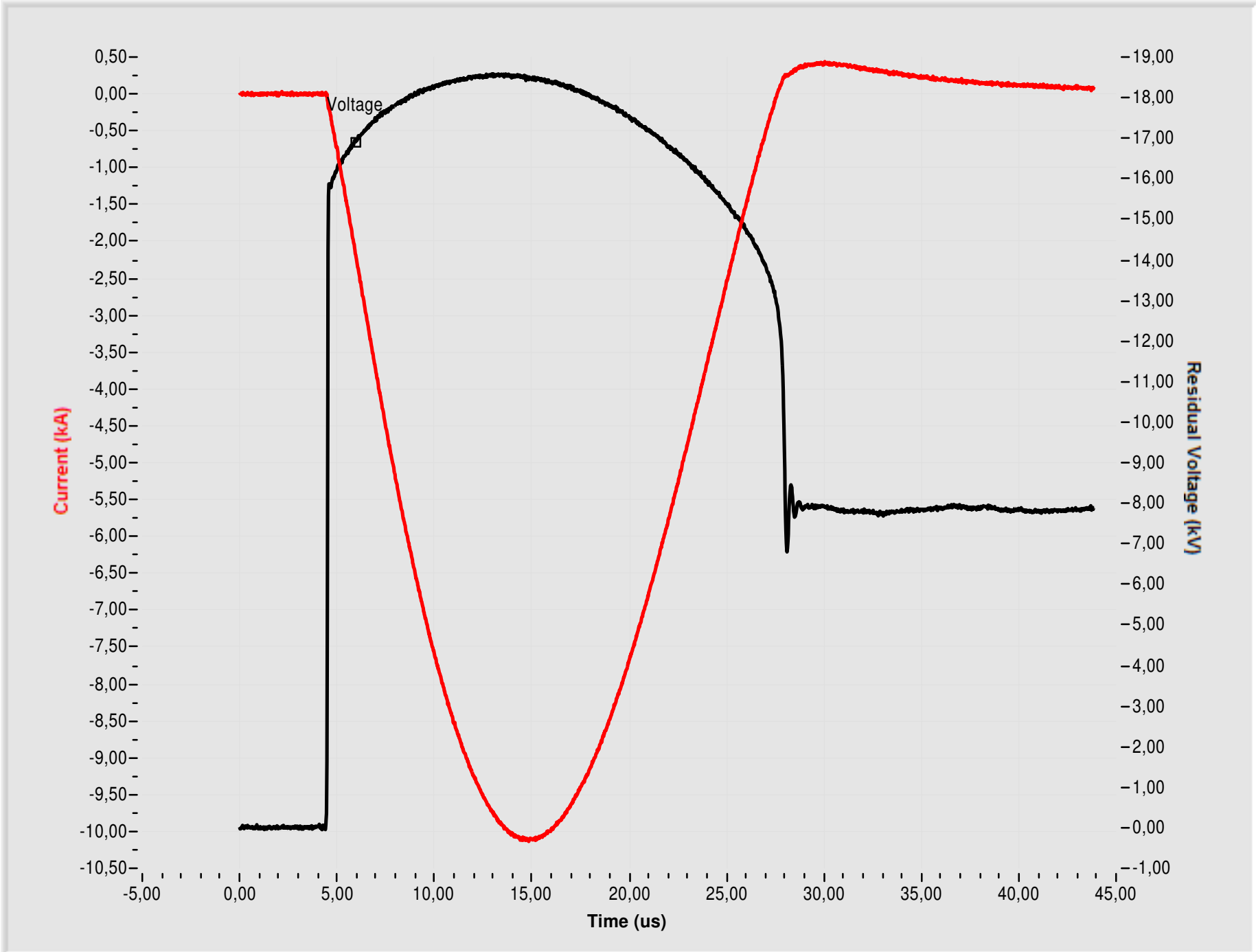
CESI C1004957 Oscillogram n. 4



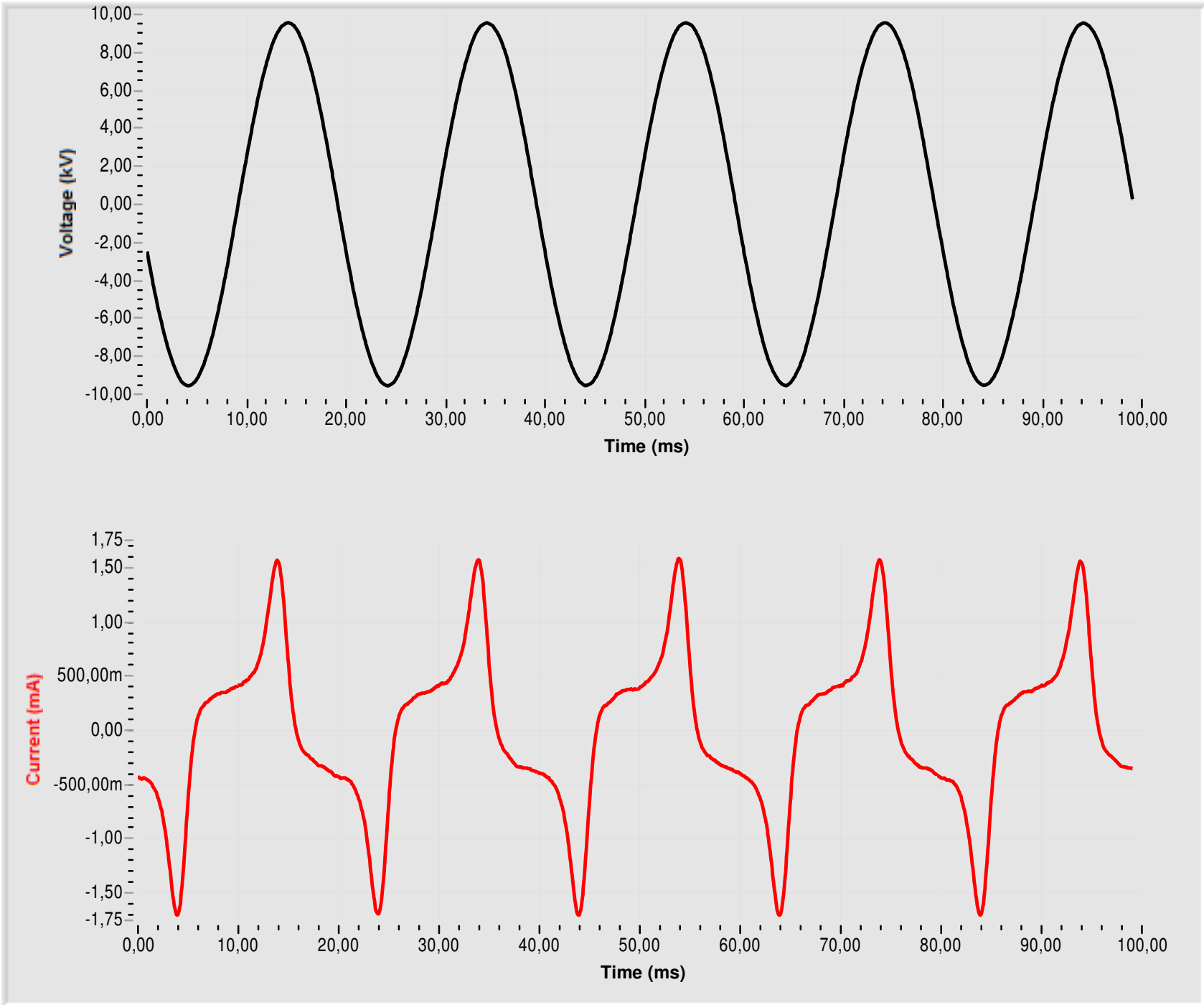
CESI C1004957 Oscillogram n. 5



CESI C1004957 Oscillogram n. 6



CESI C1004957 Oscillogram n. 7



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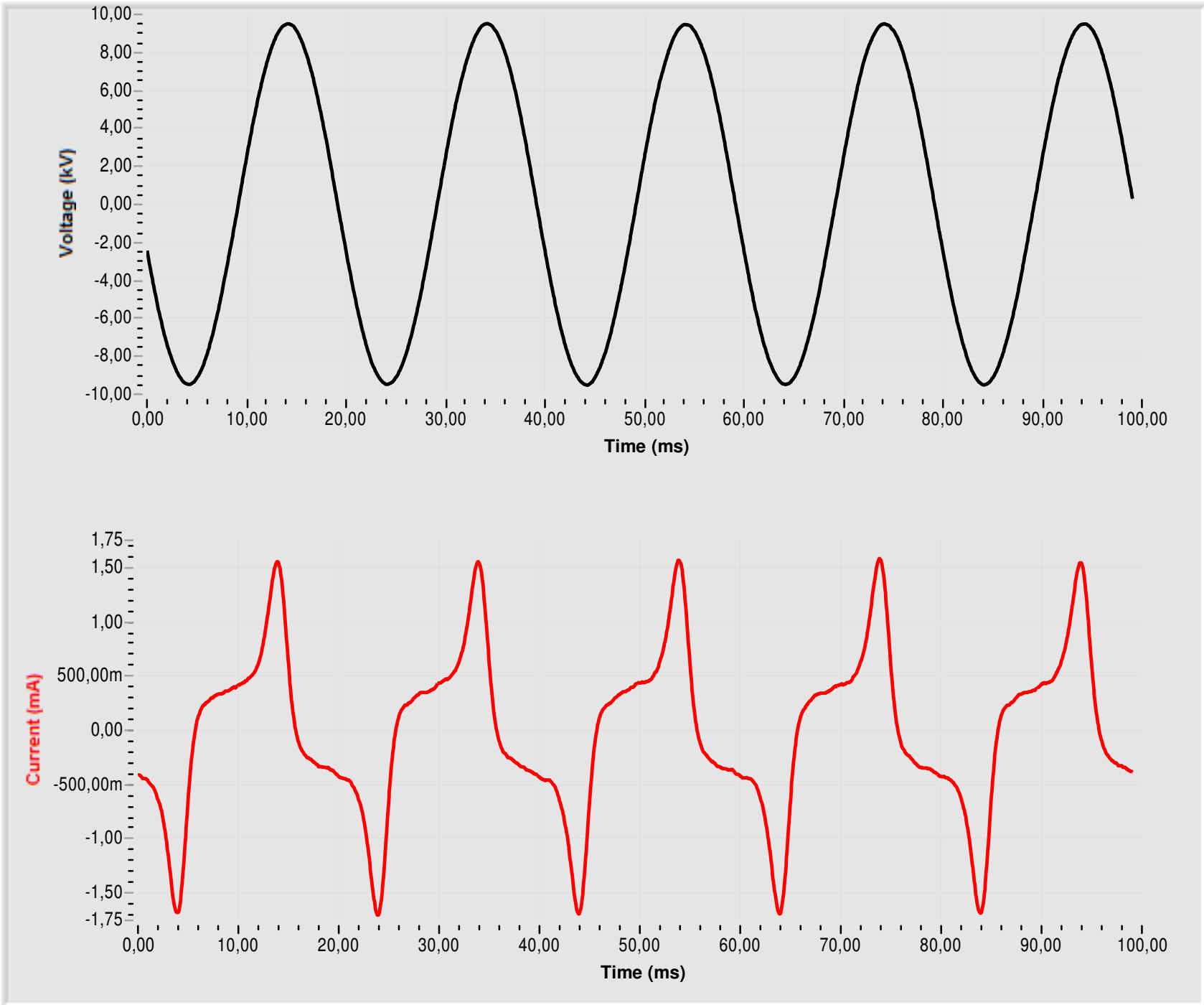

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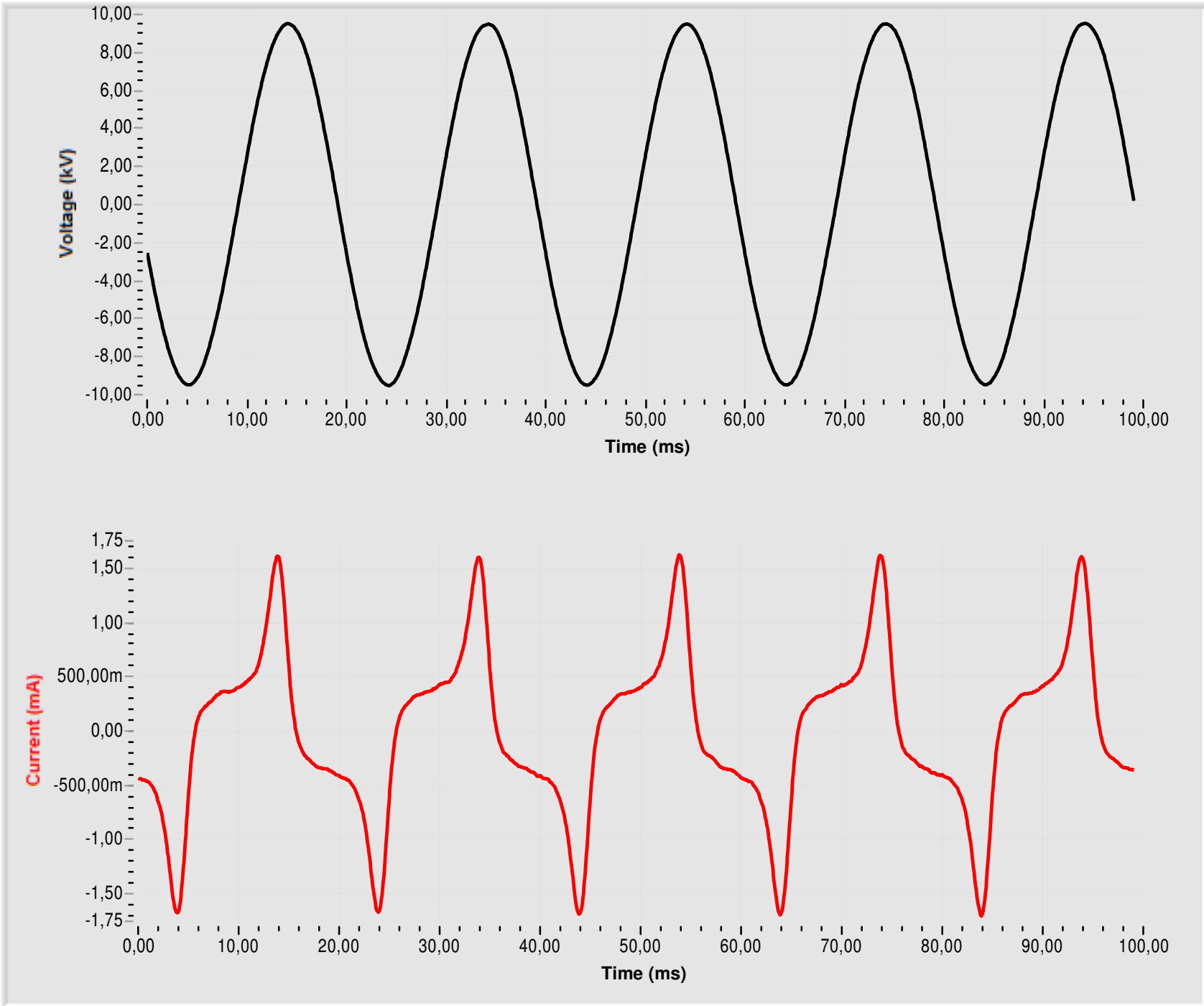

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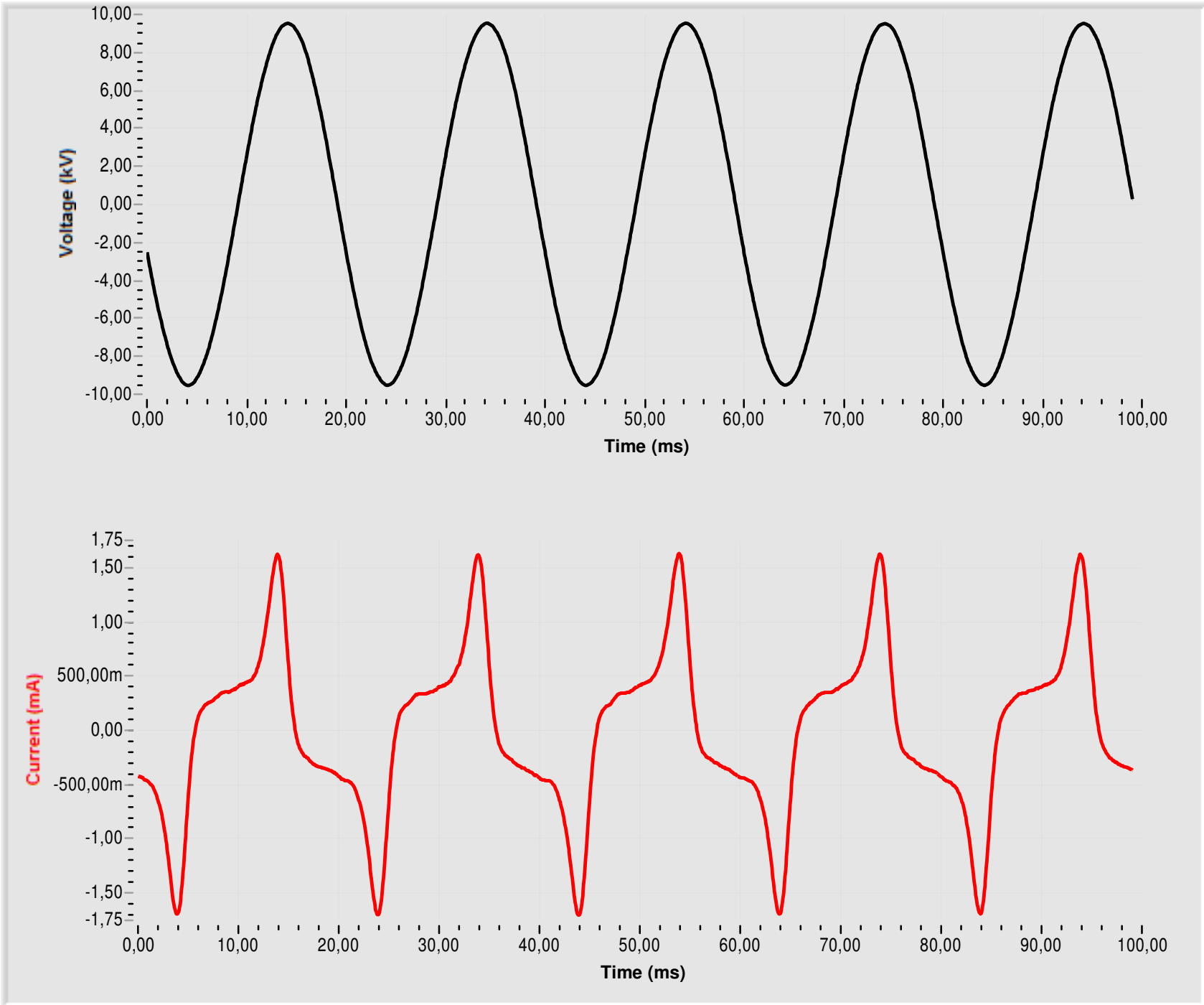

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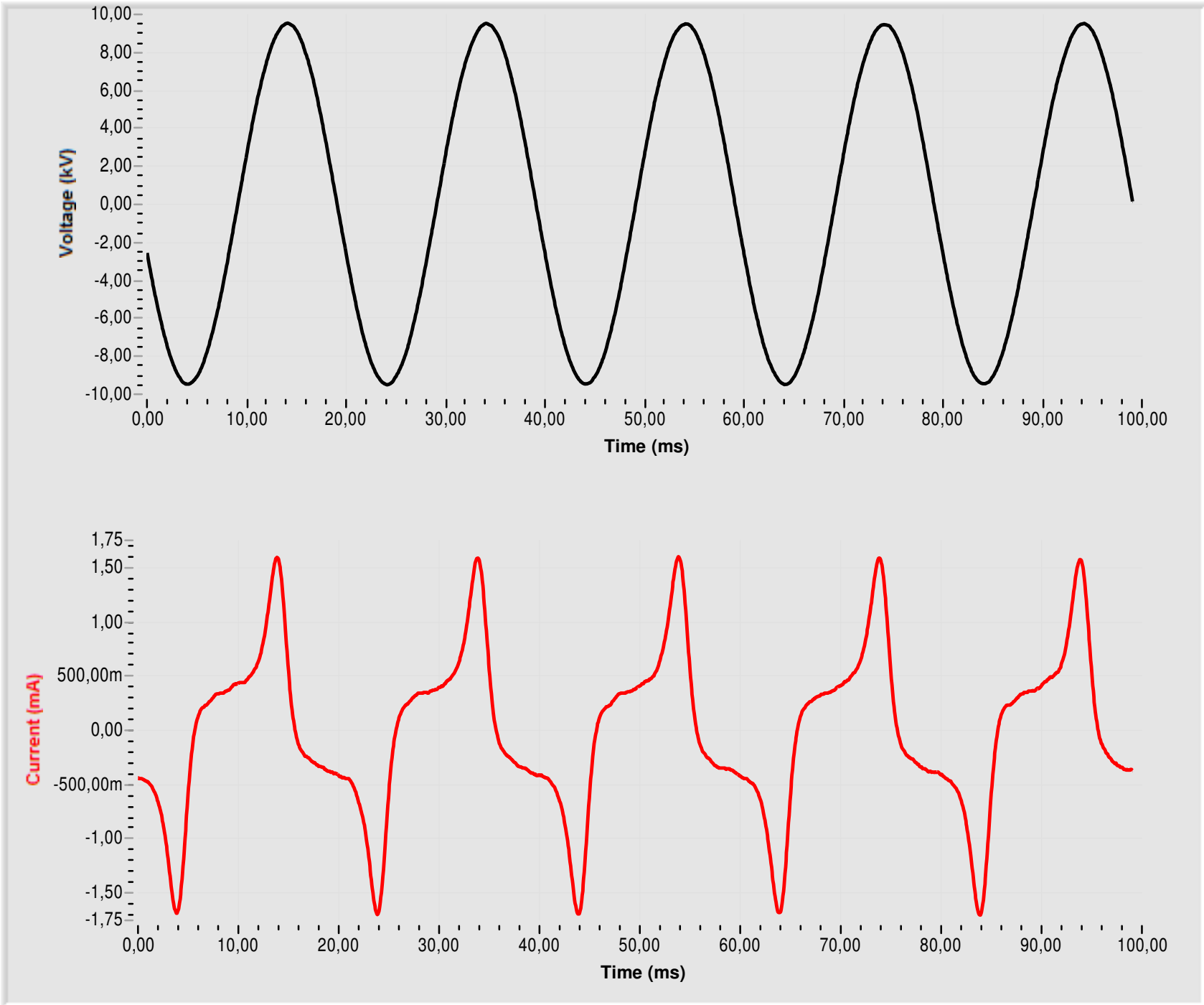

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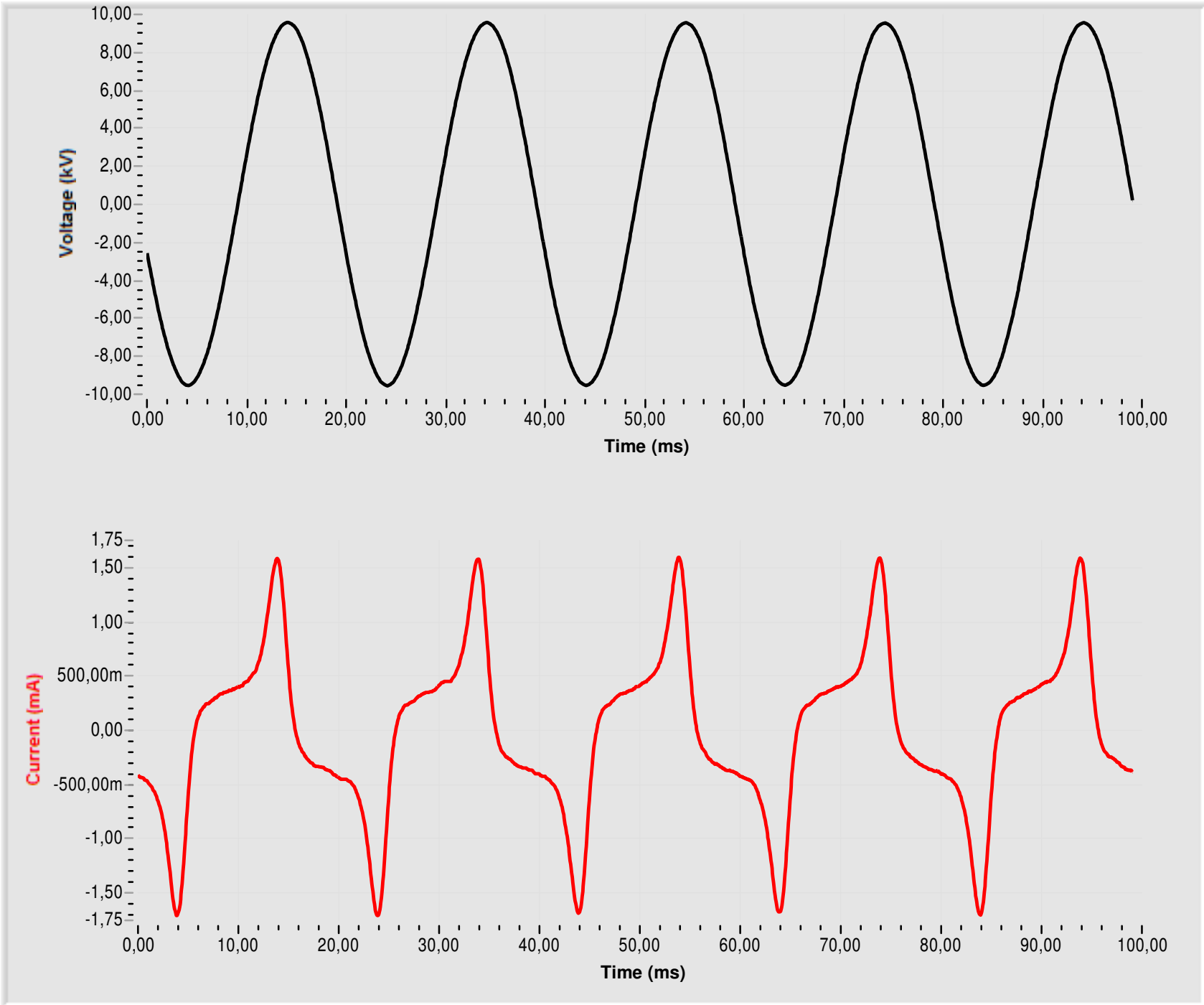

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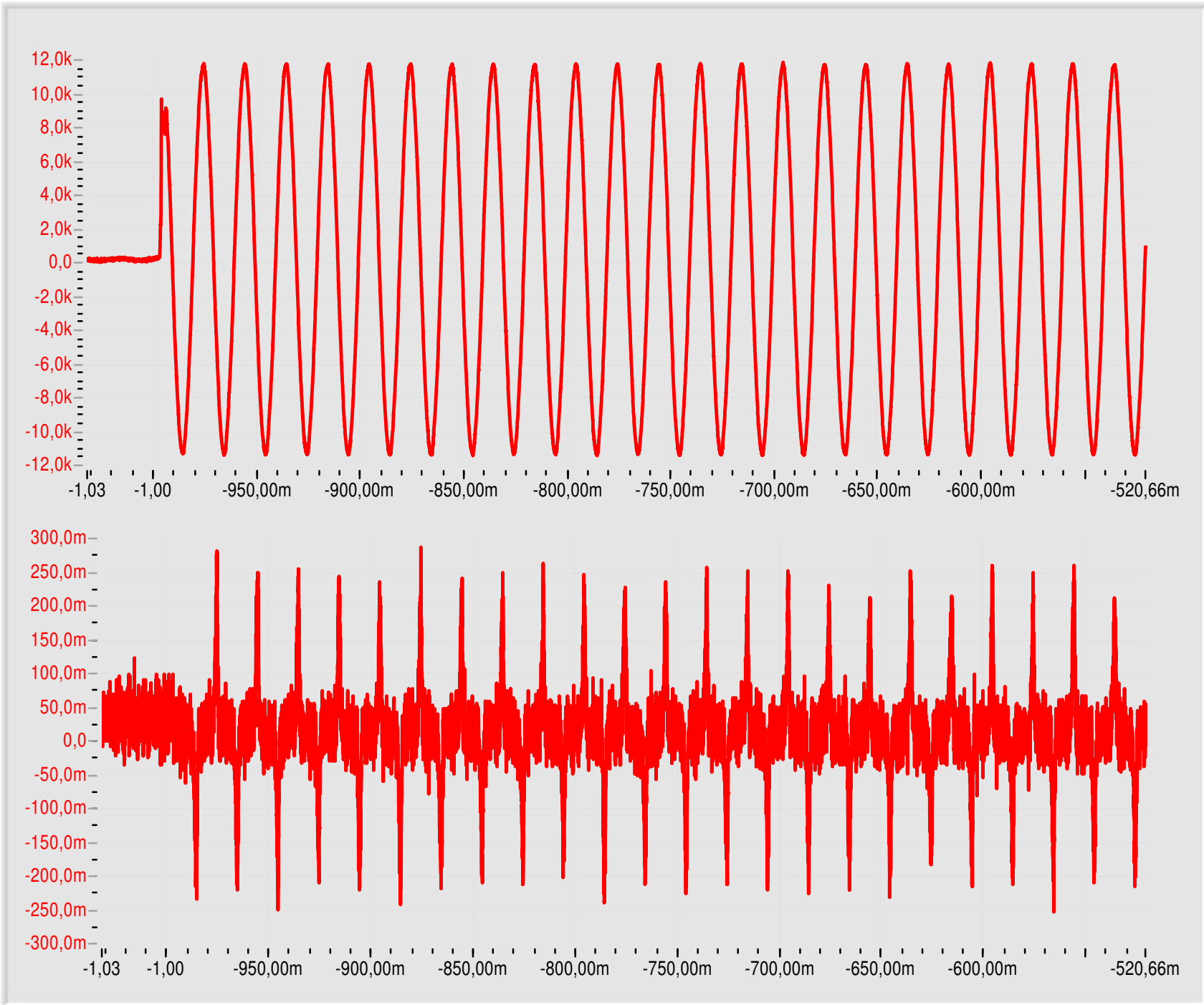

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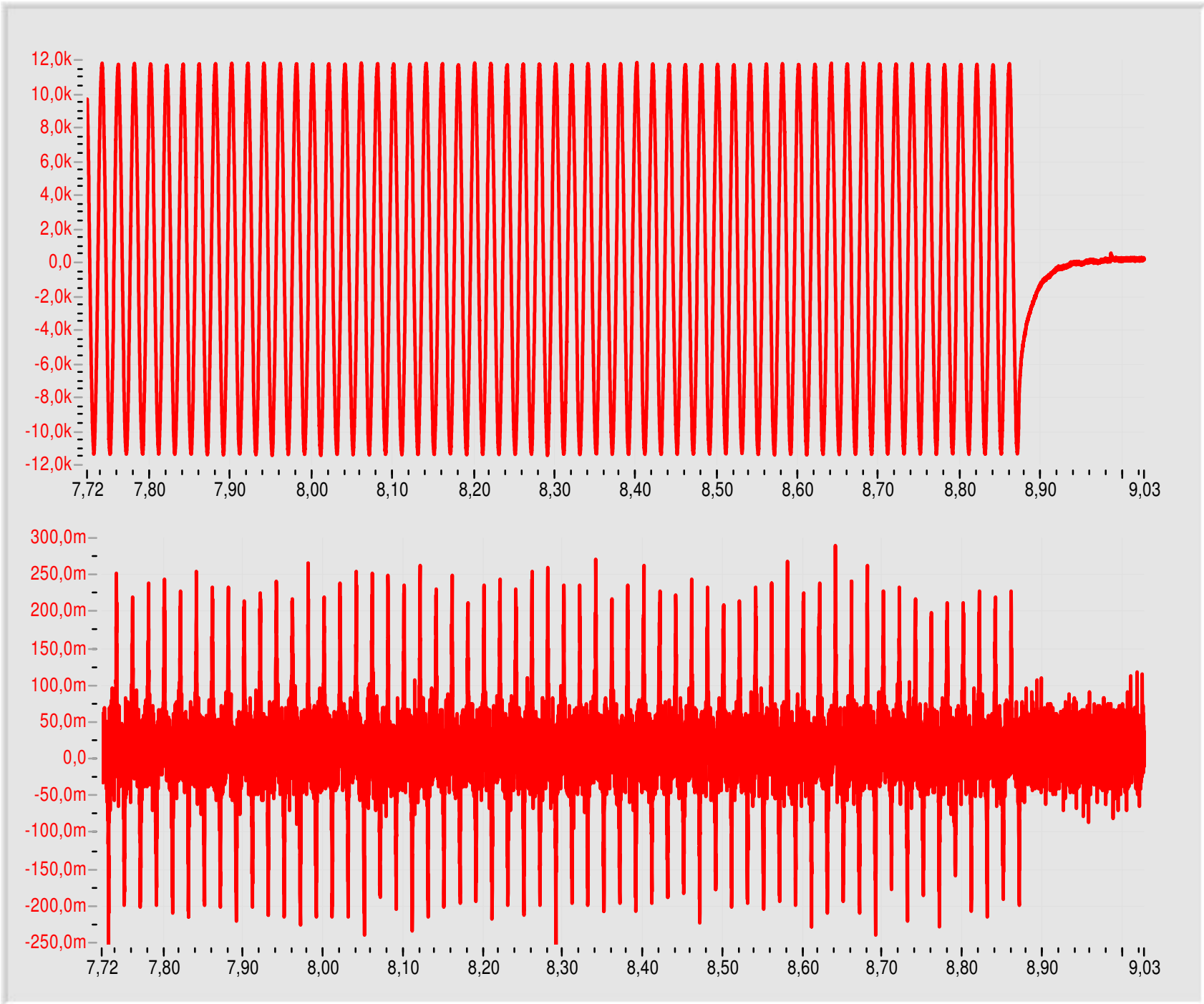

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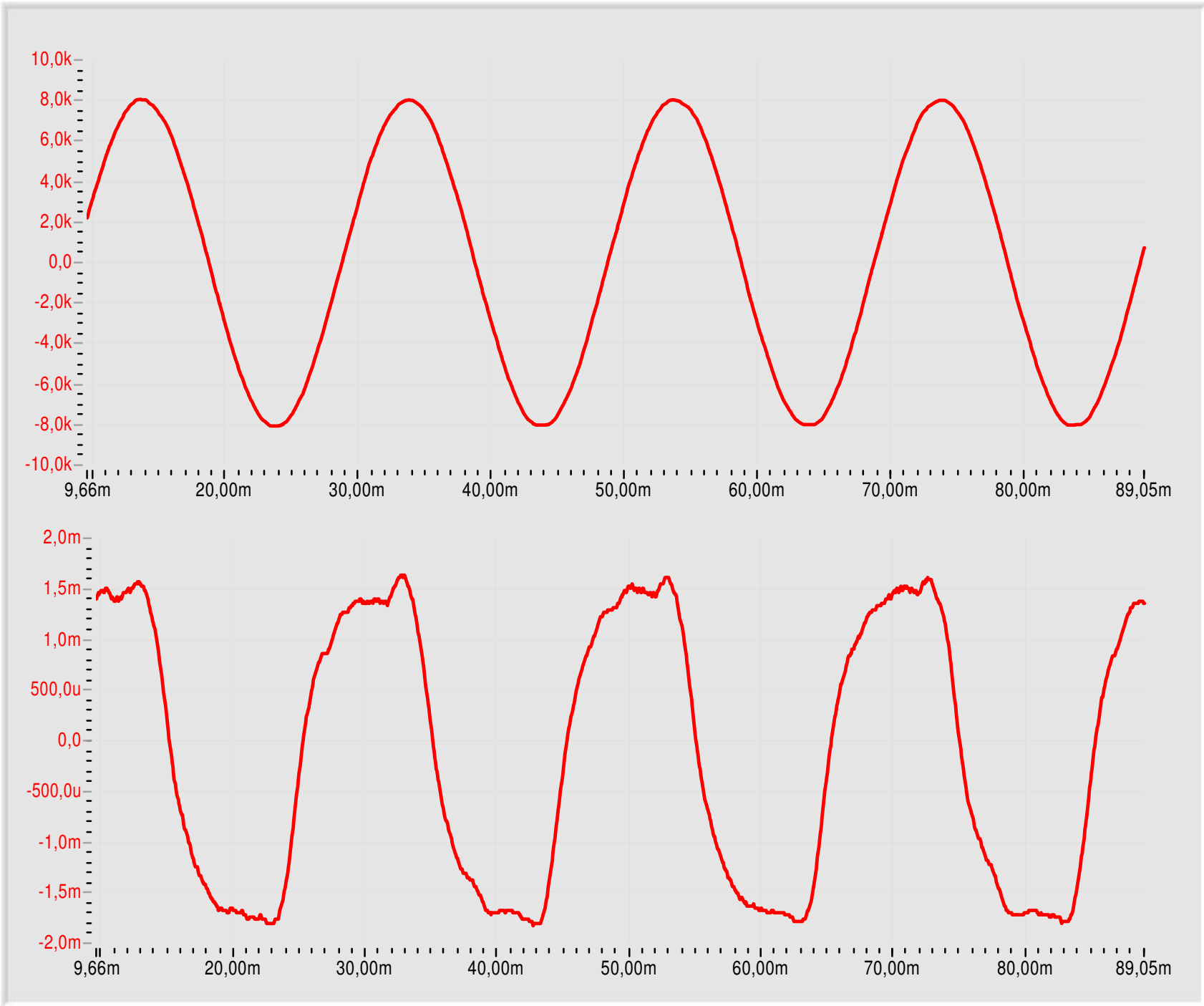

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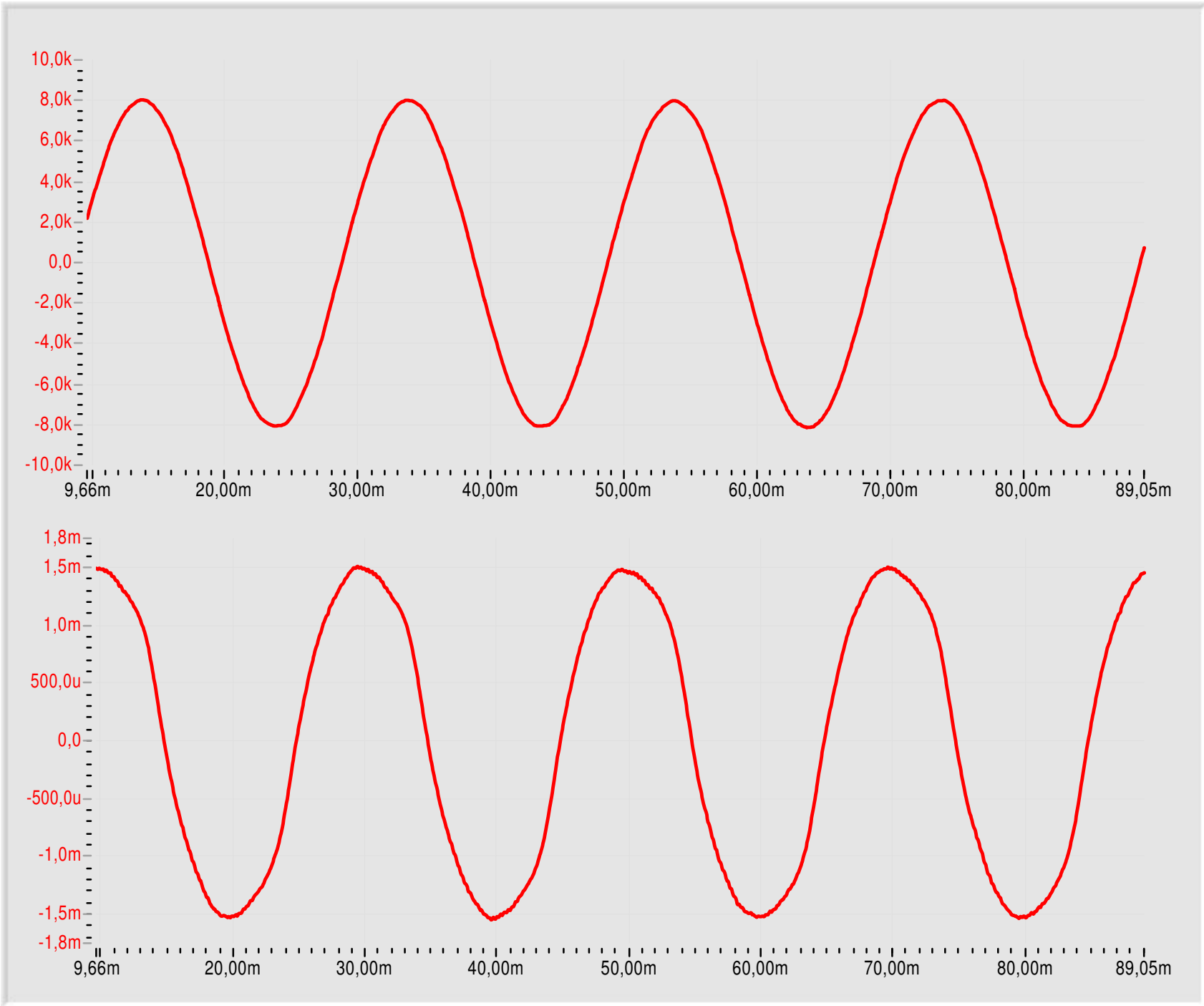

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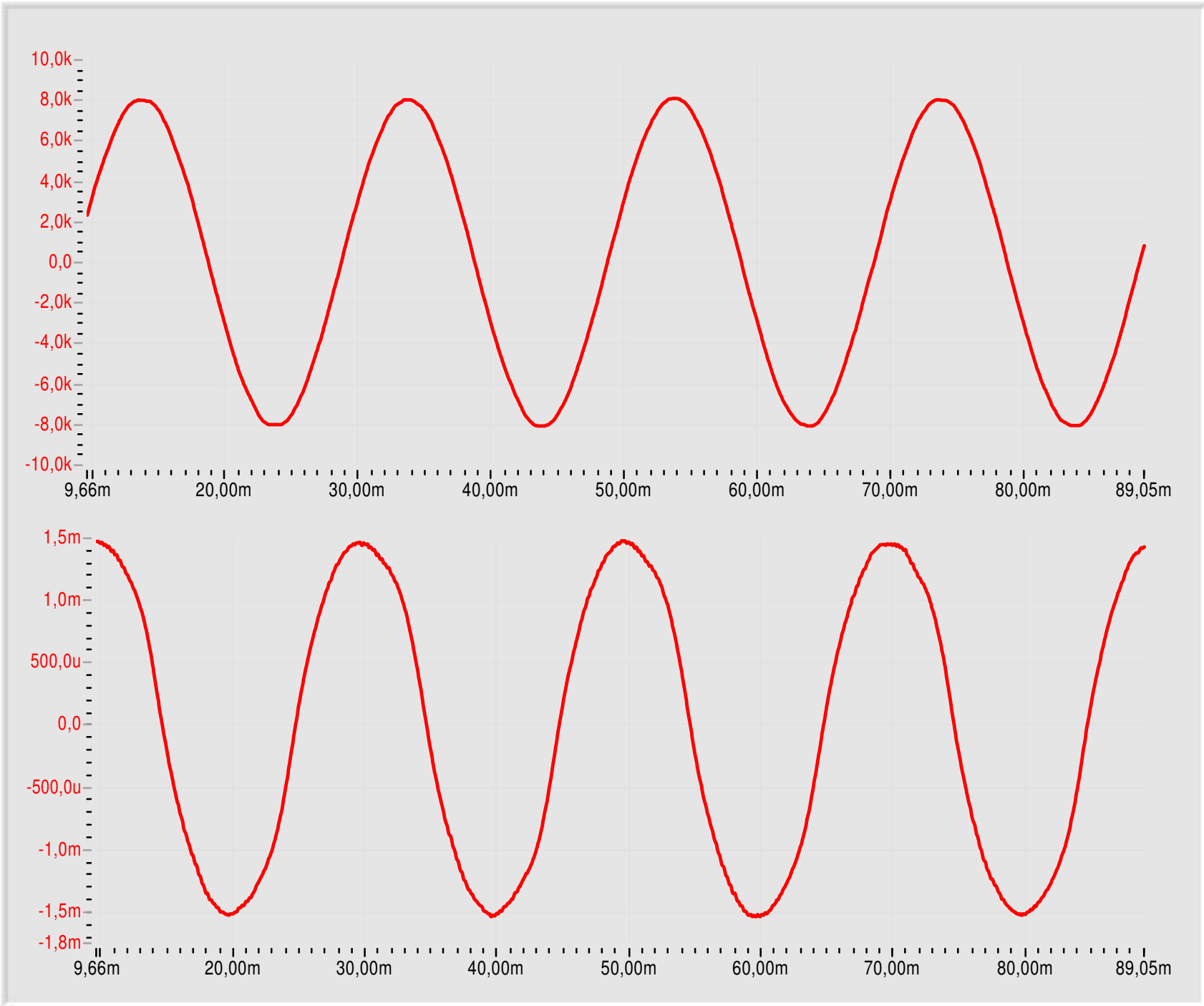

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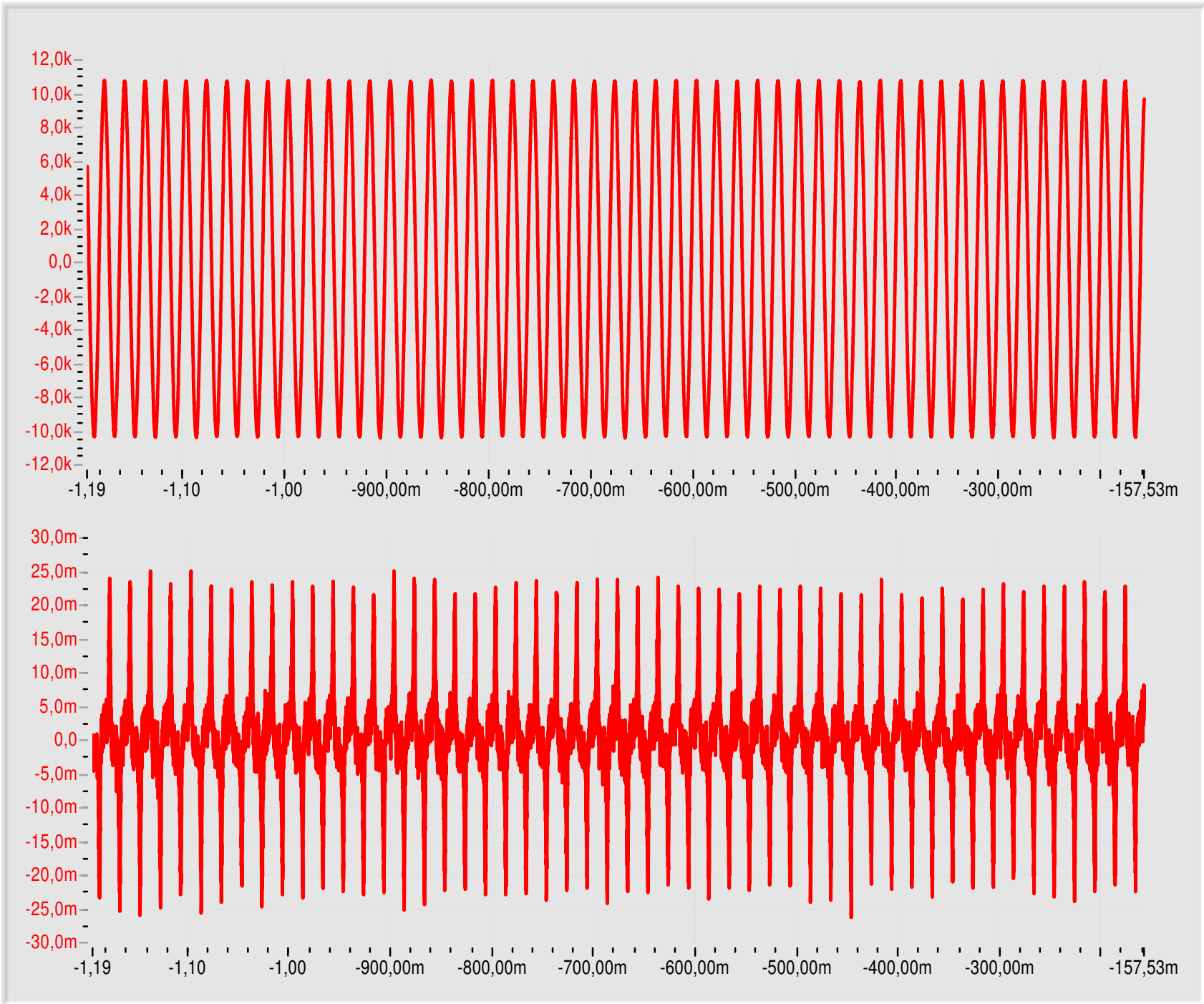

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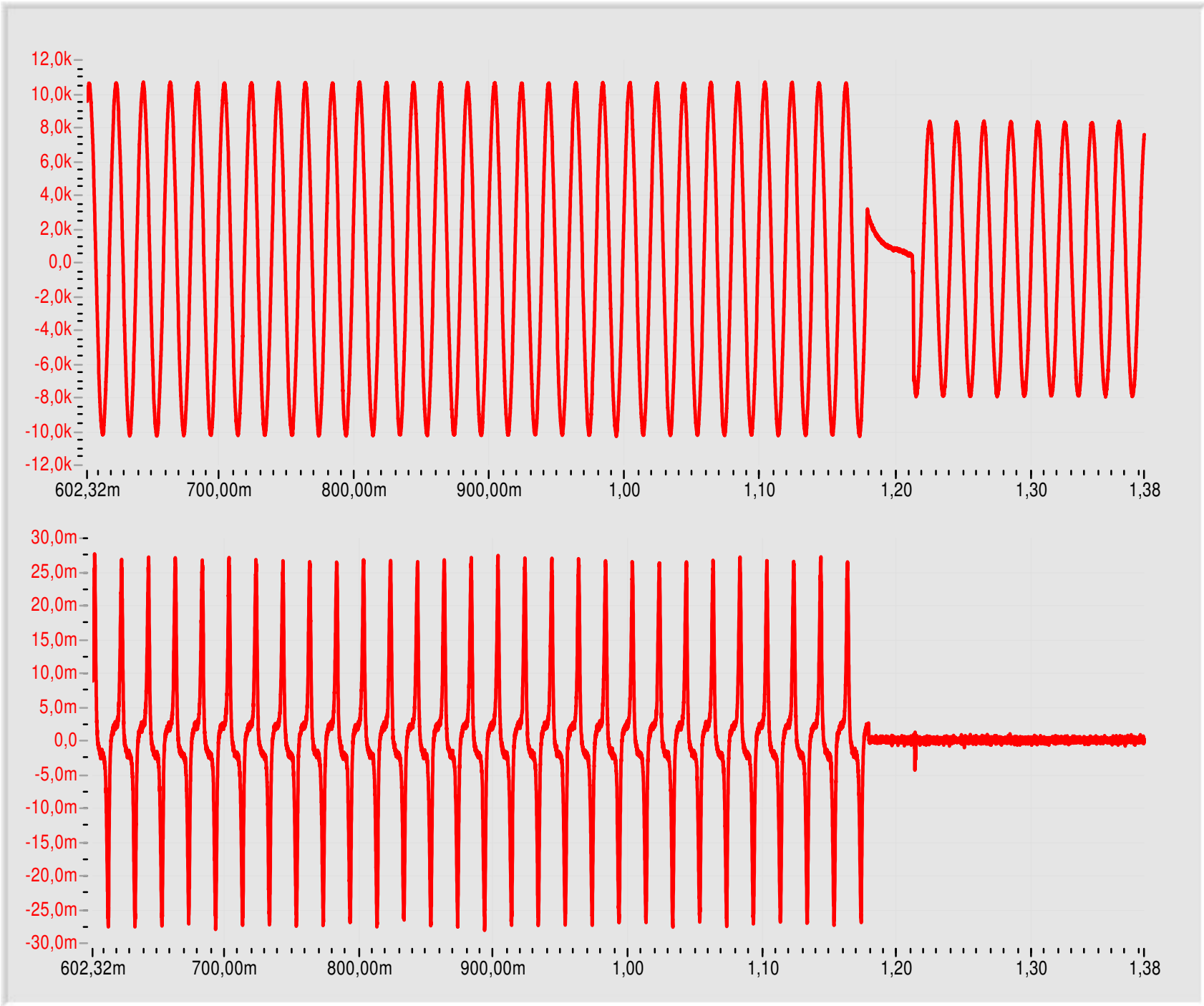

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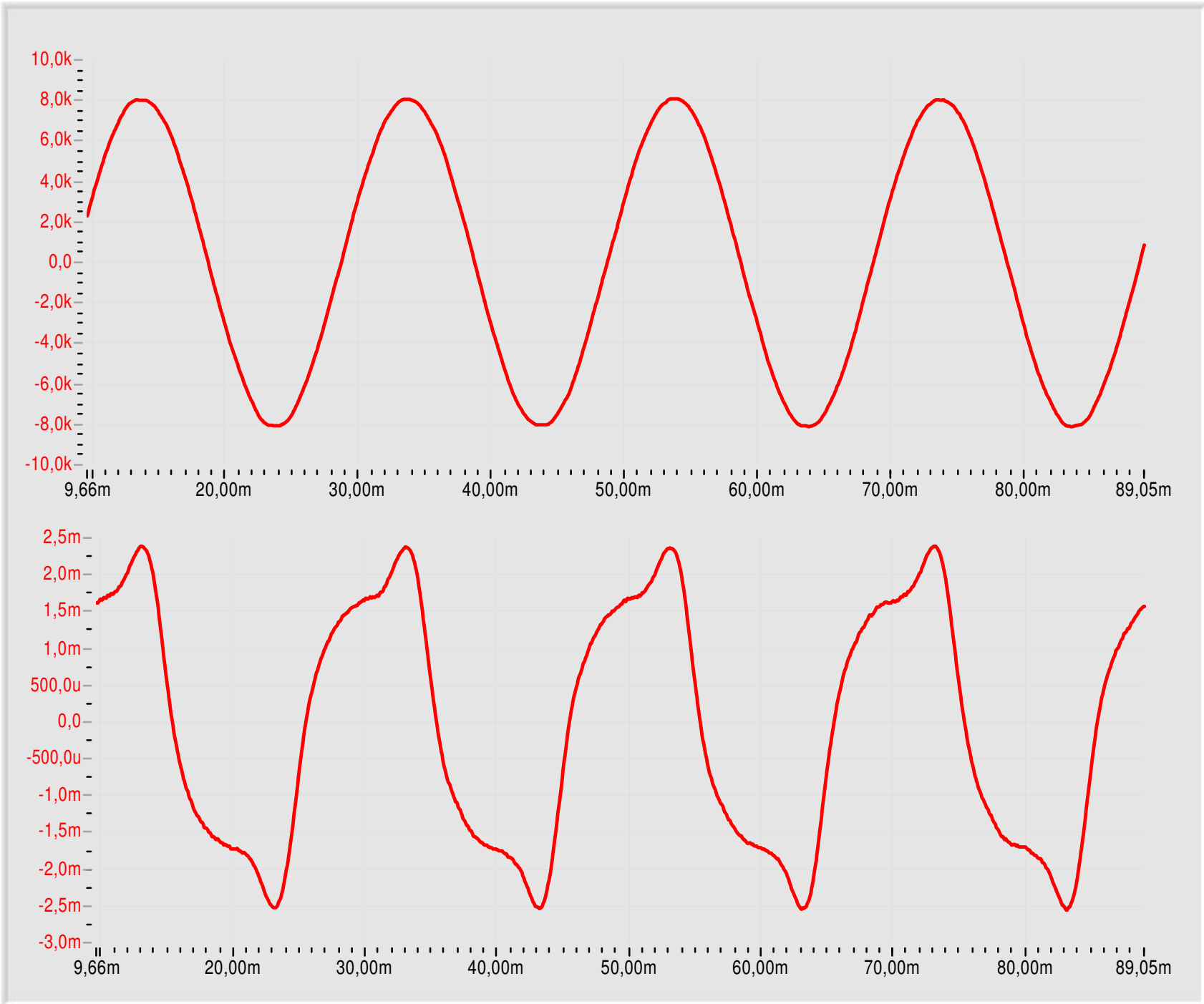

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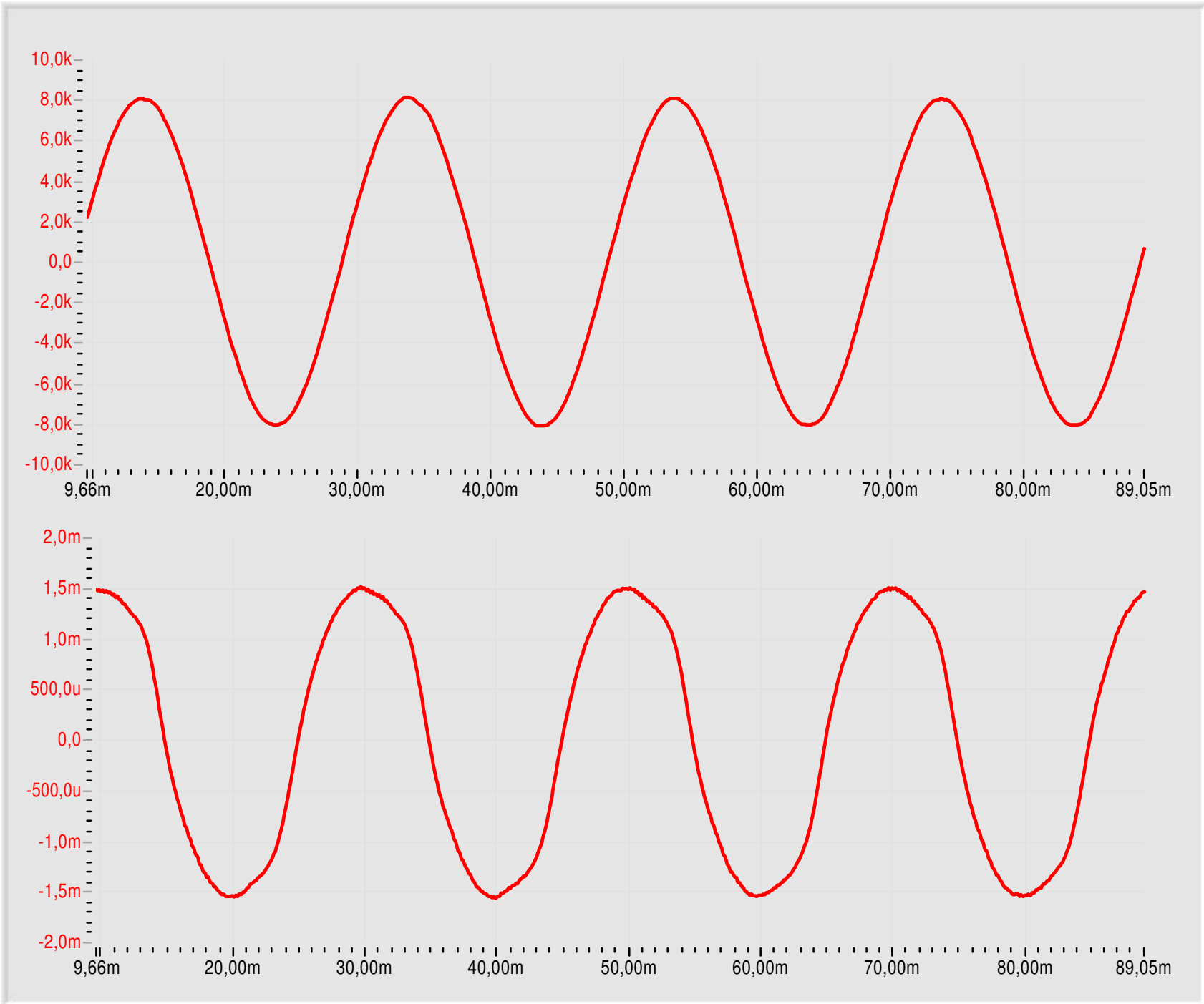

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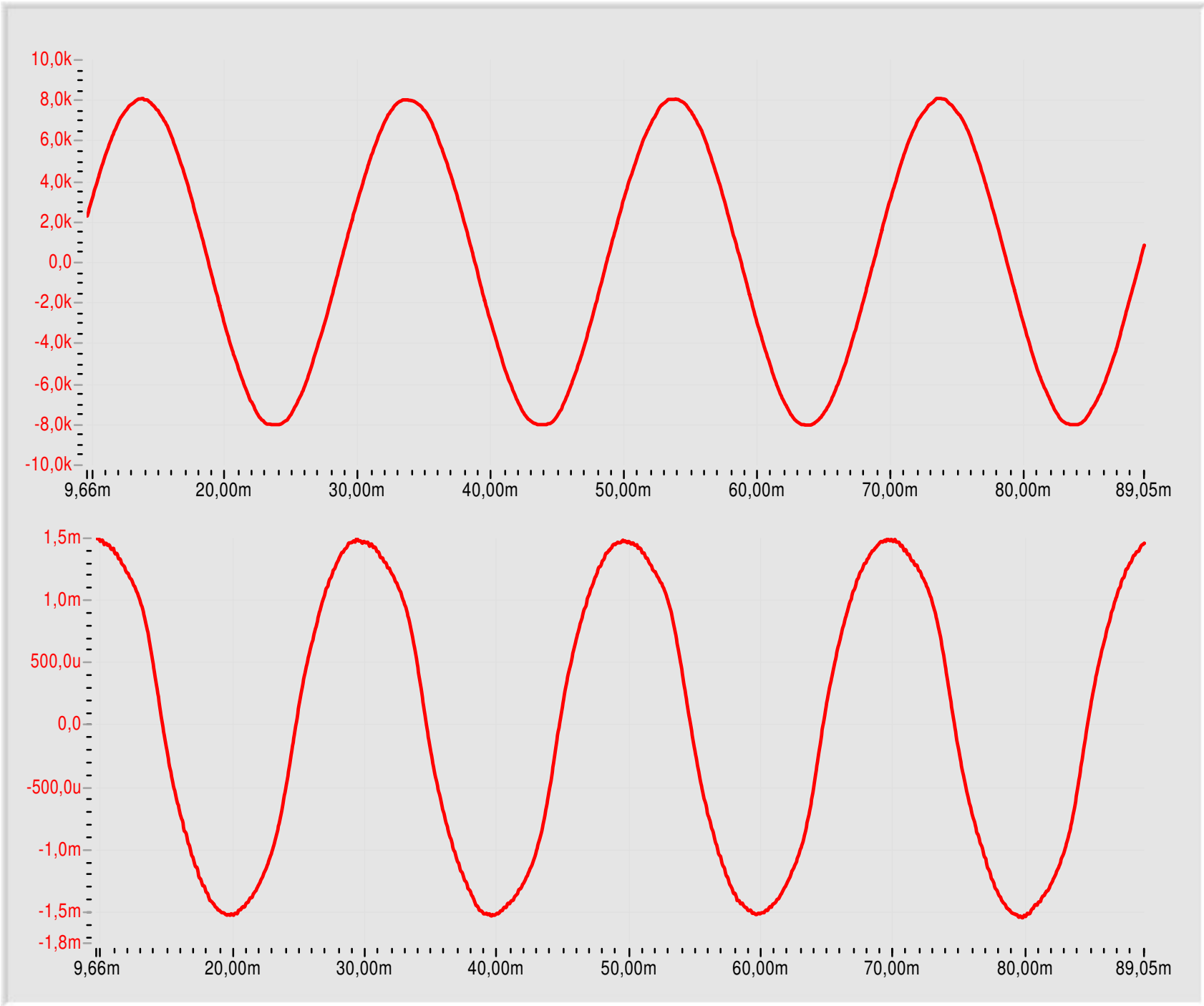

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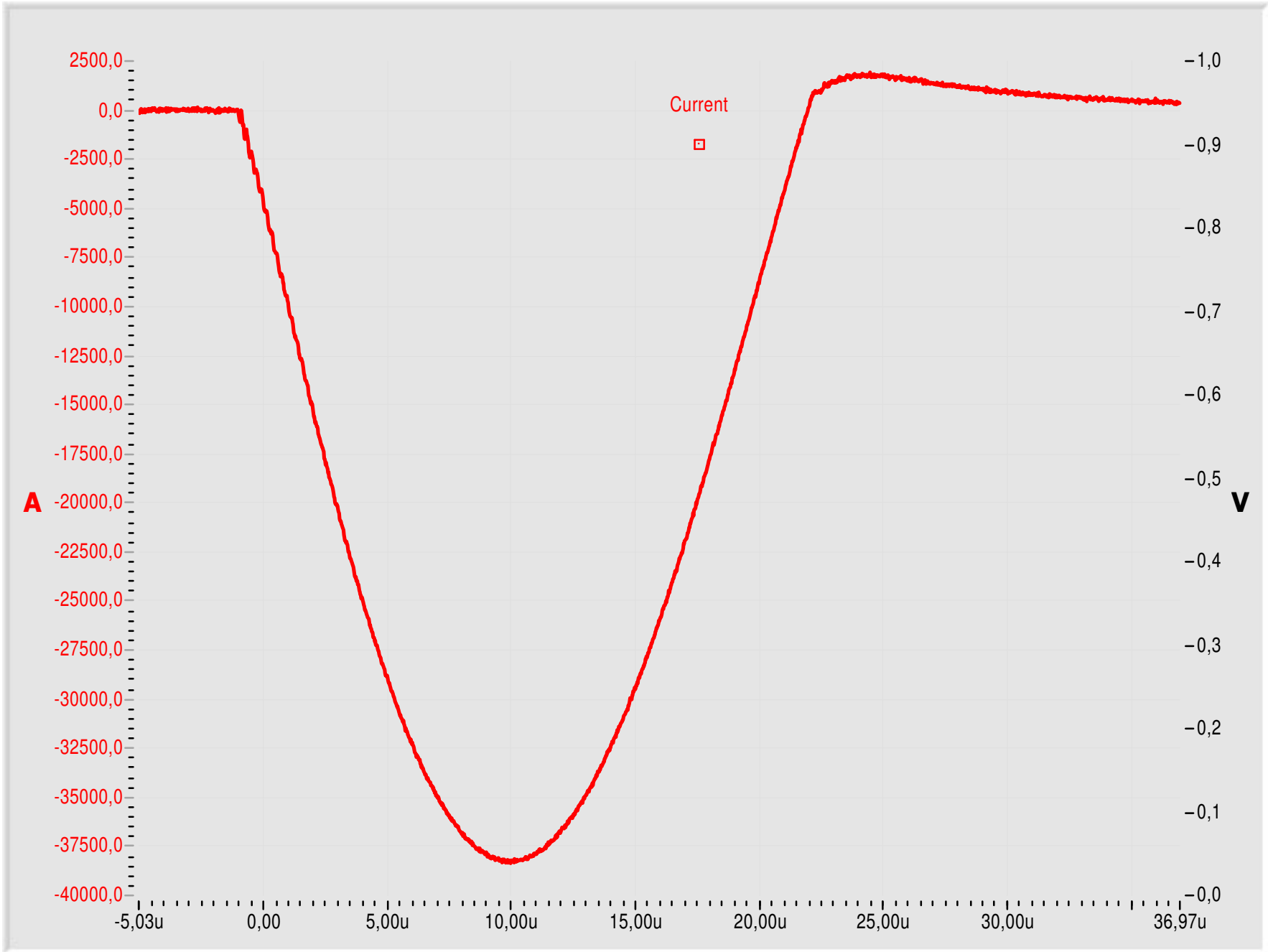
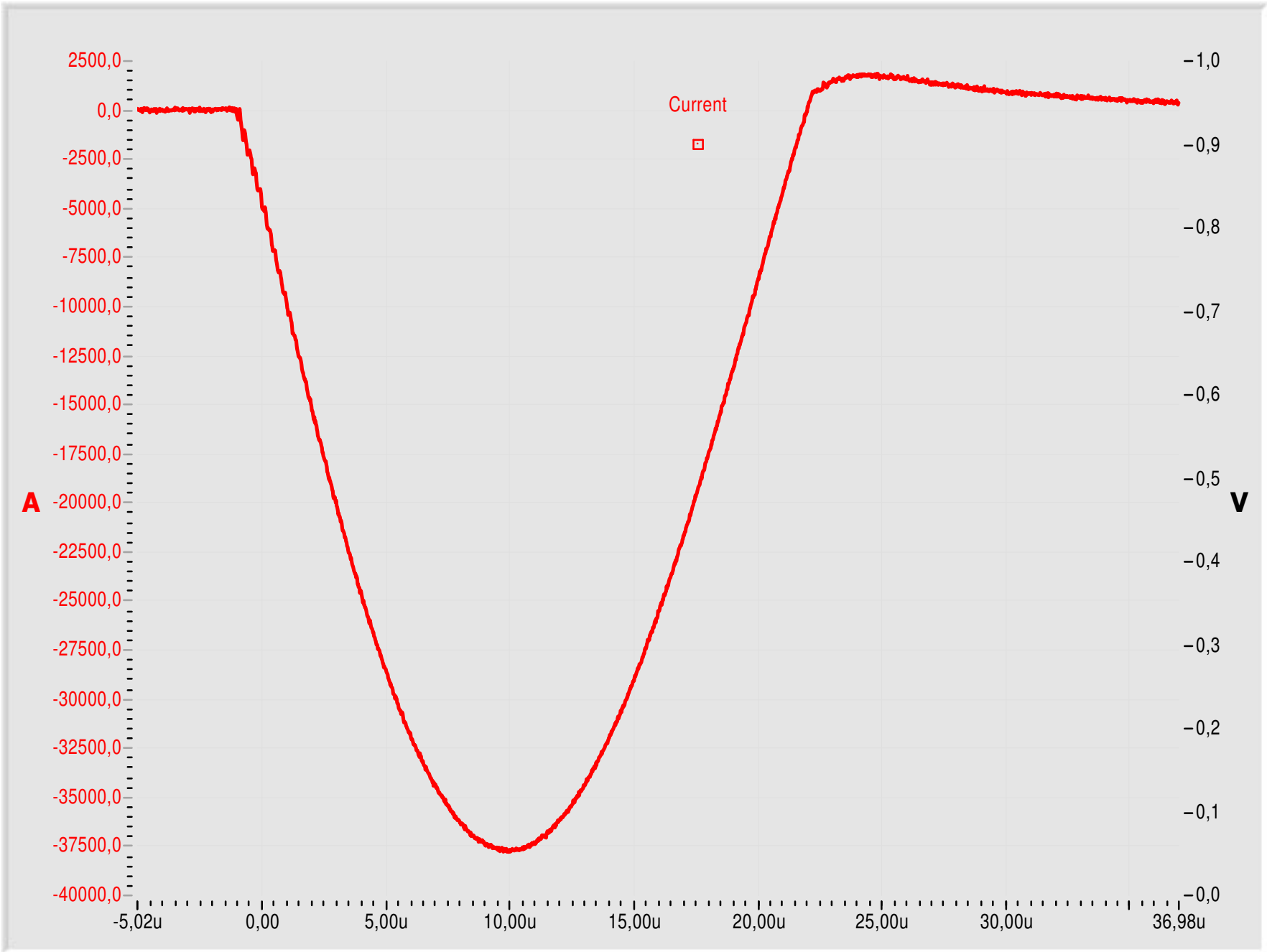


CESI C1004957 Oscillogram n. 24



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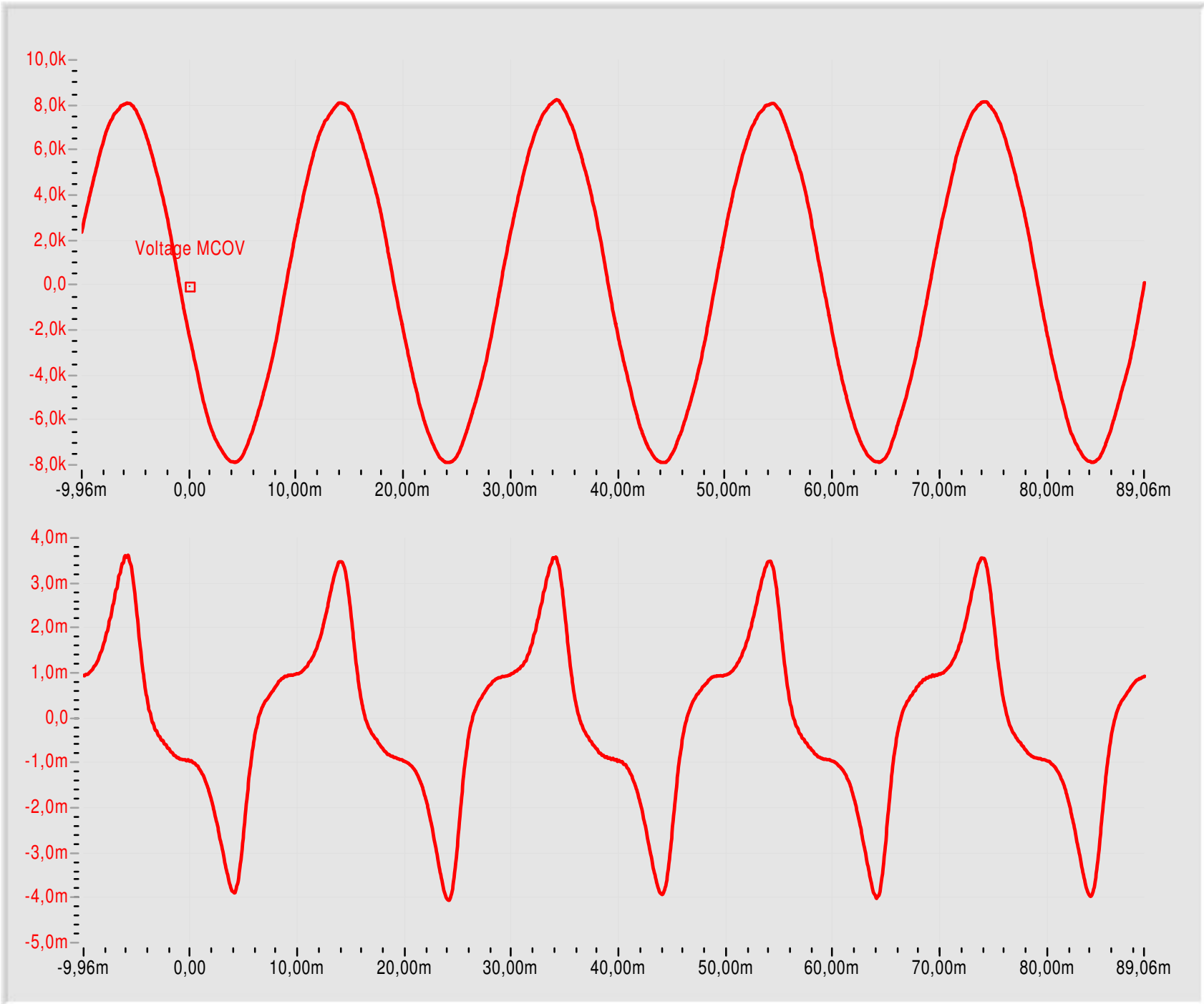

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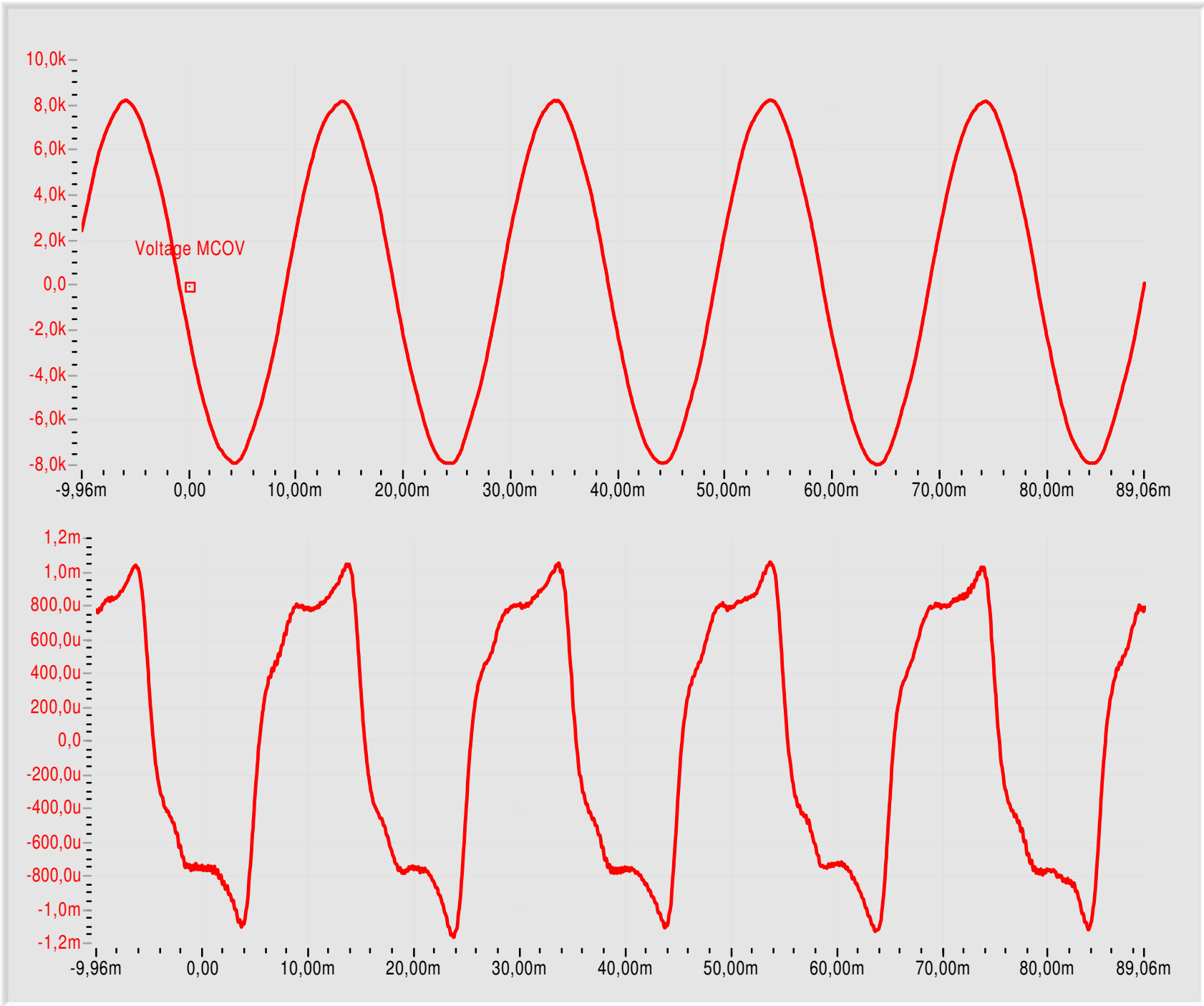

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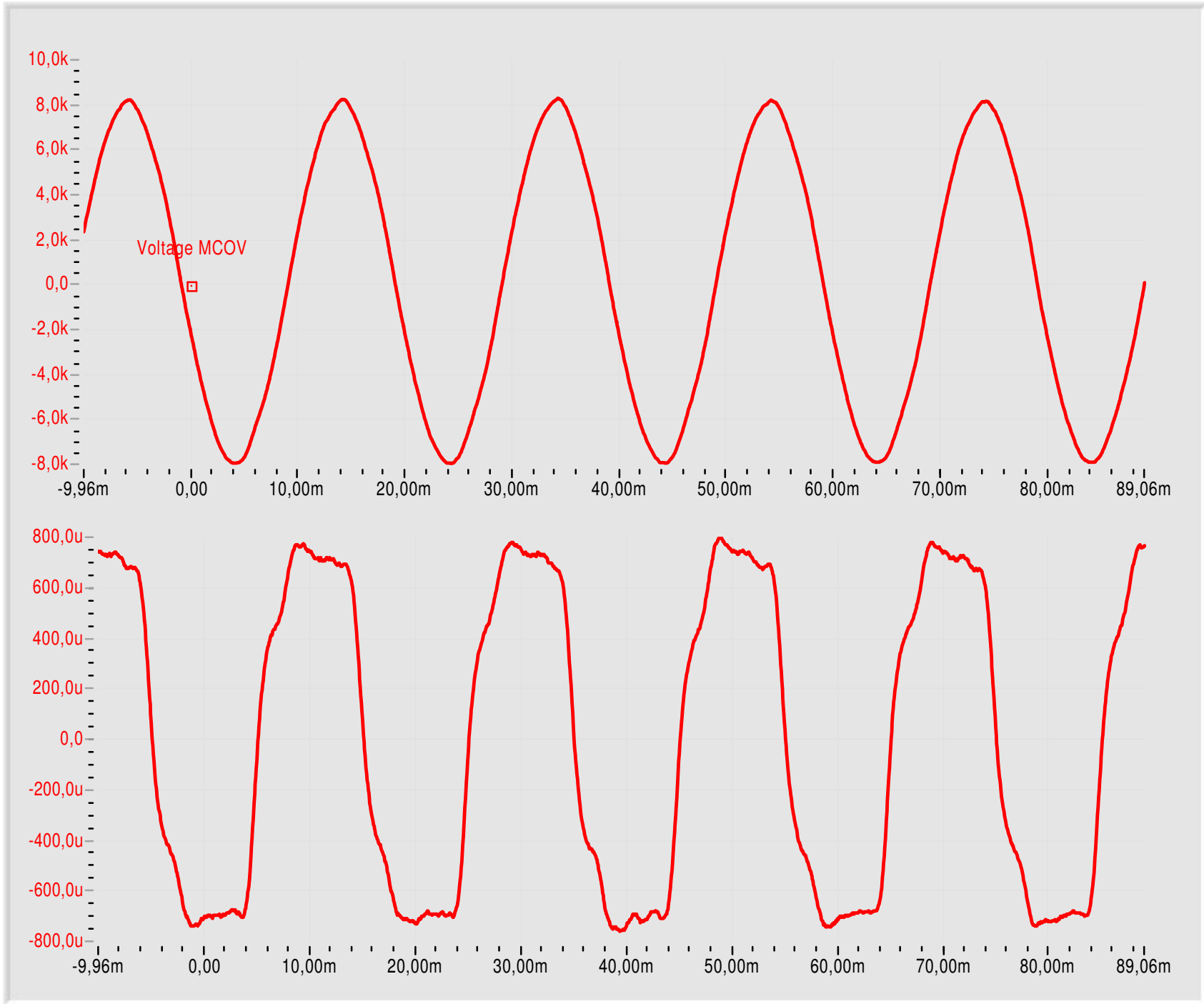

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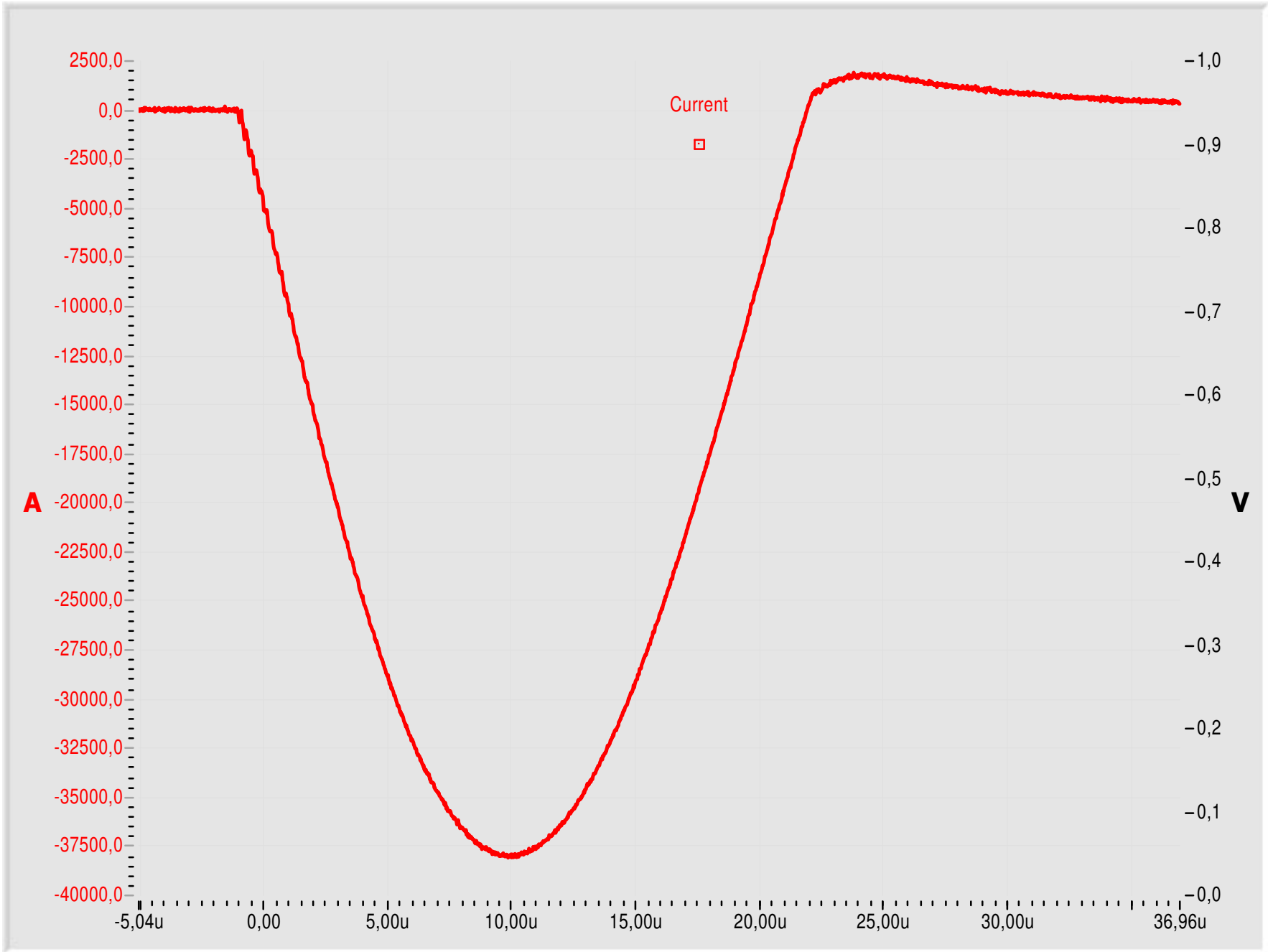

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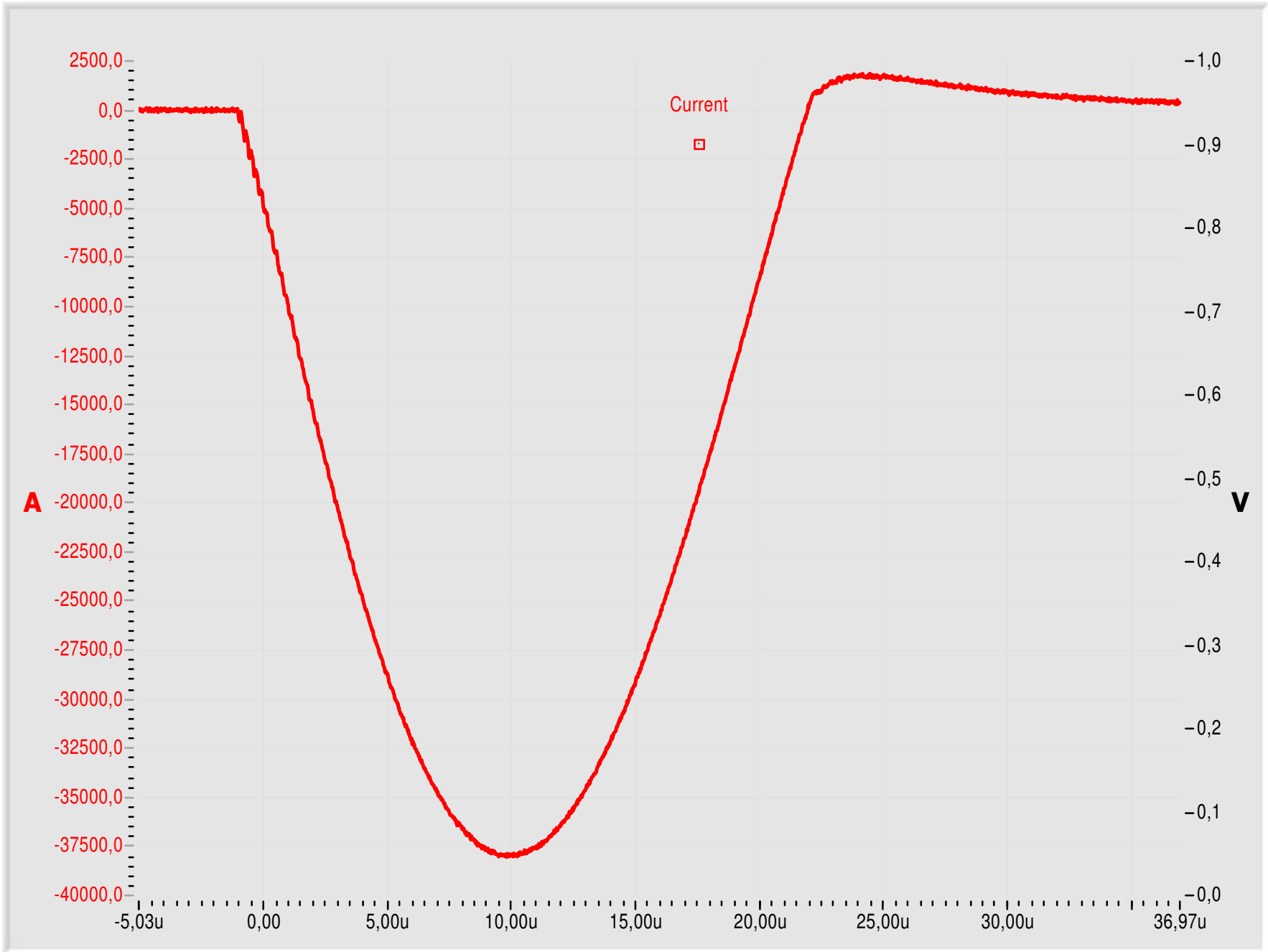

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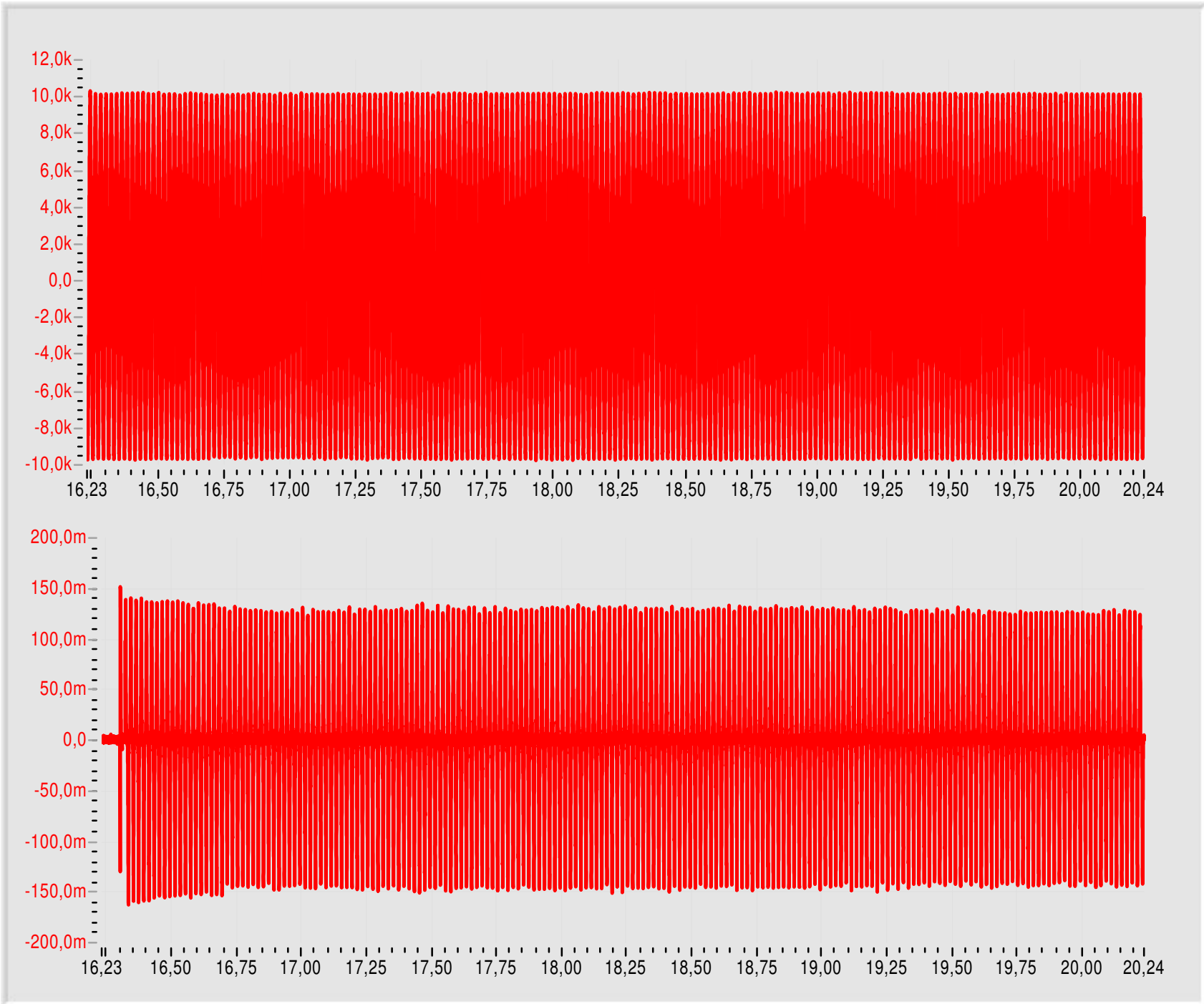

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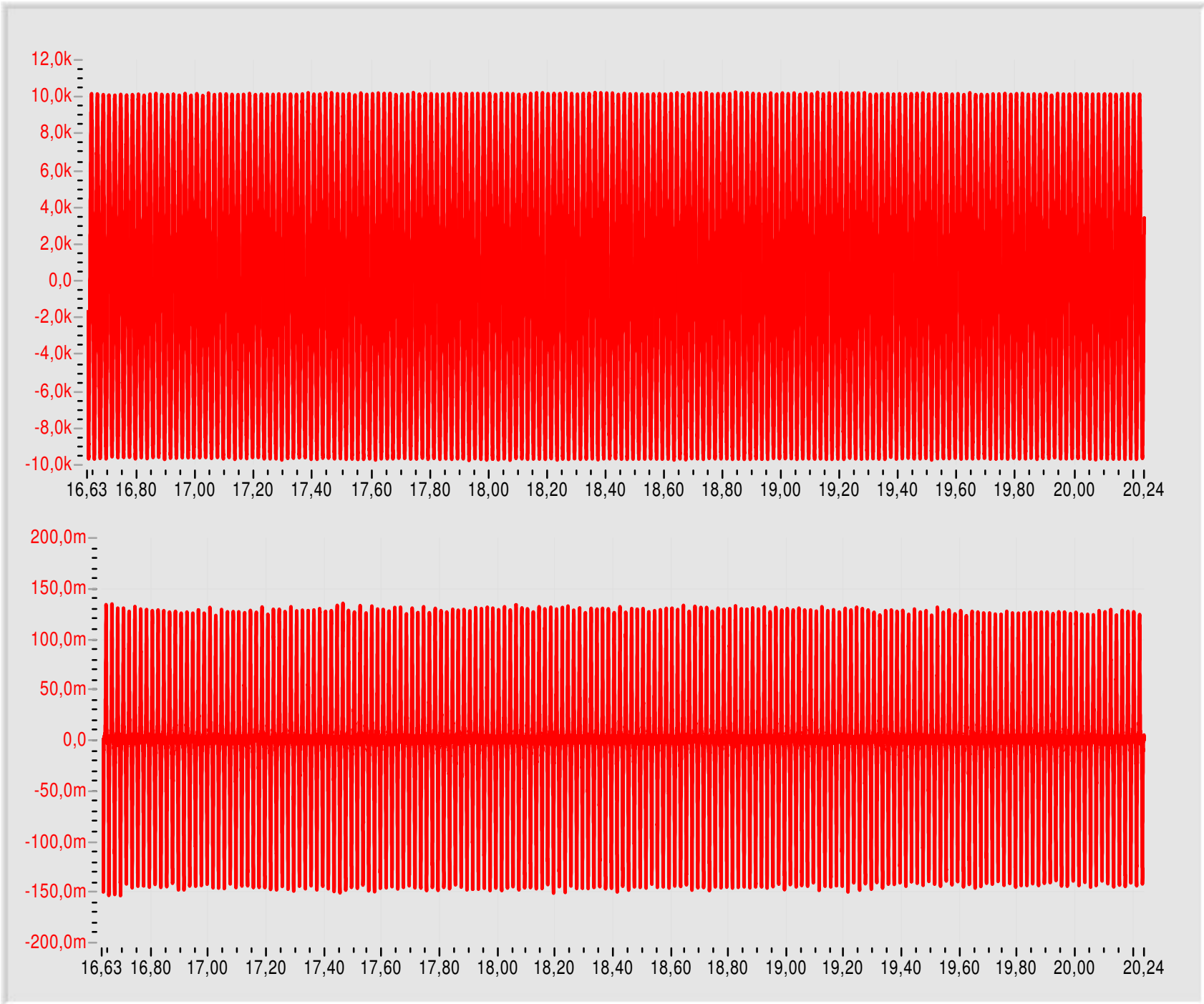
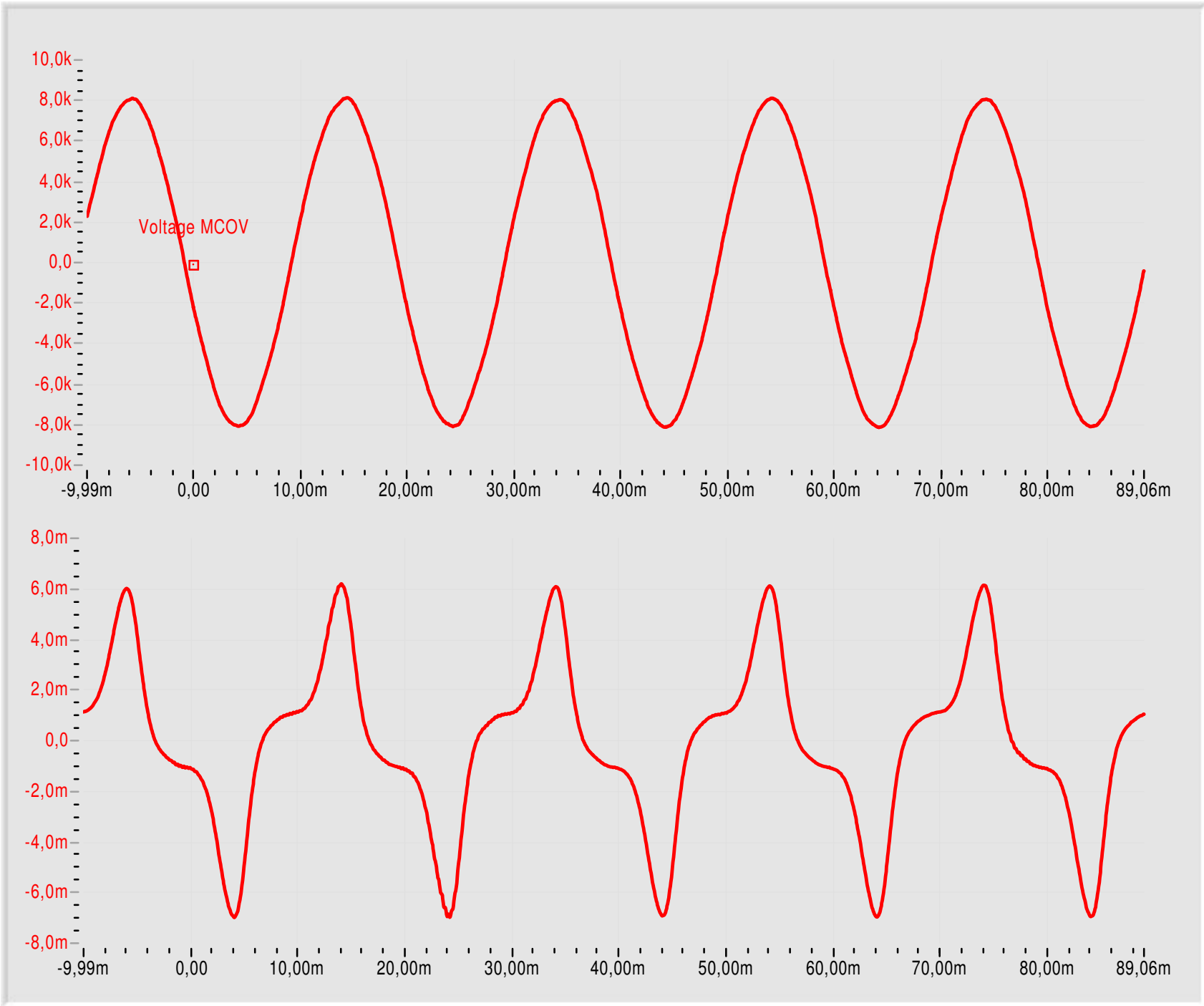


CESI C1004957 Oscillogram n. 34



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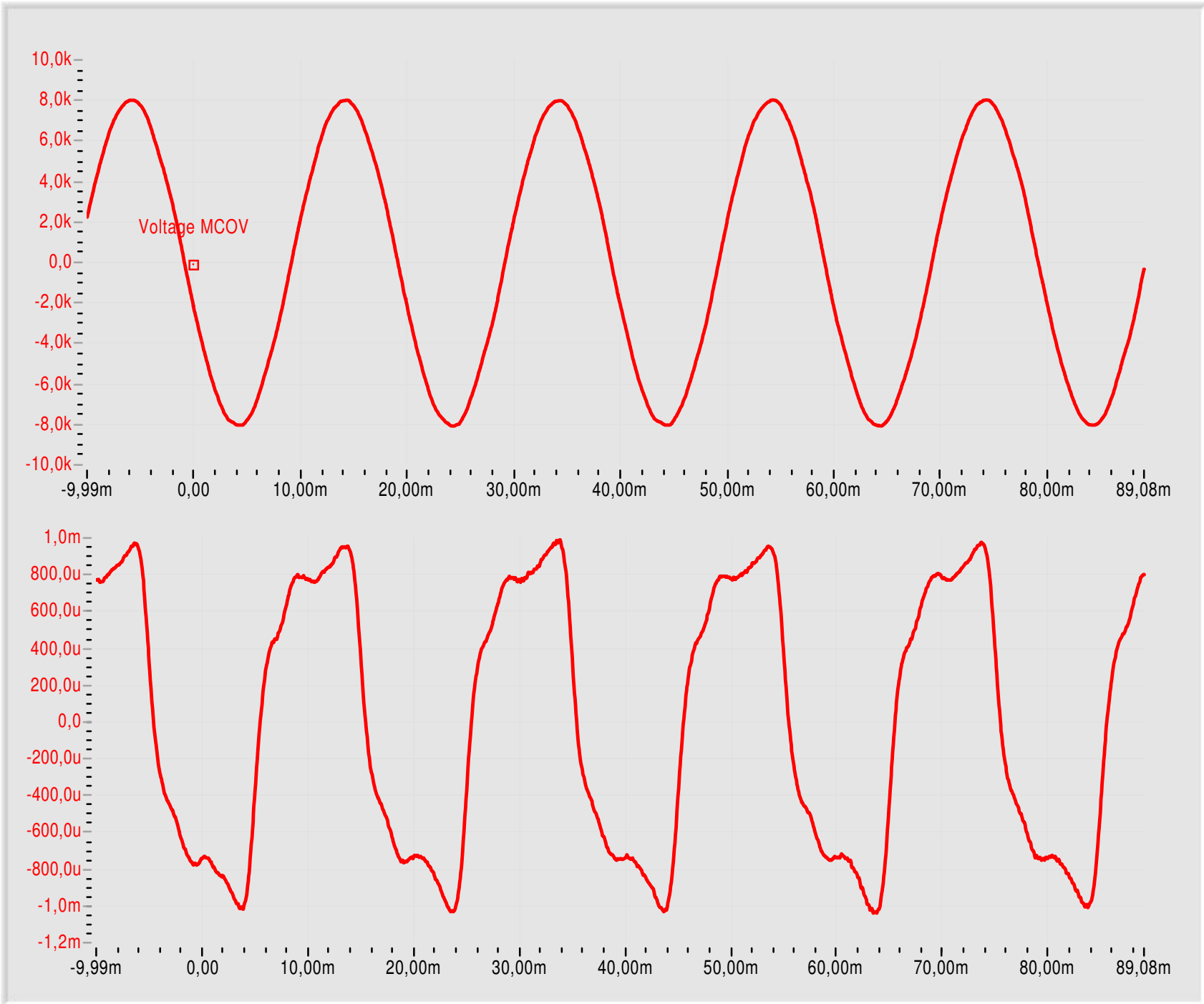
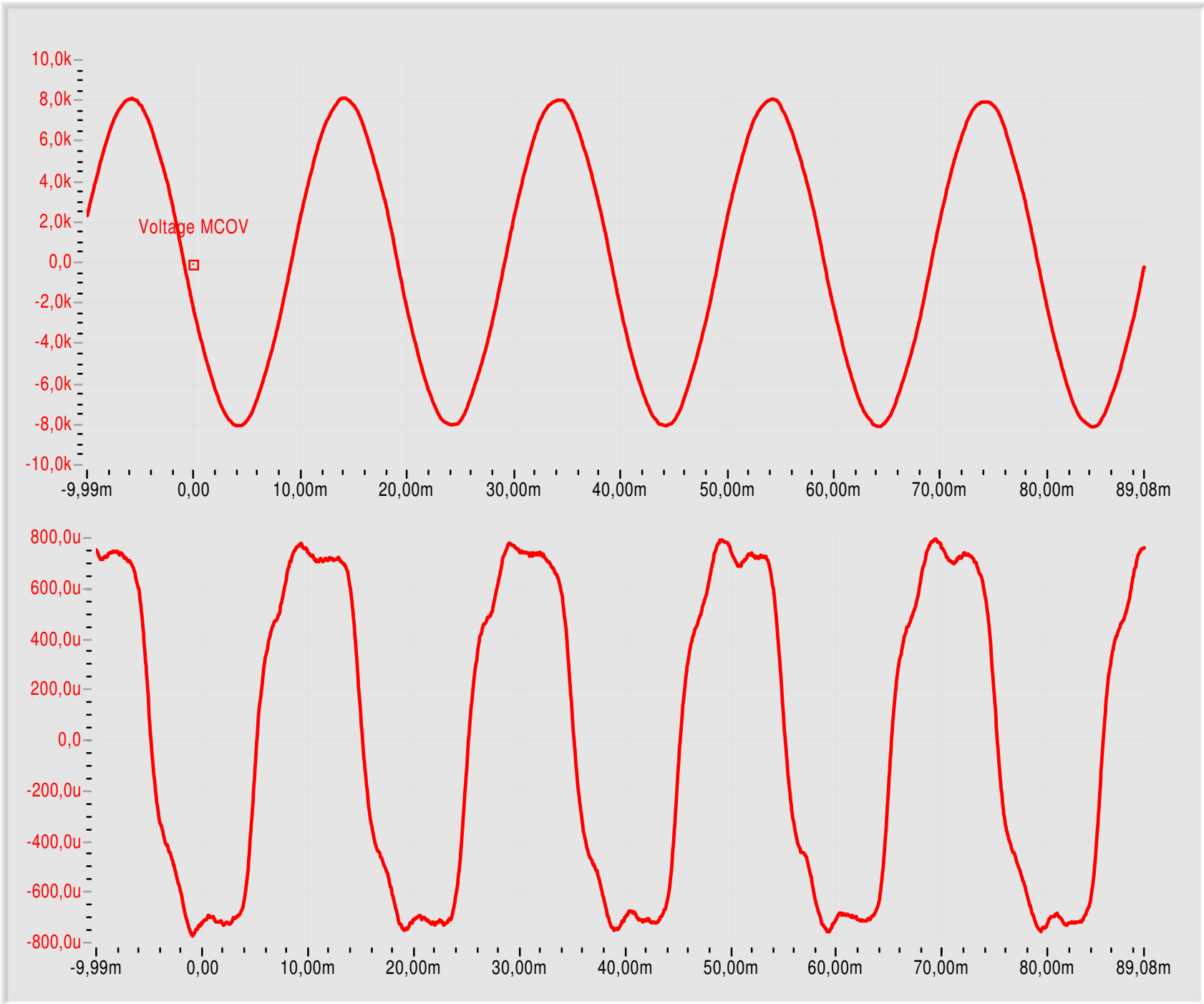


CESI C1004957 Oscillogram n. 36



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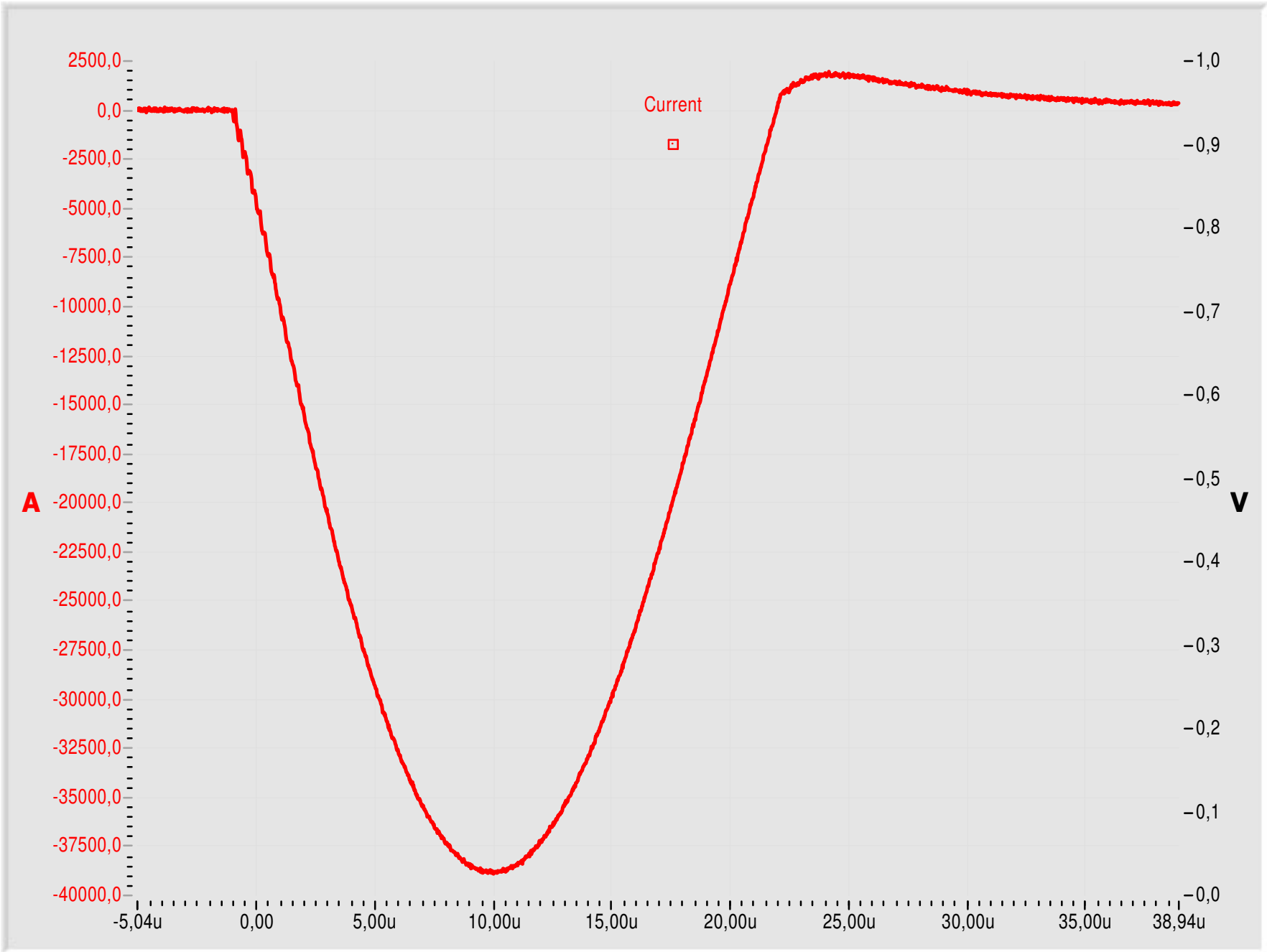
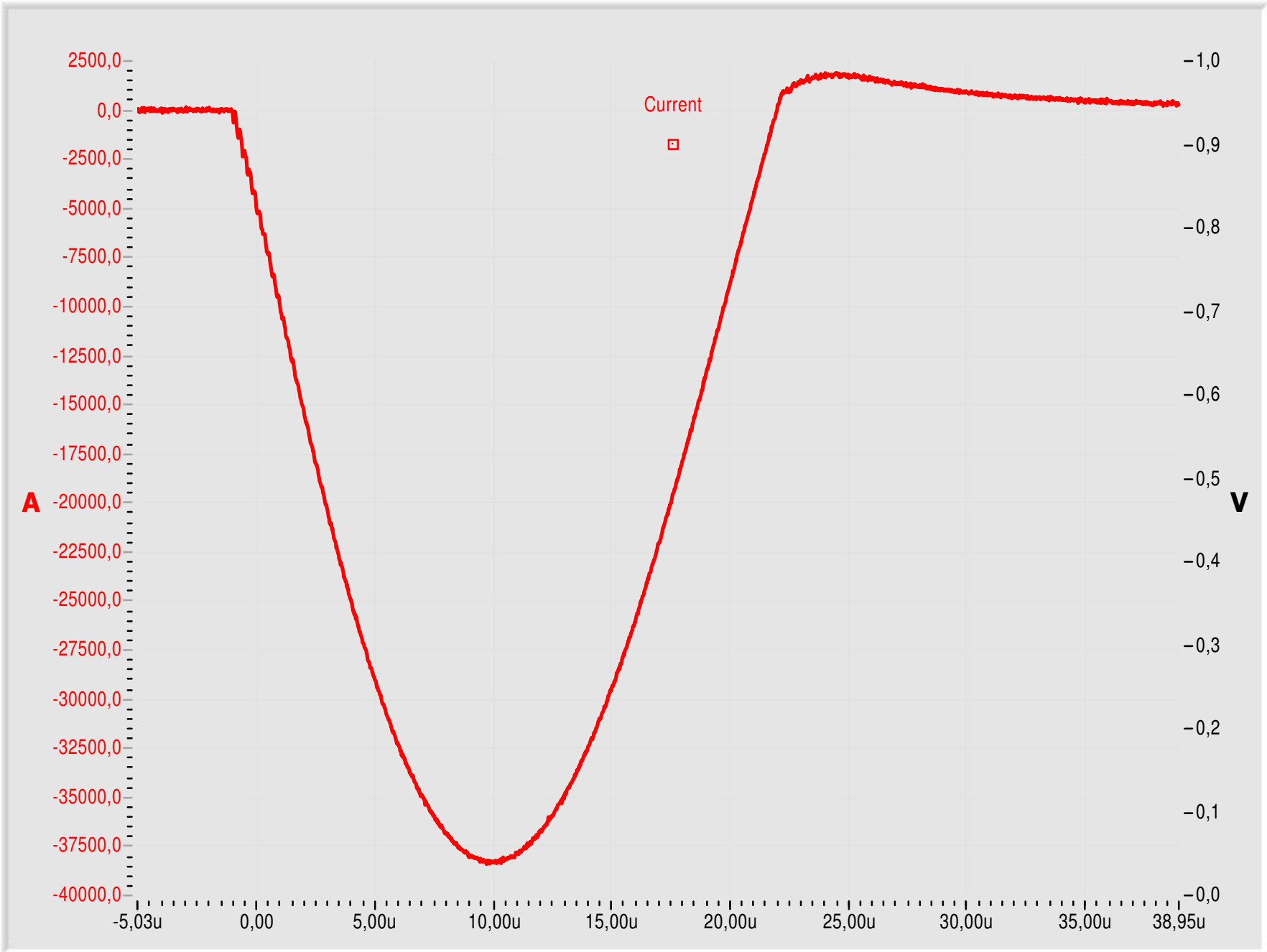


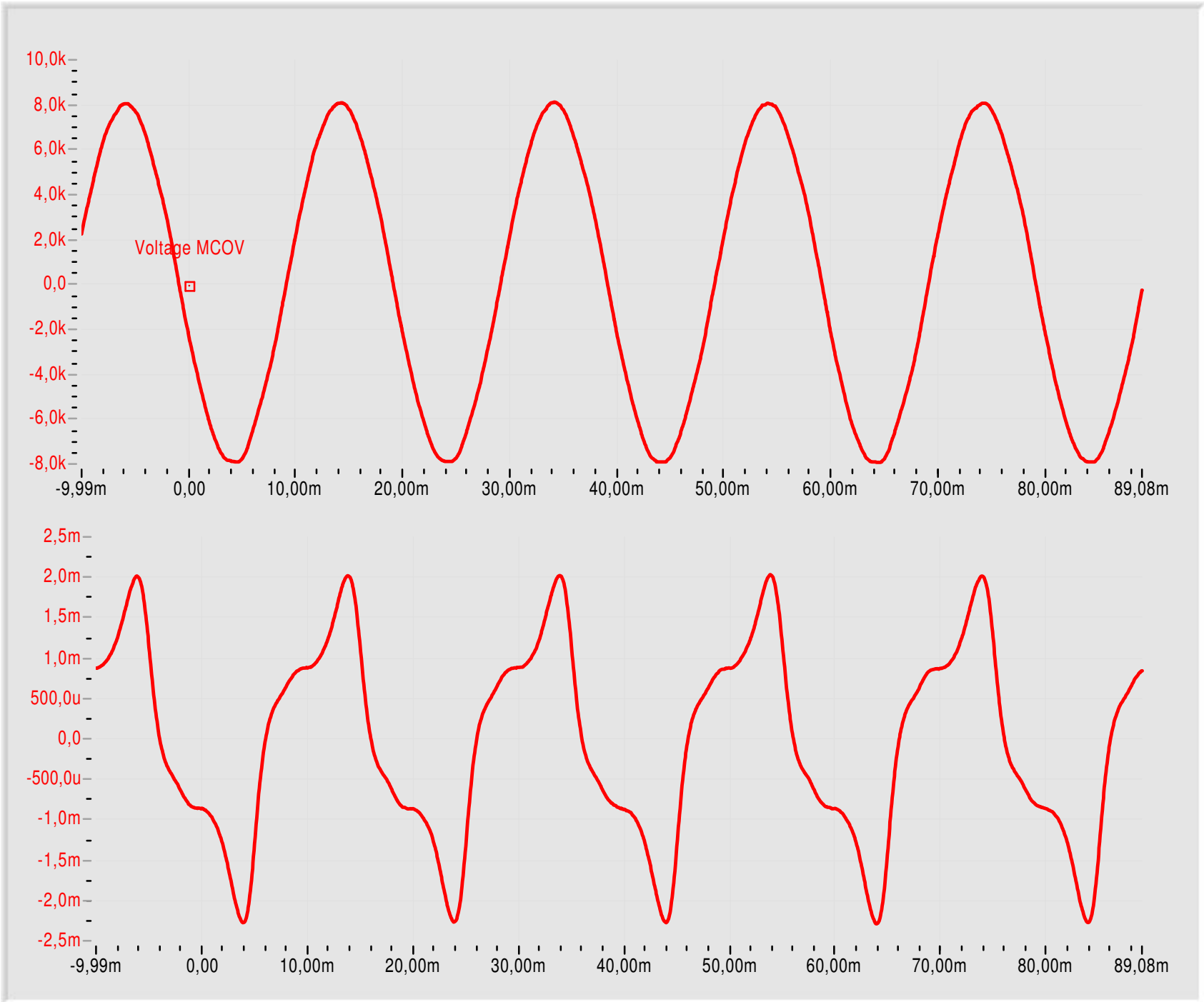
CESI C1004957 Oscillogram n. 38



CESI C1004957 Oscillogram n. 39

CESI C1004957 Oscillogram n. 40

CESI C1004957 Oscillogram n. 41



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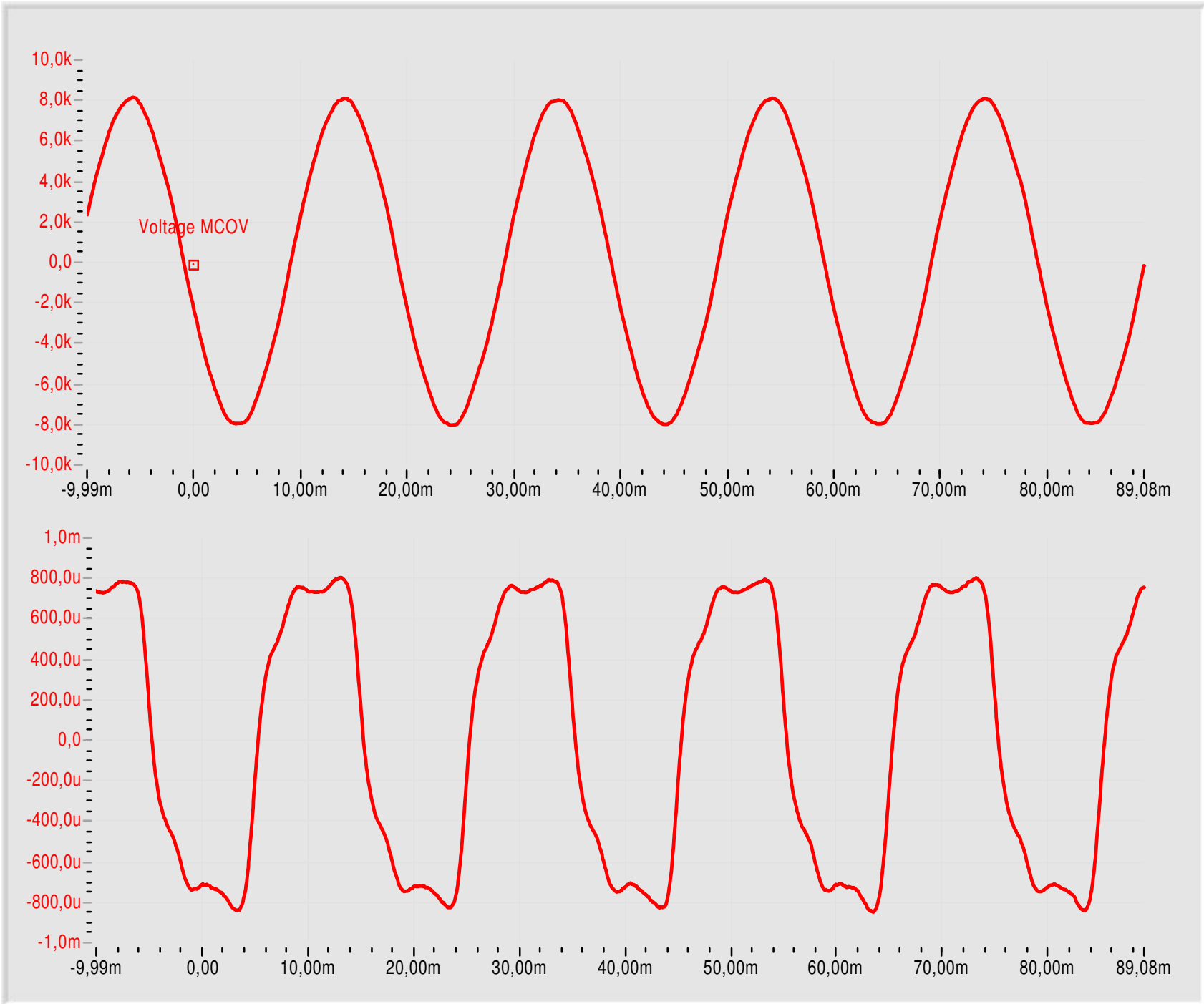

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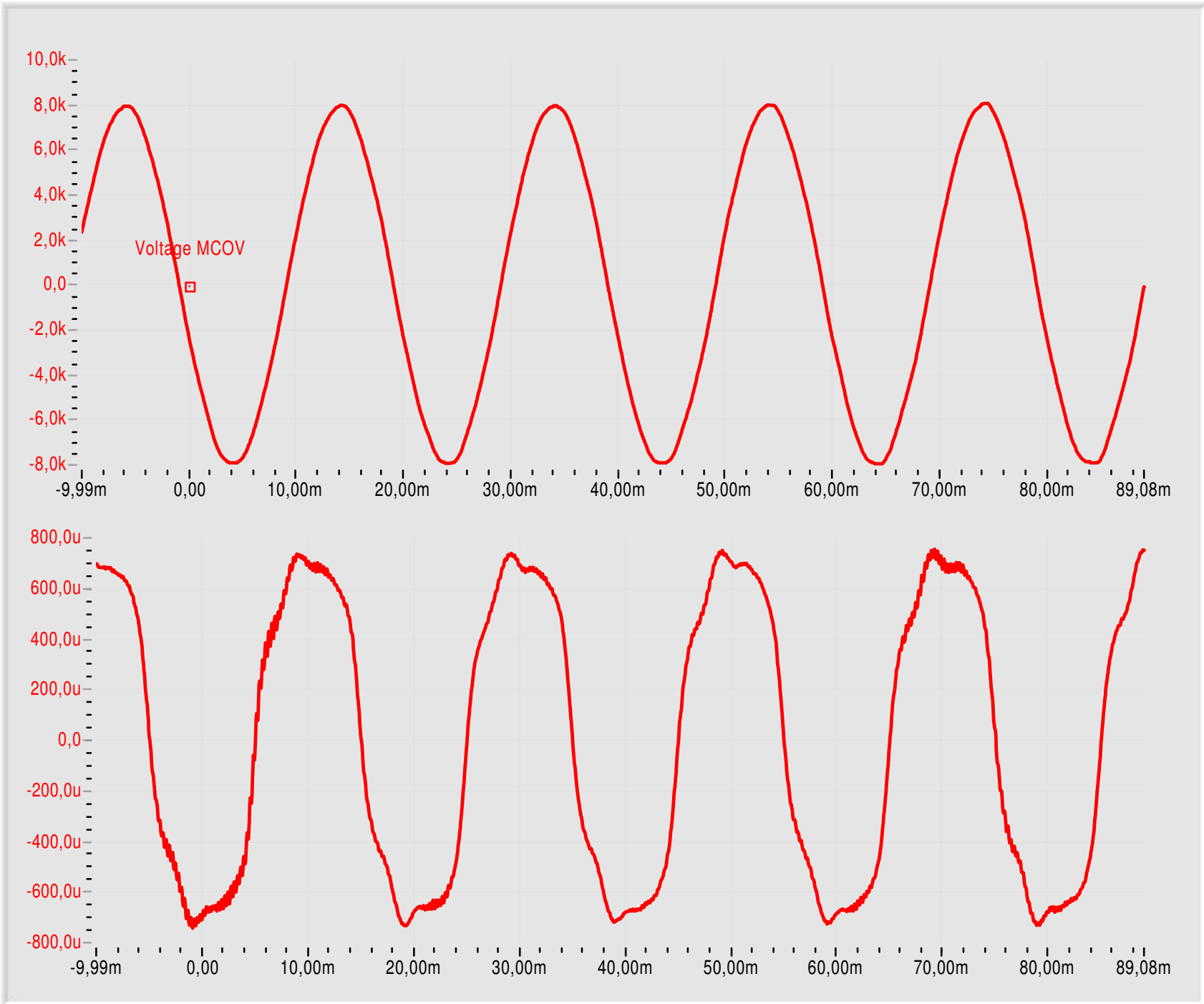
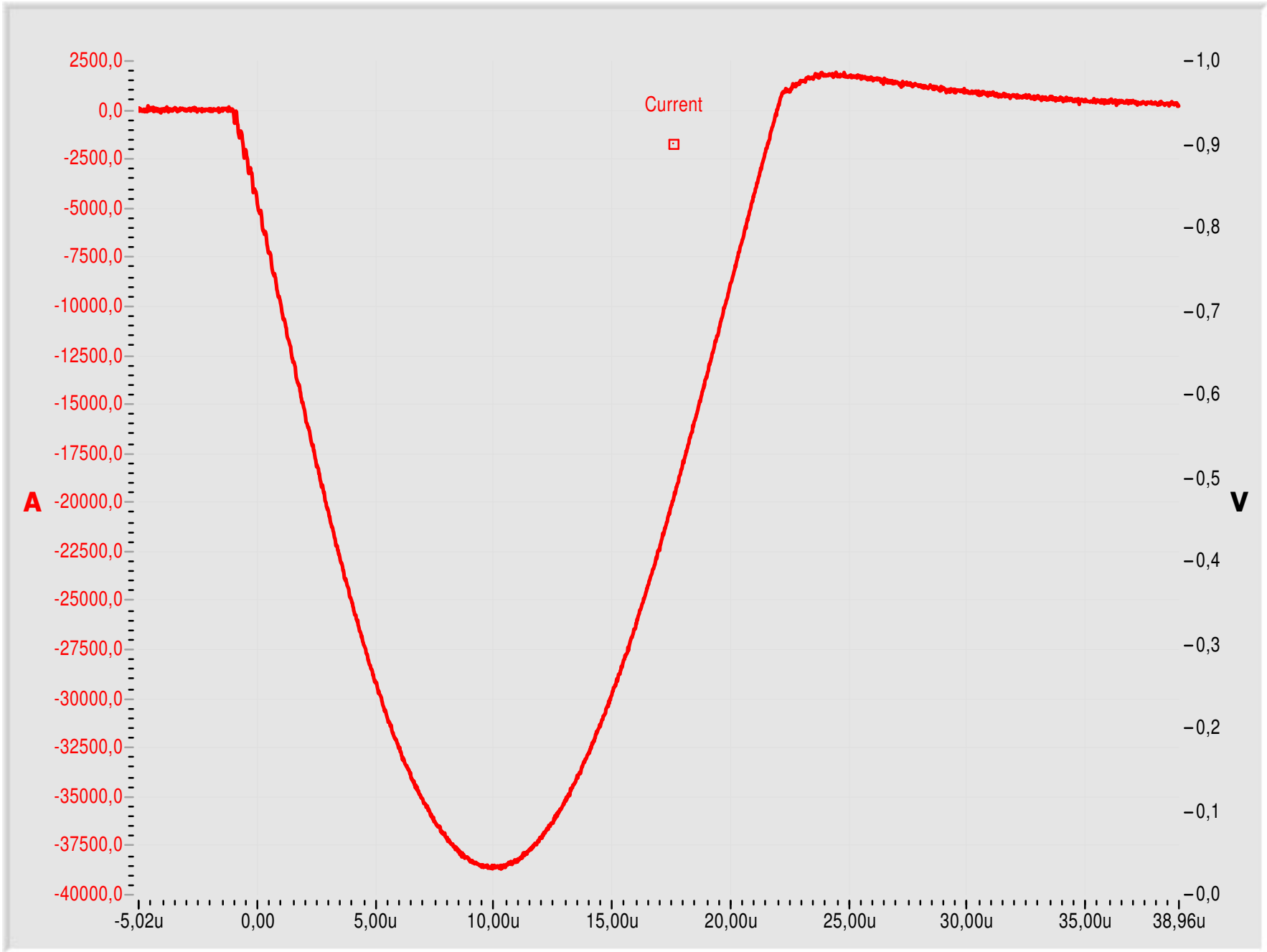


CESI C1004957 Oscillogram n. 47



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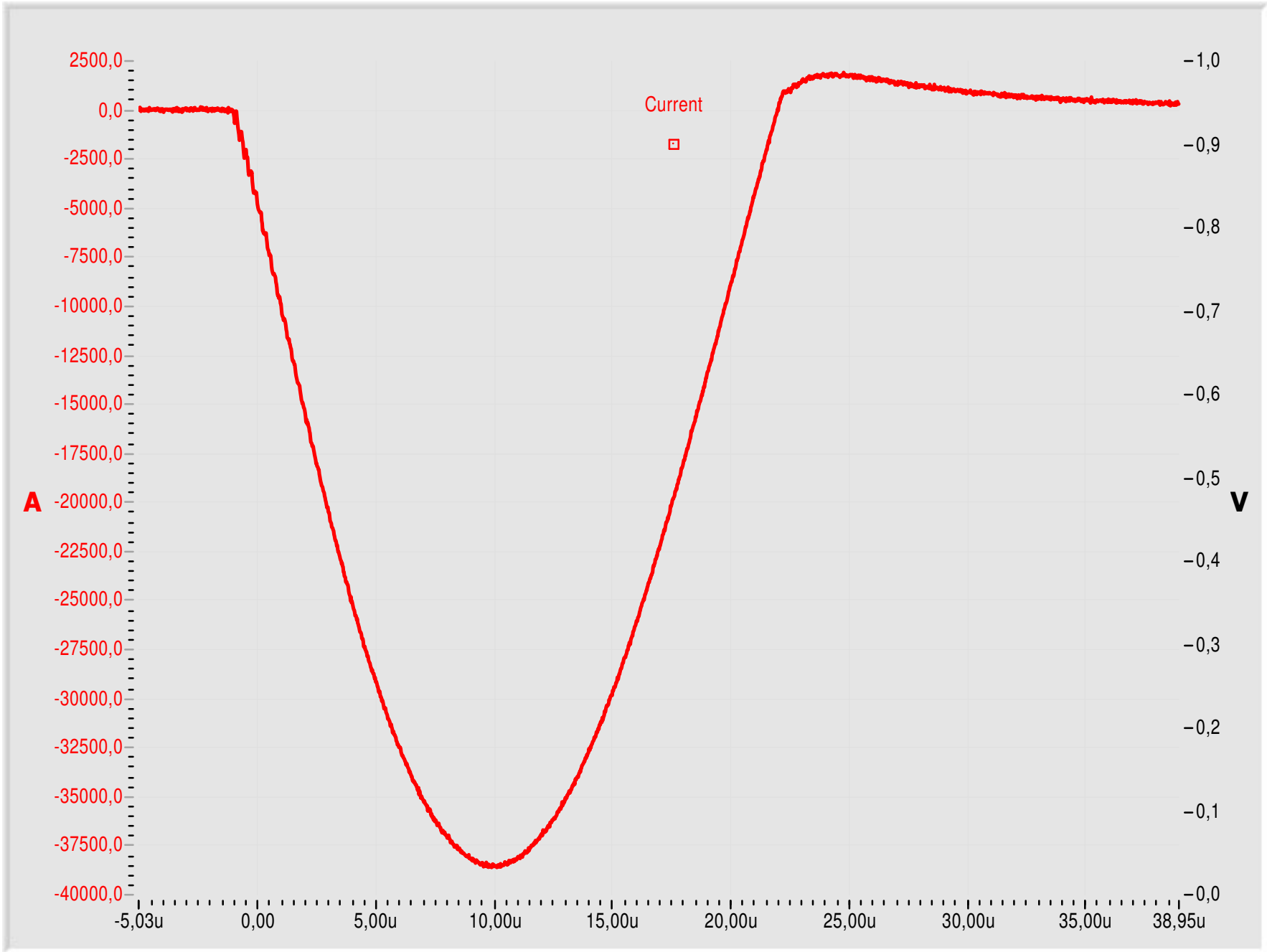

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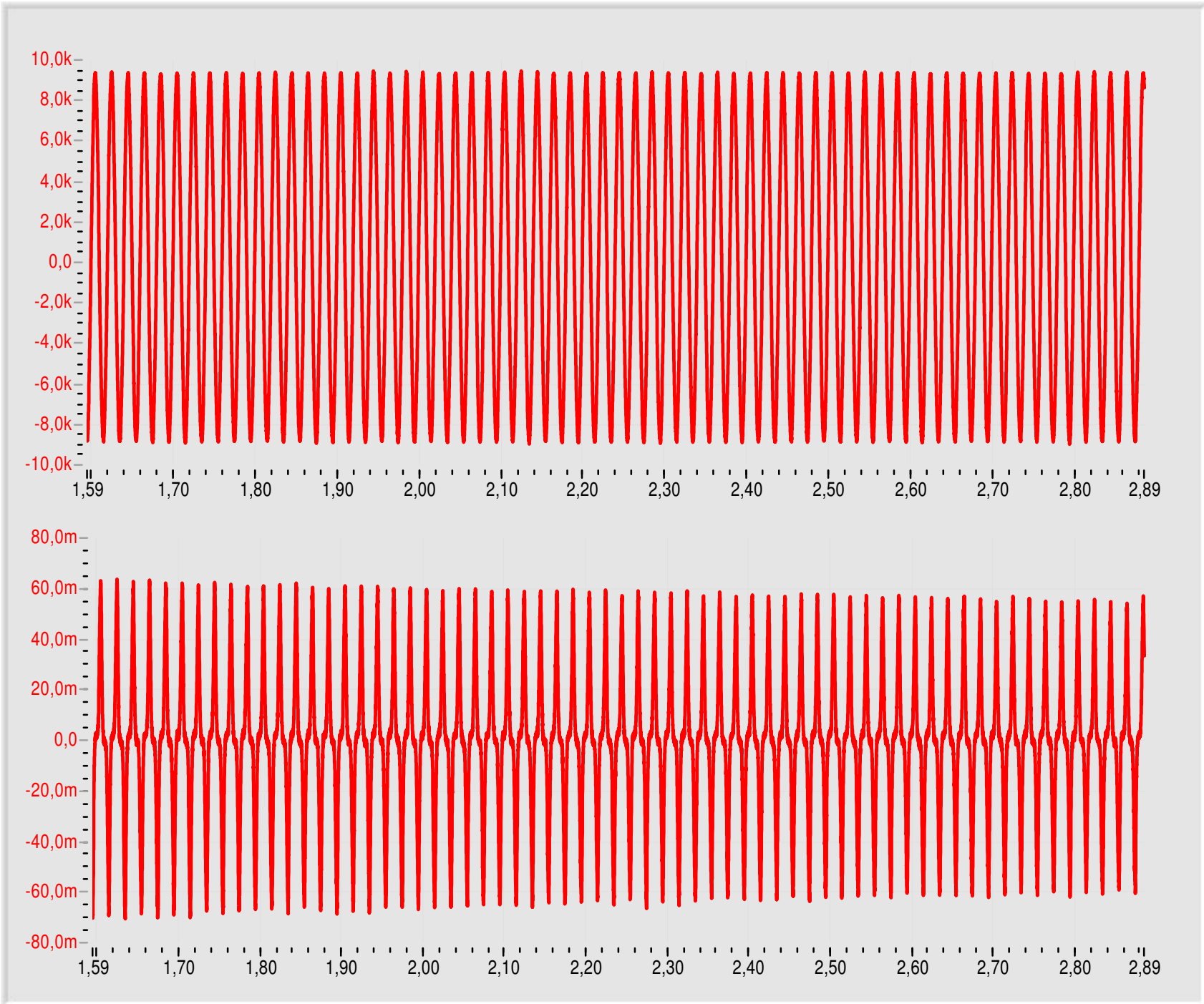

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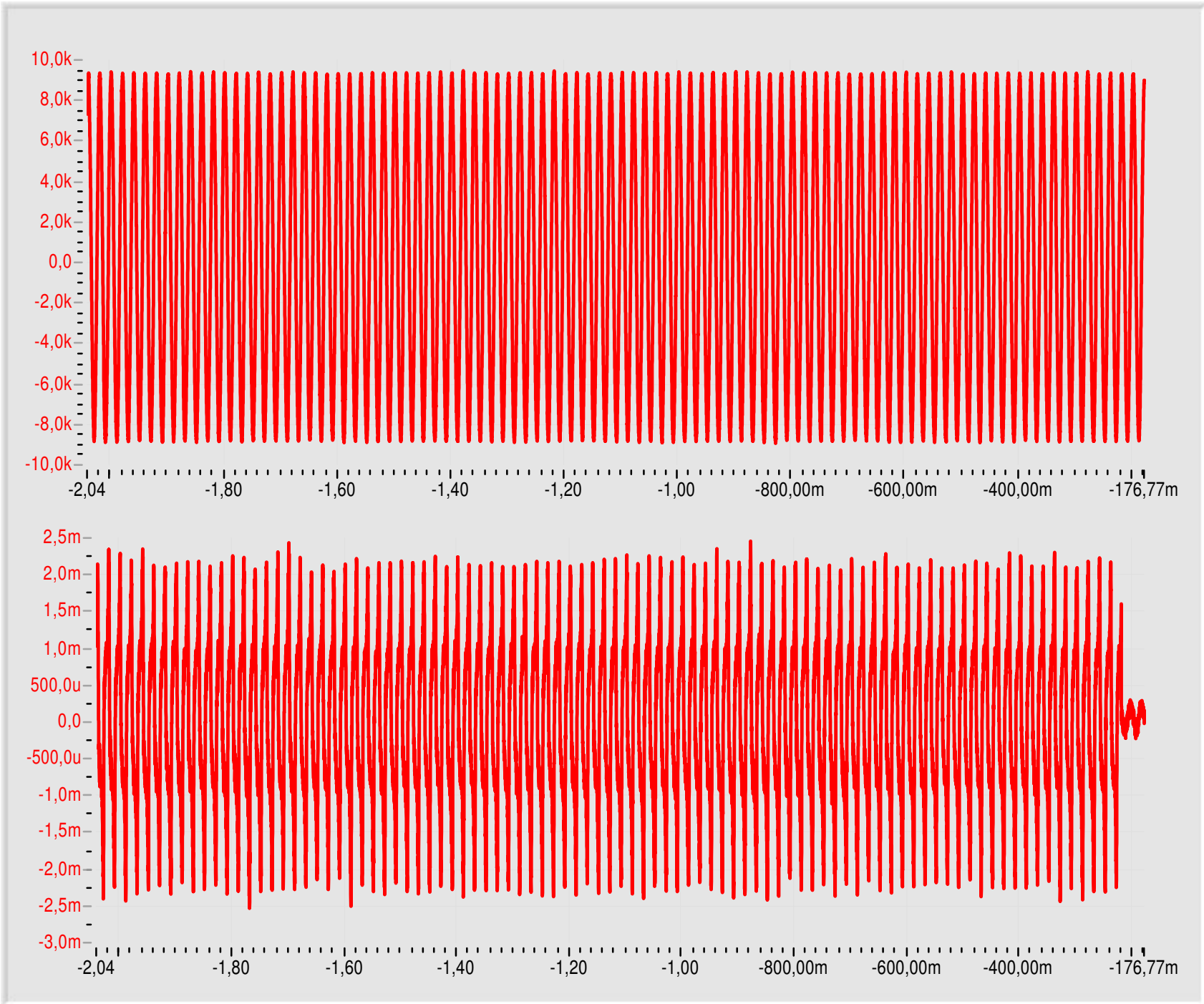

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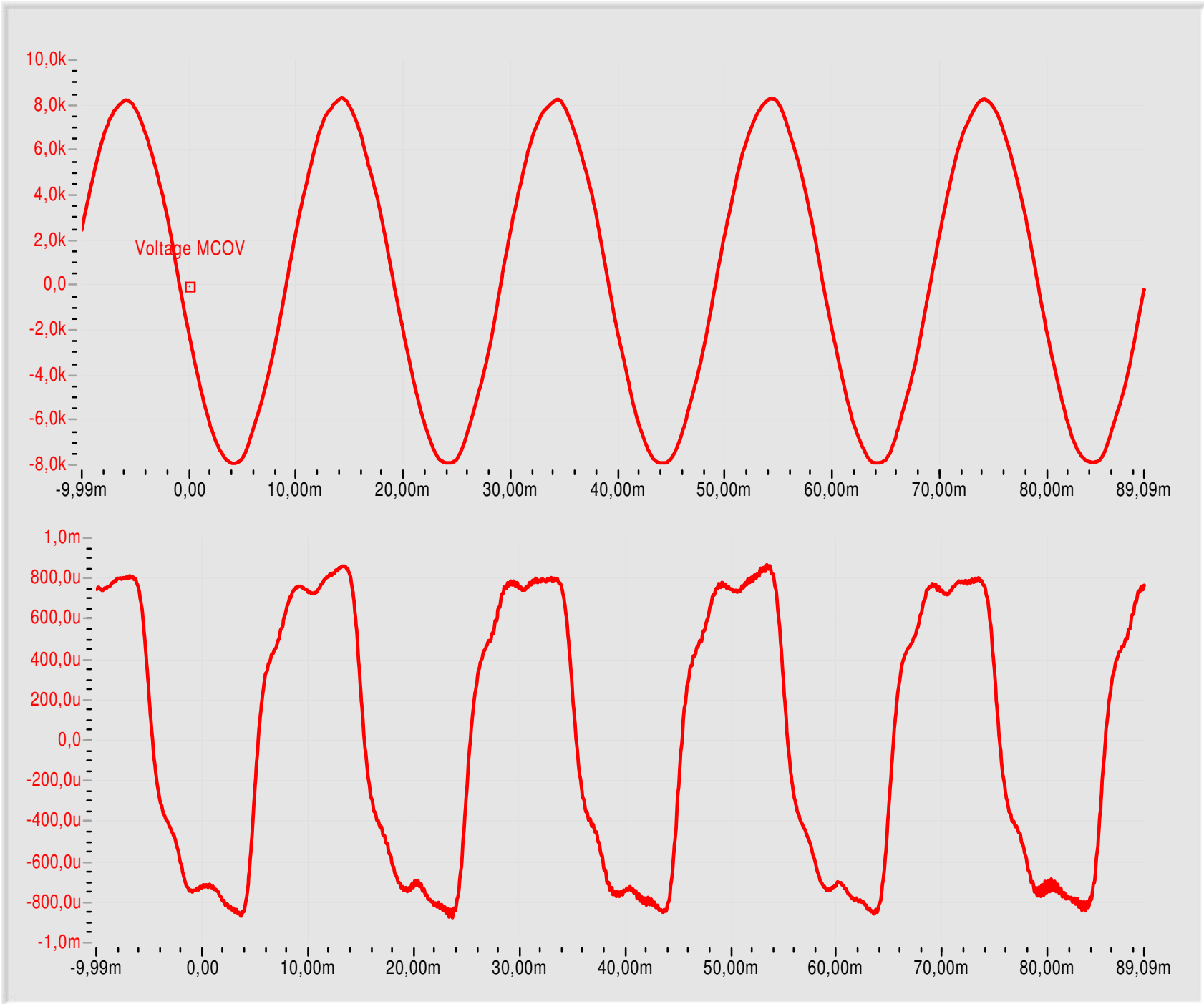

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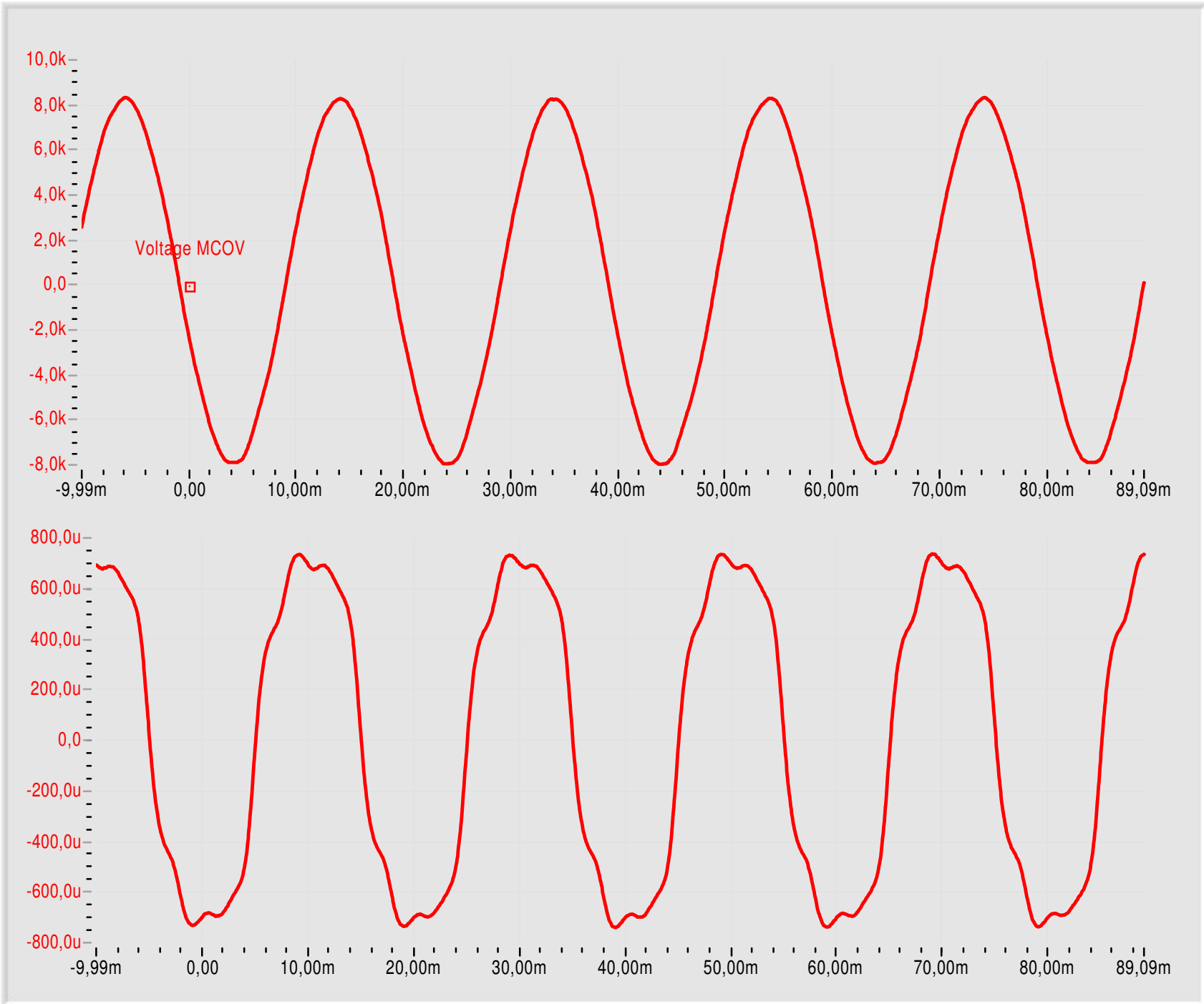

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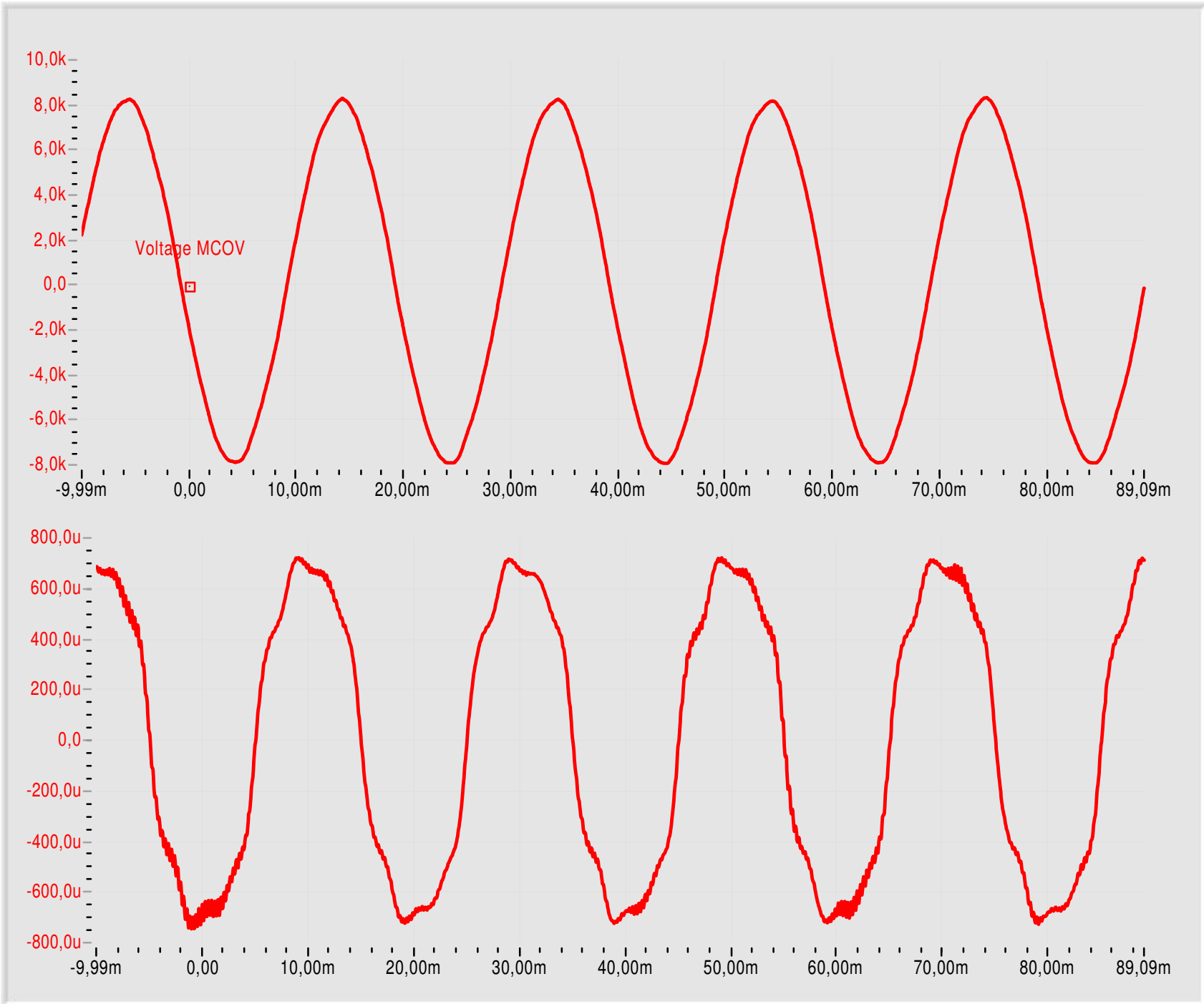
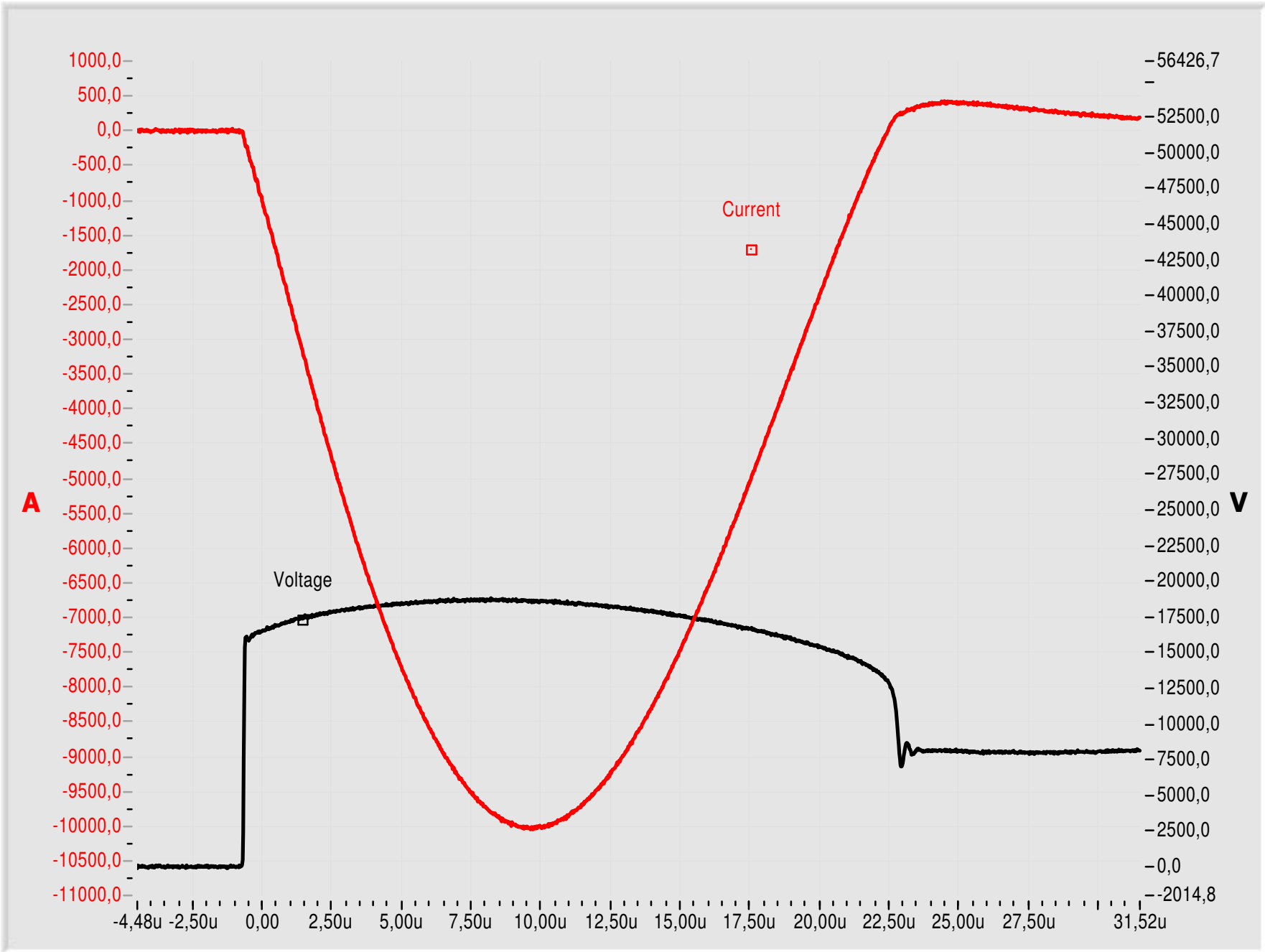


CESI C1004957 Oscillogram n. 54



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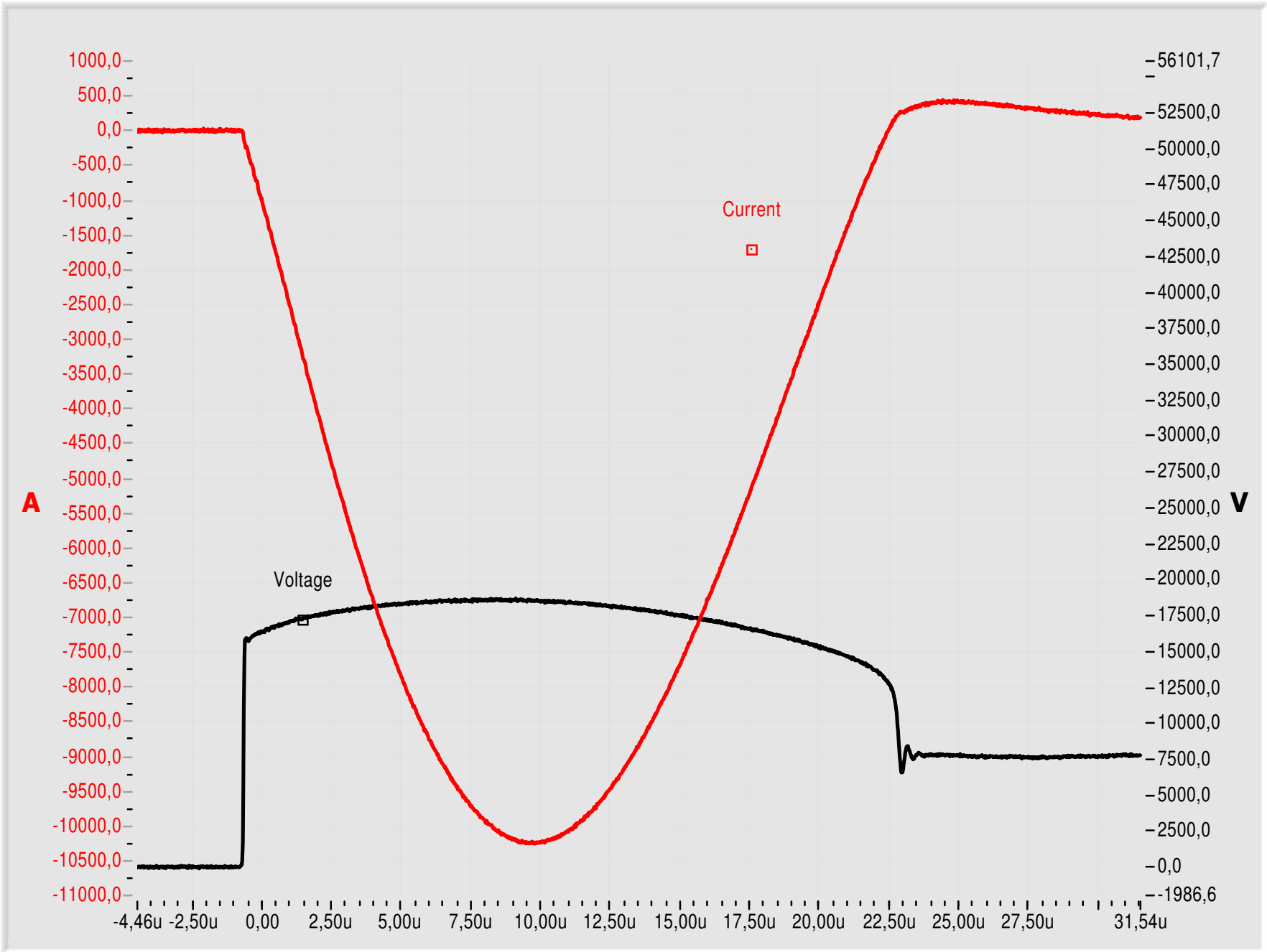

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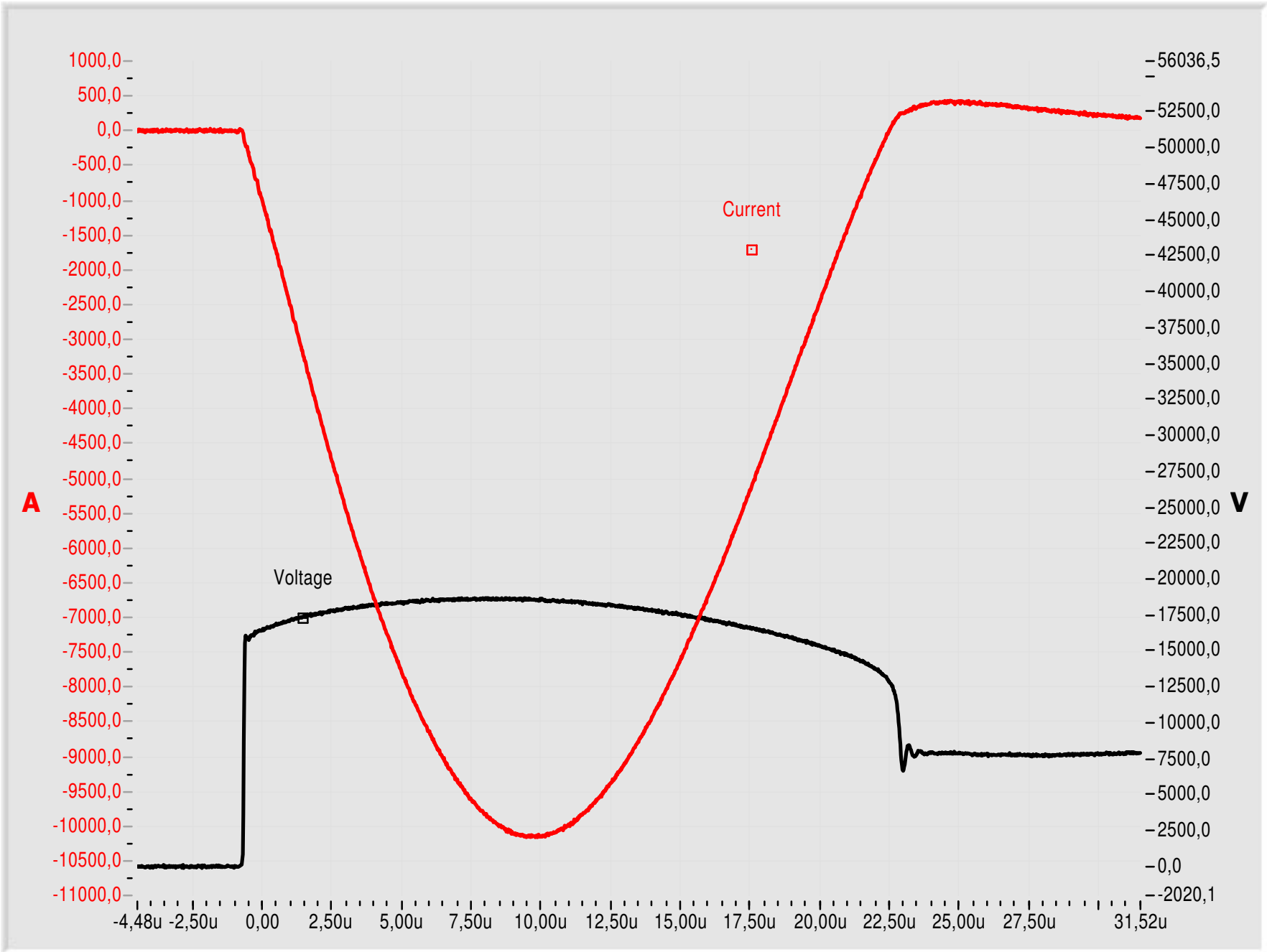

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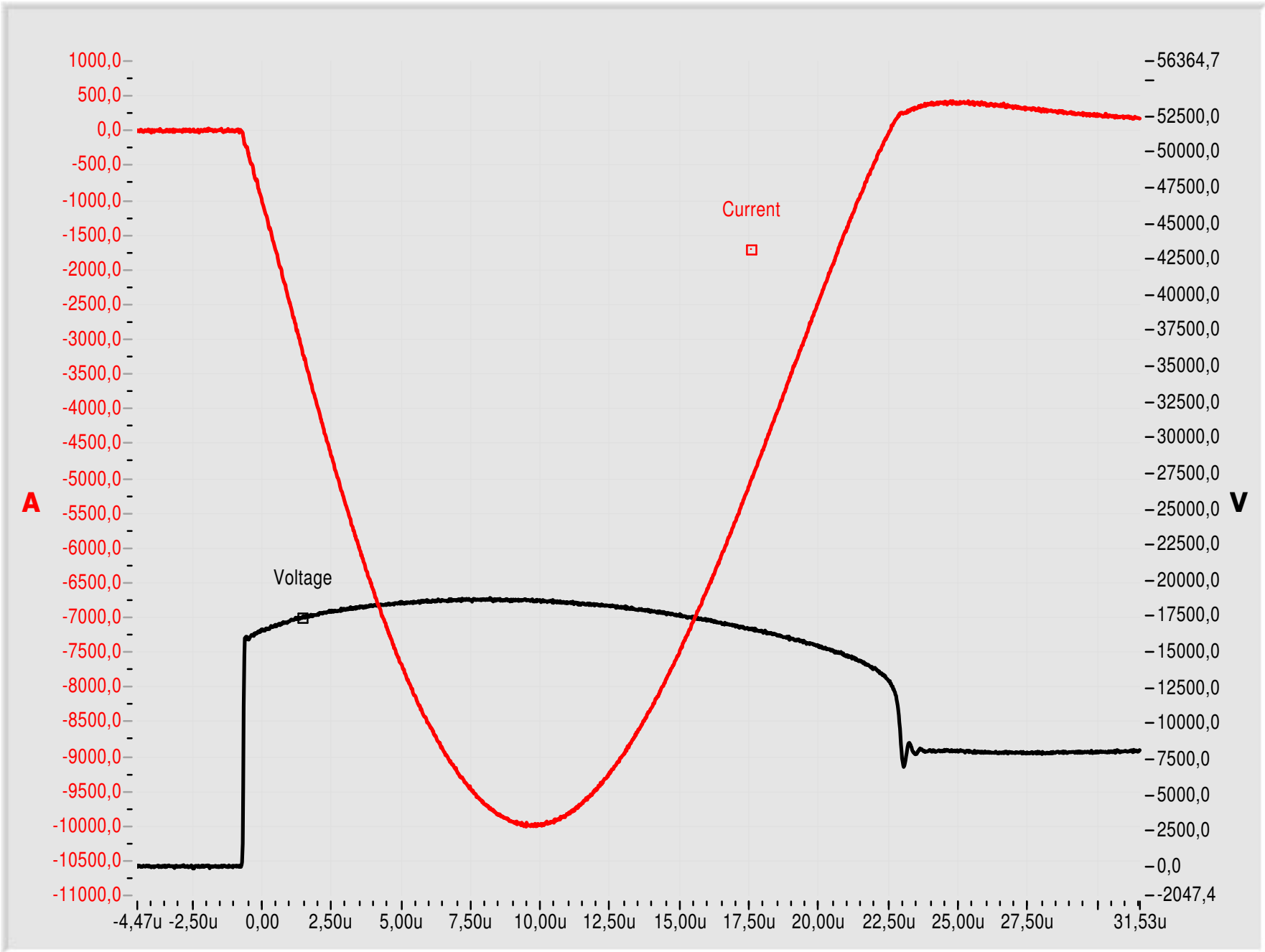
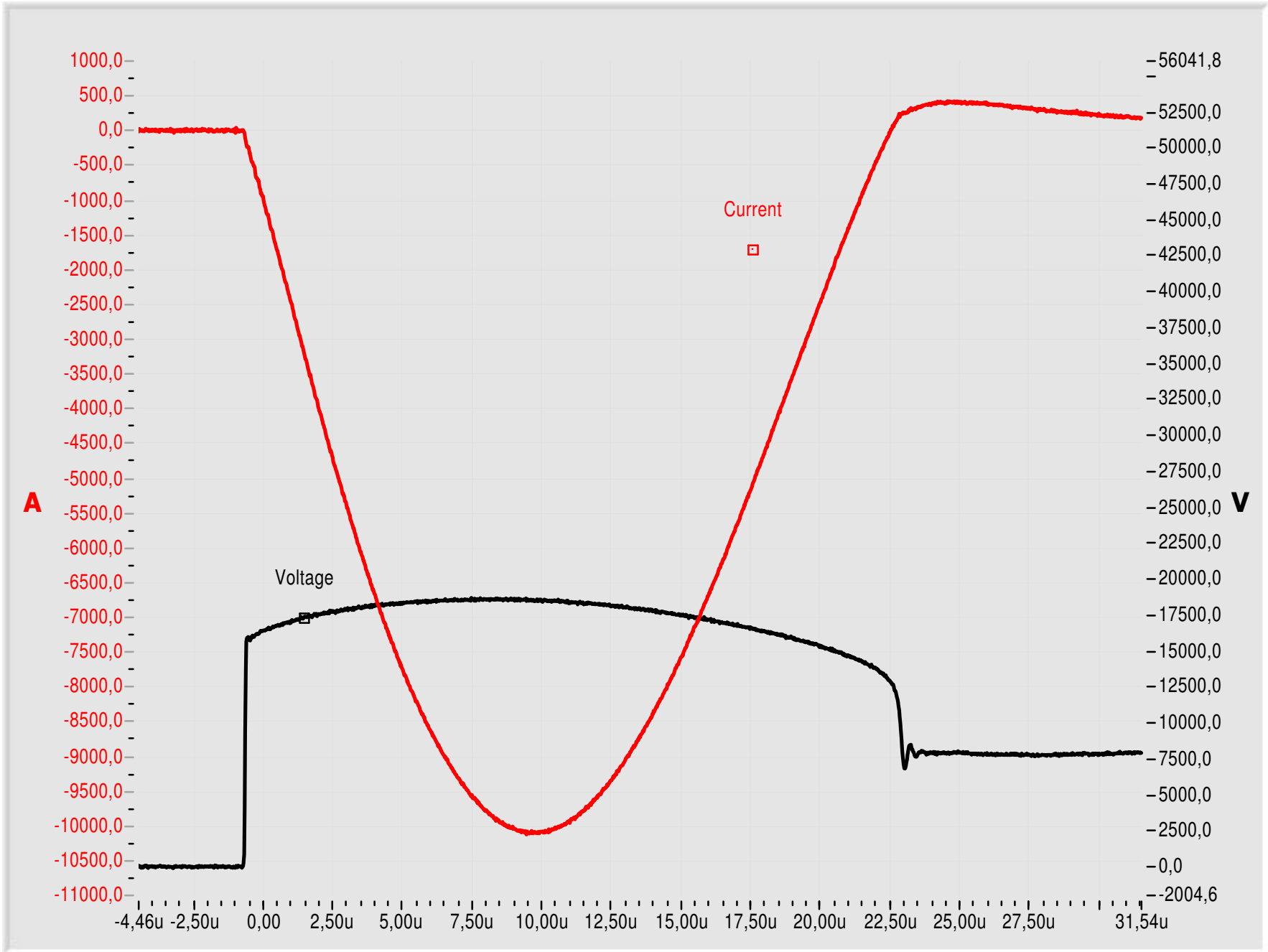


CESI C1004957 Oscillogram n. 58



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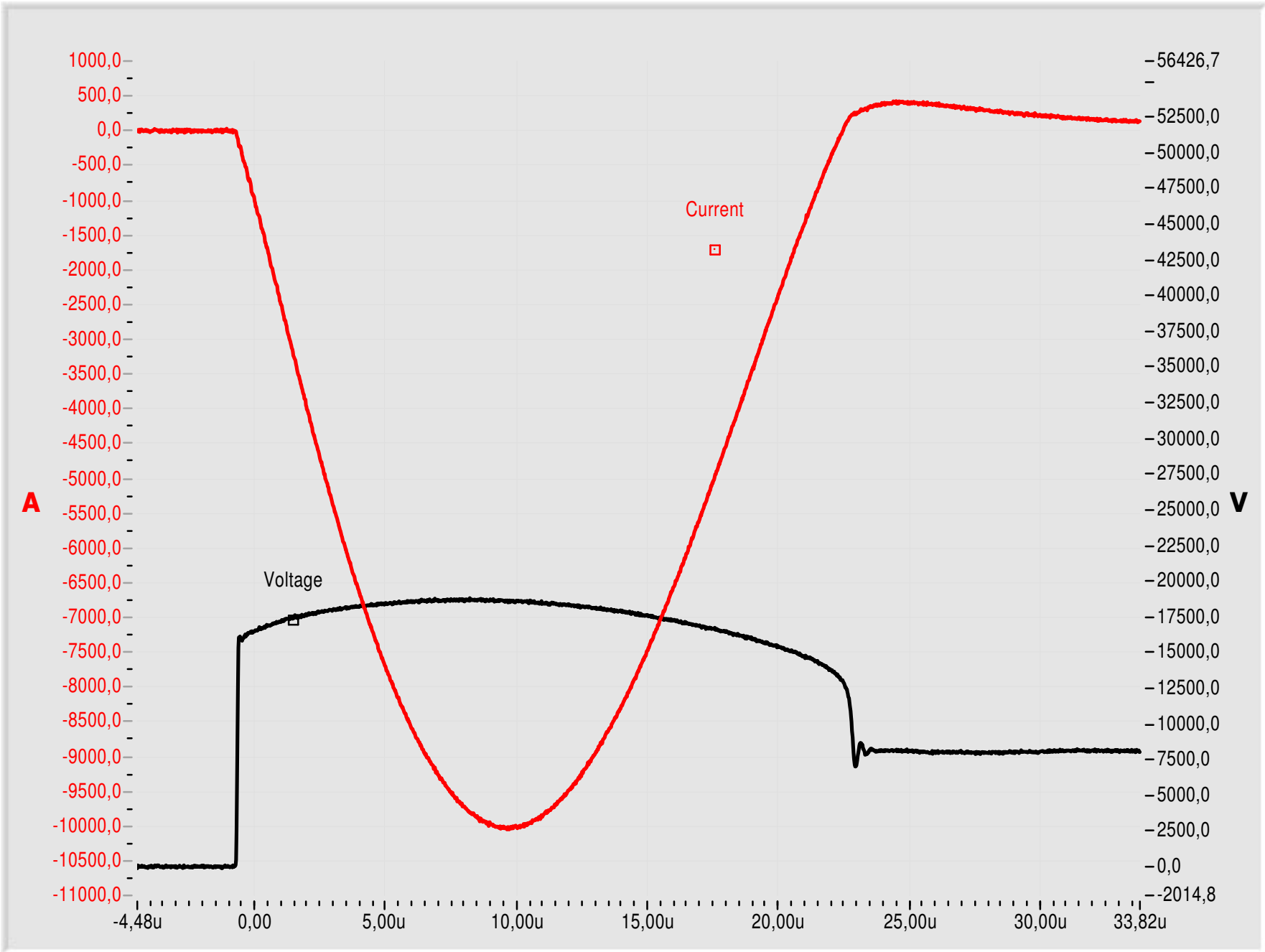

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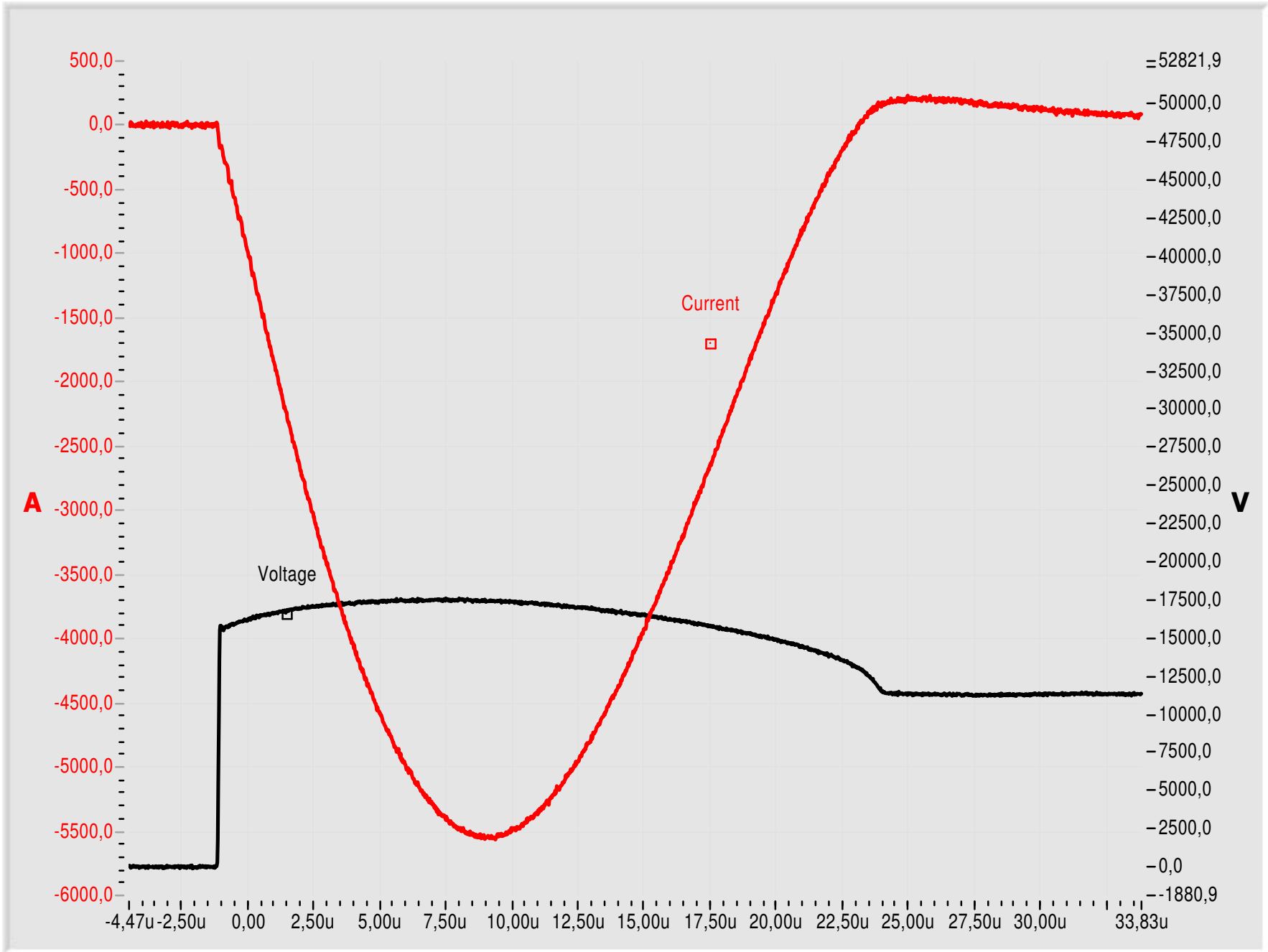

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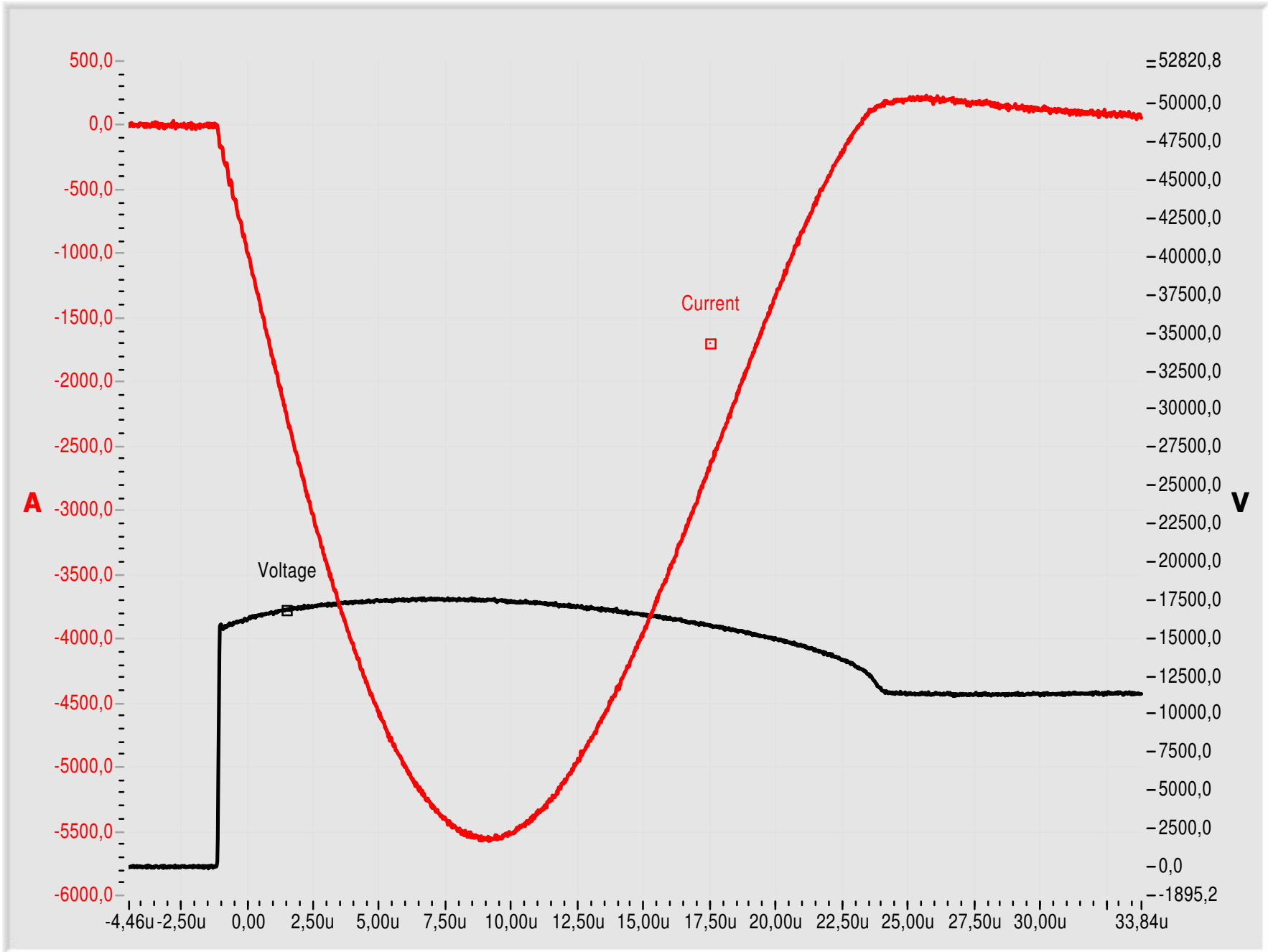
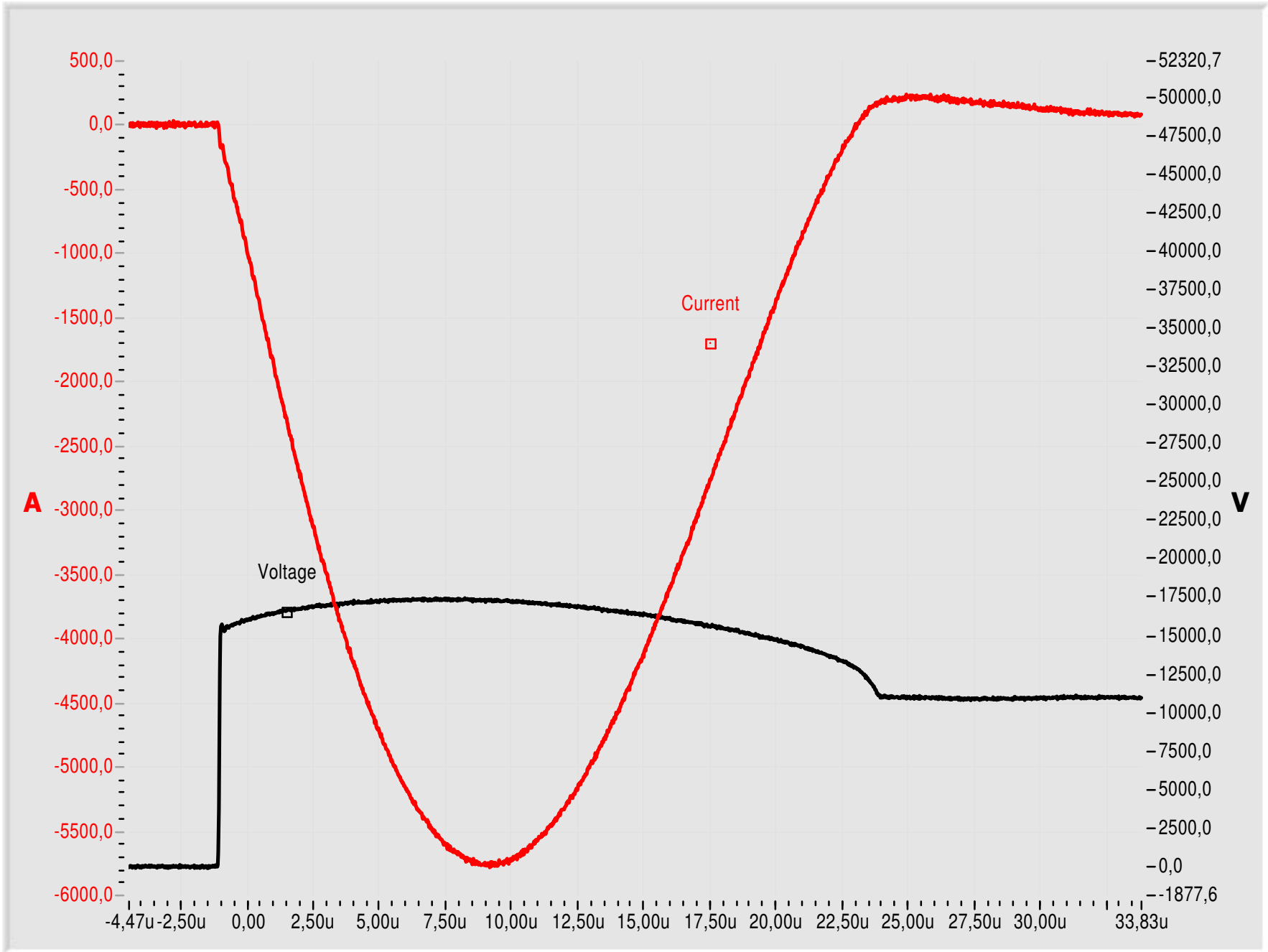


CESI C1004957 Oscillogram n. 62



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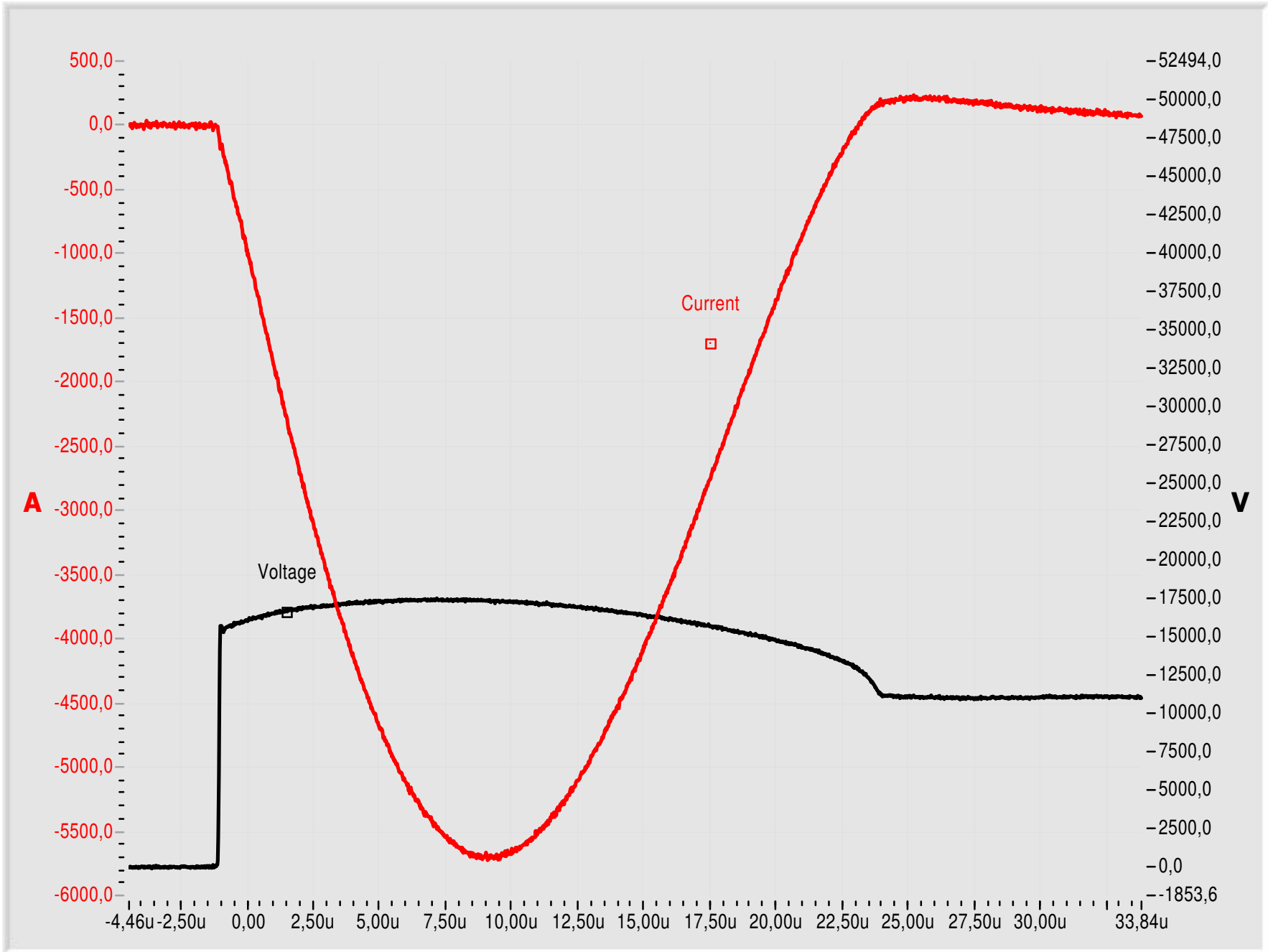

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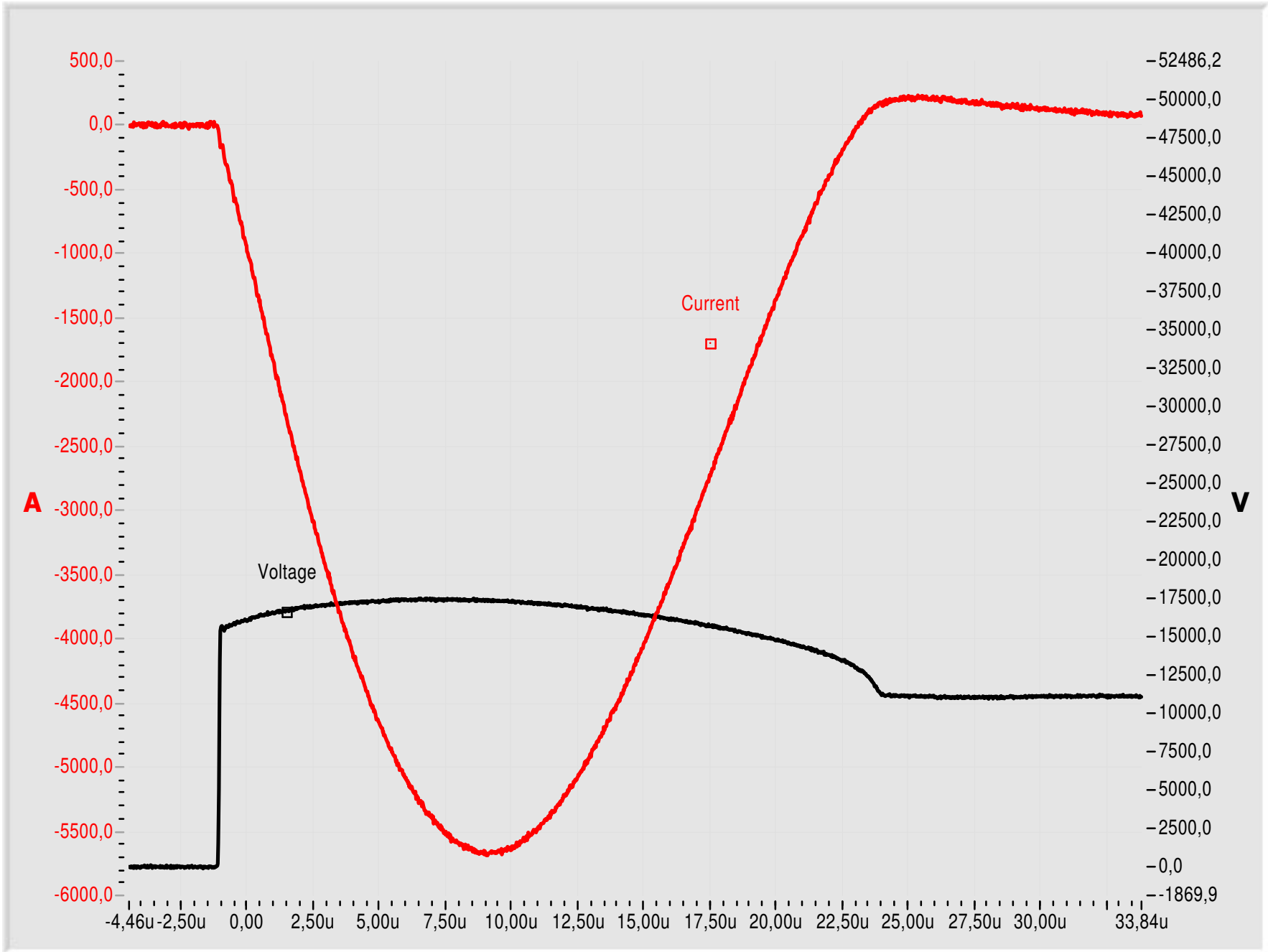

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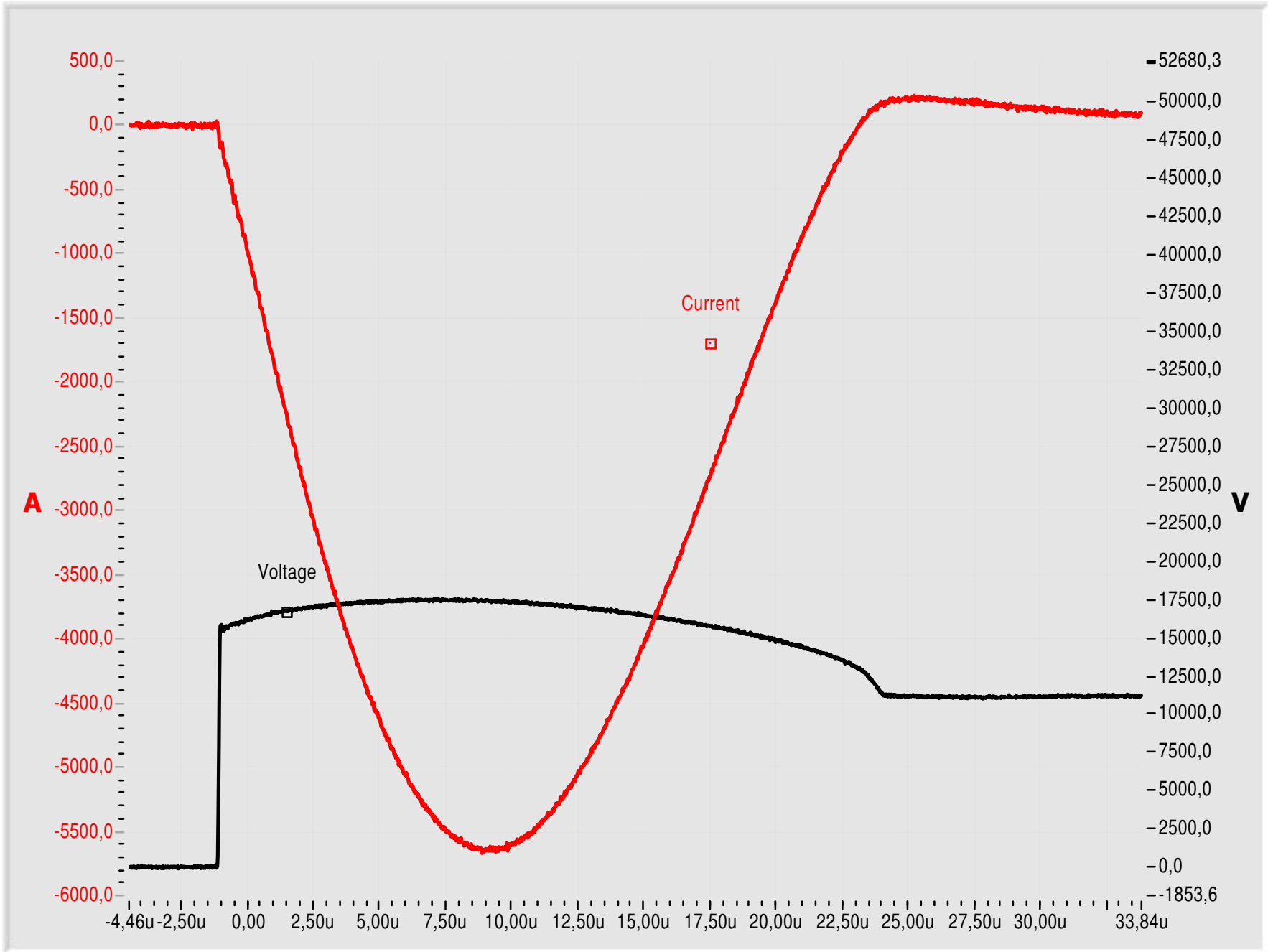

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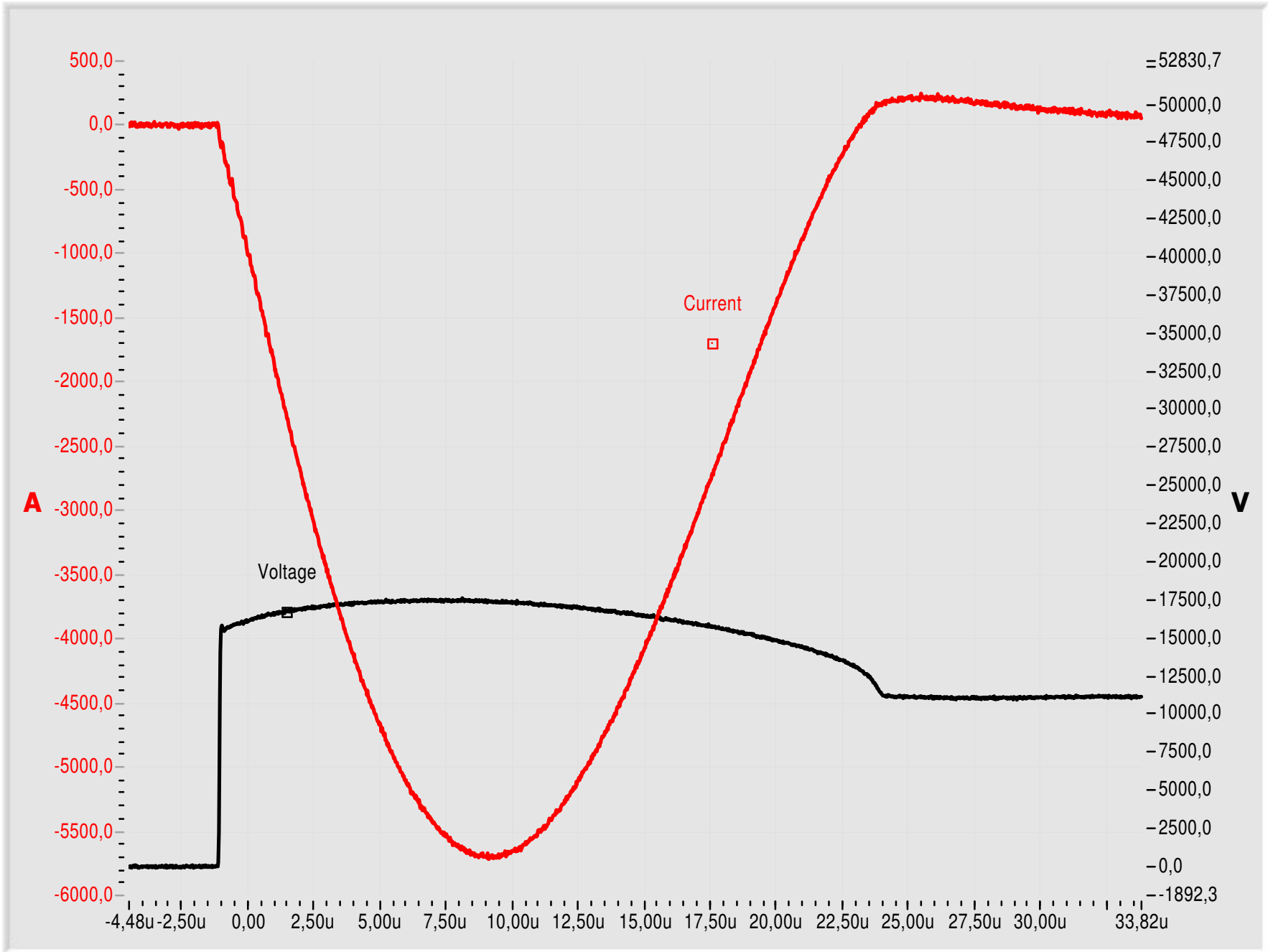

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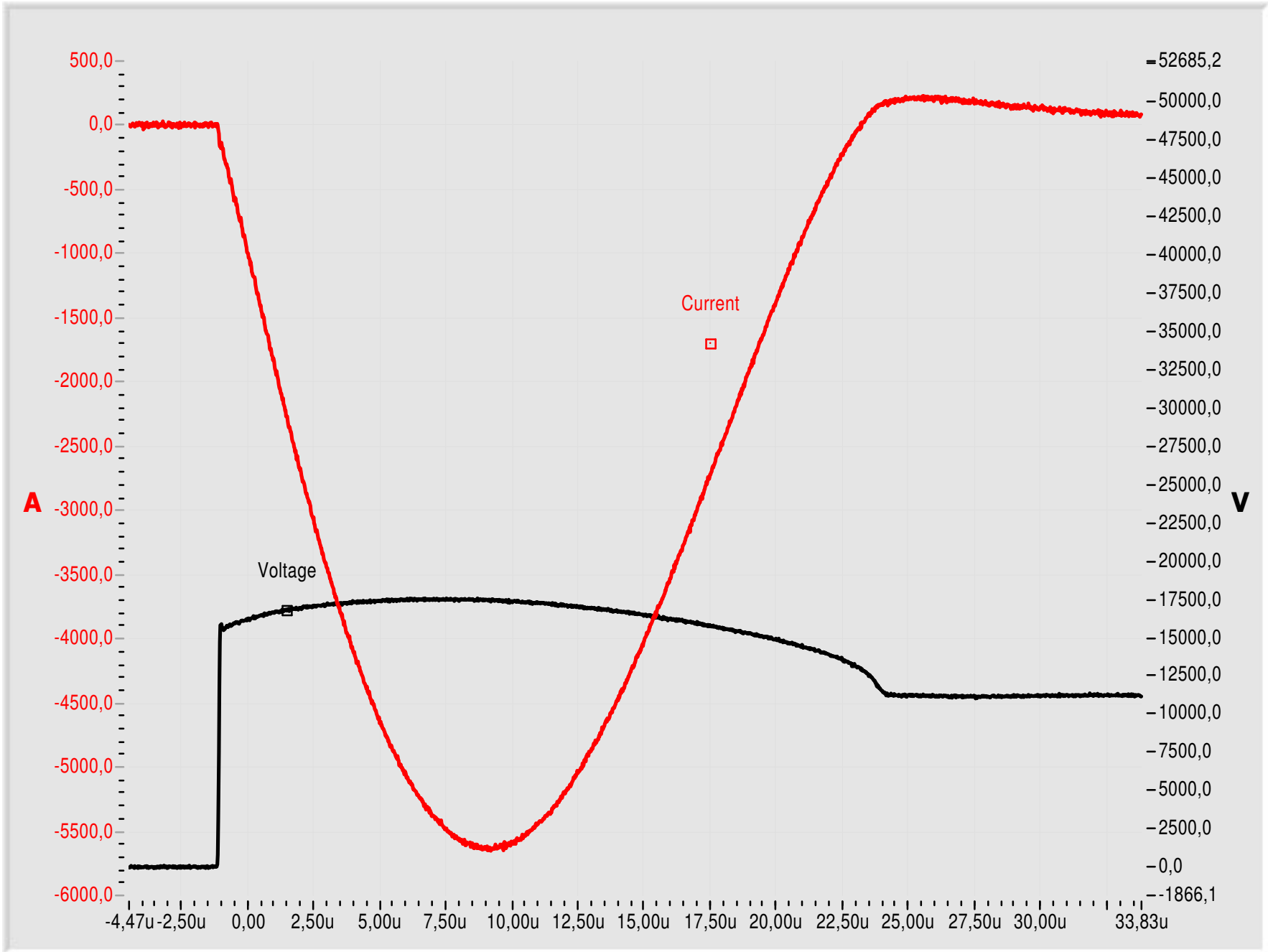

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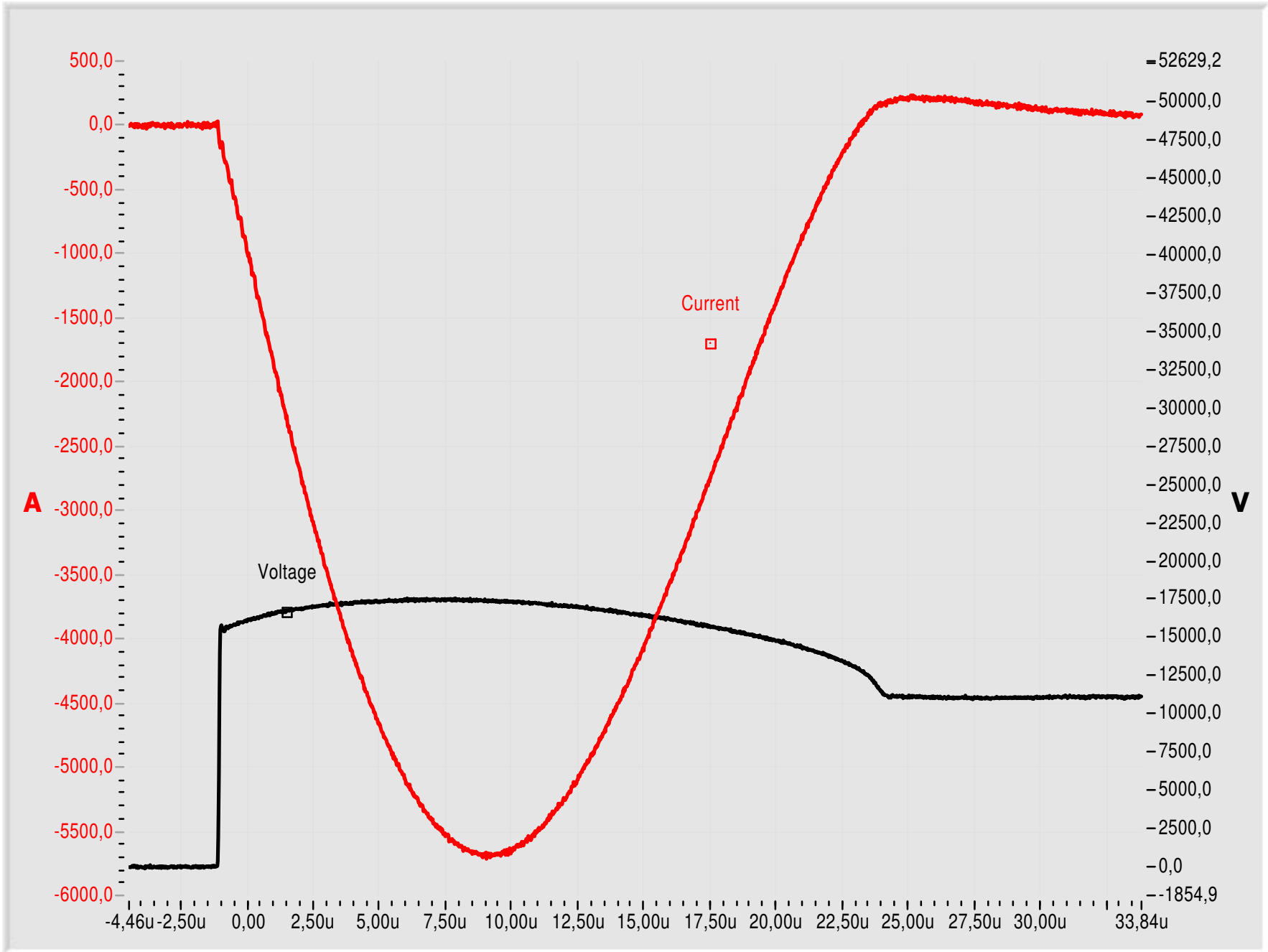

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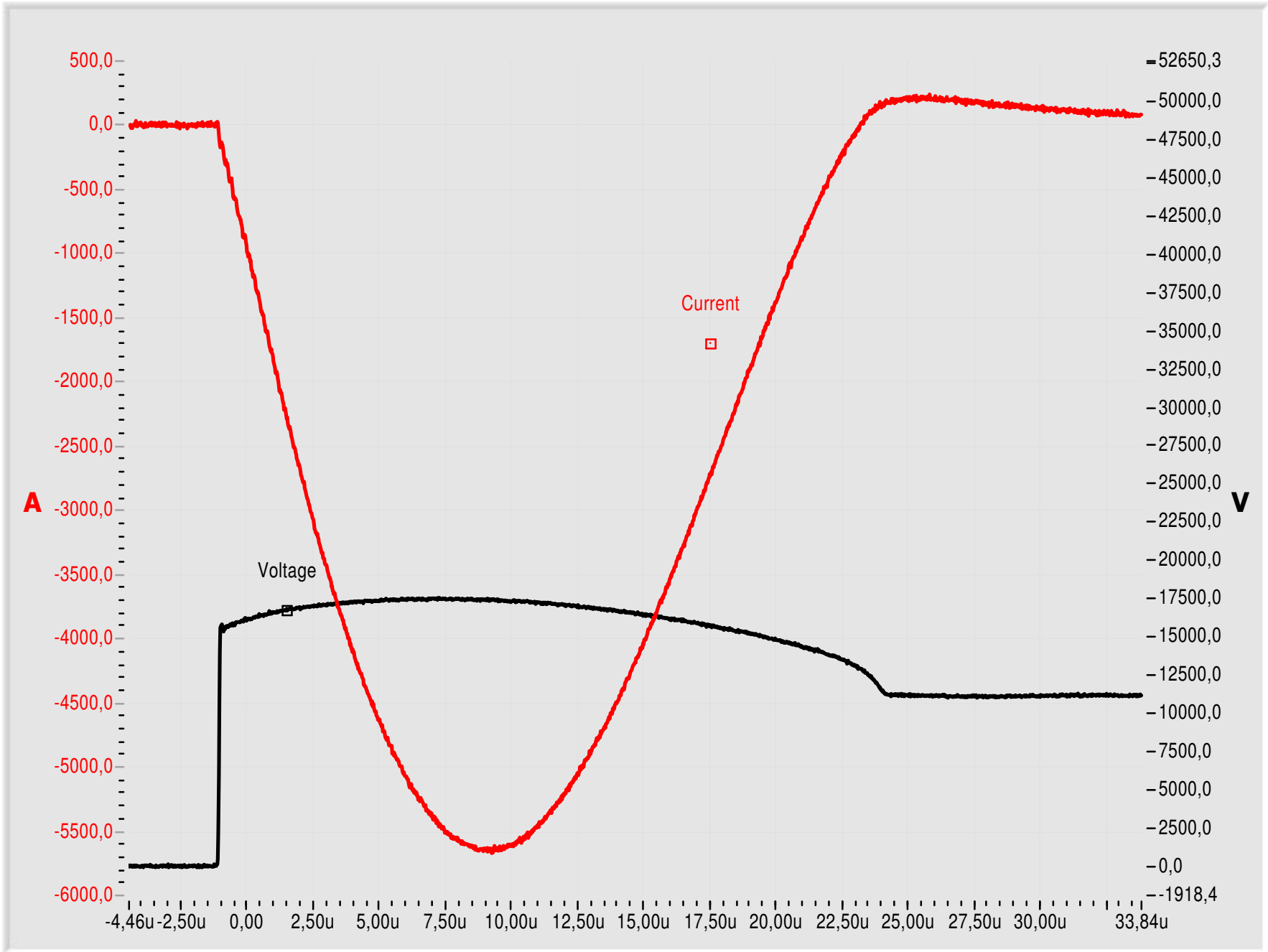

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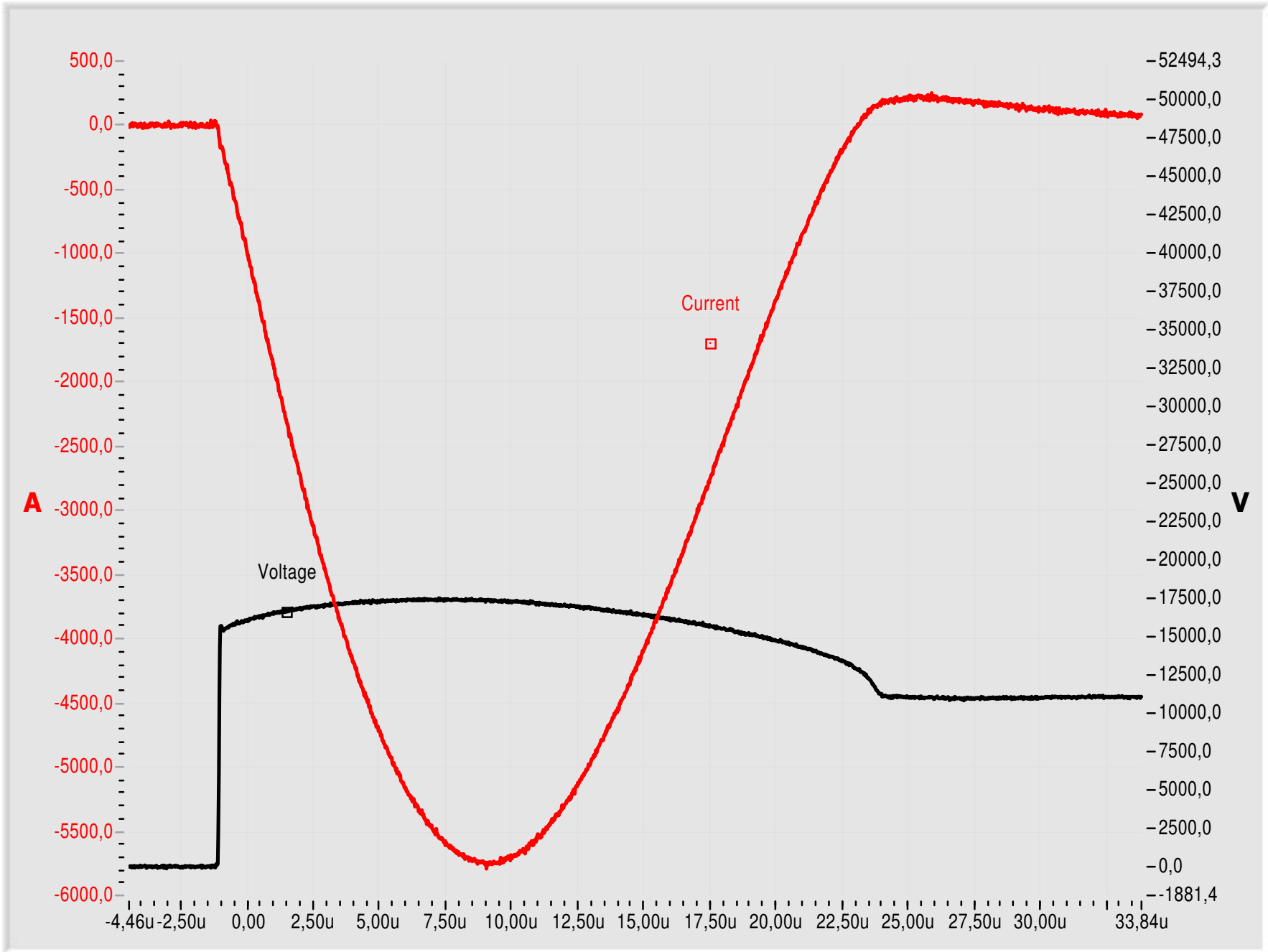
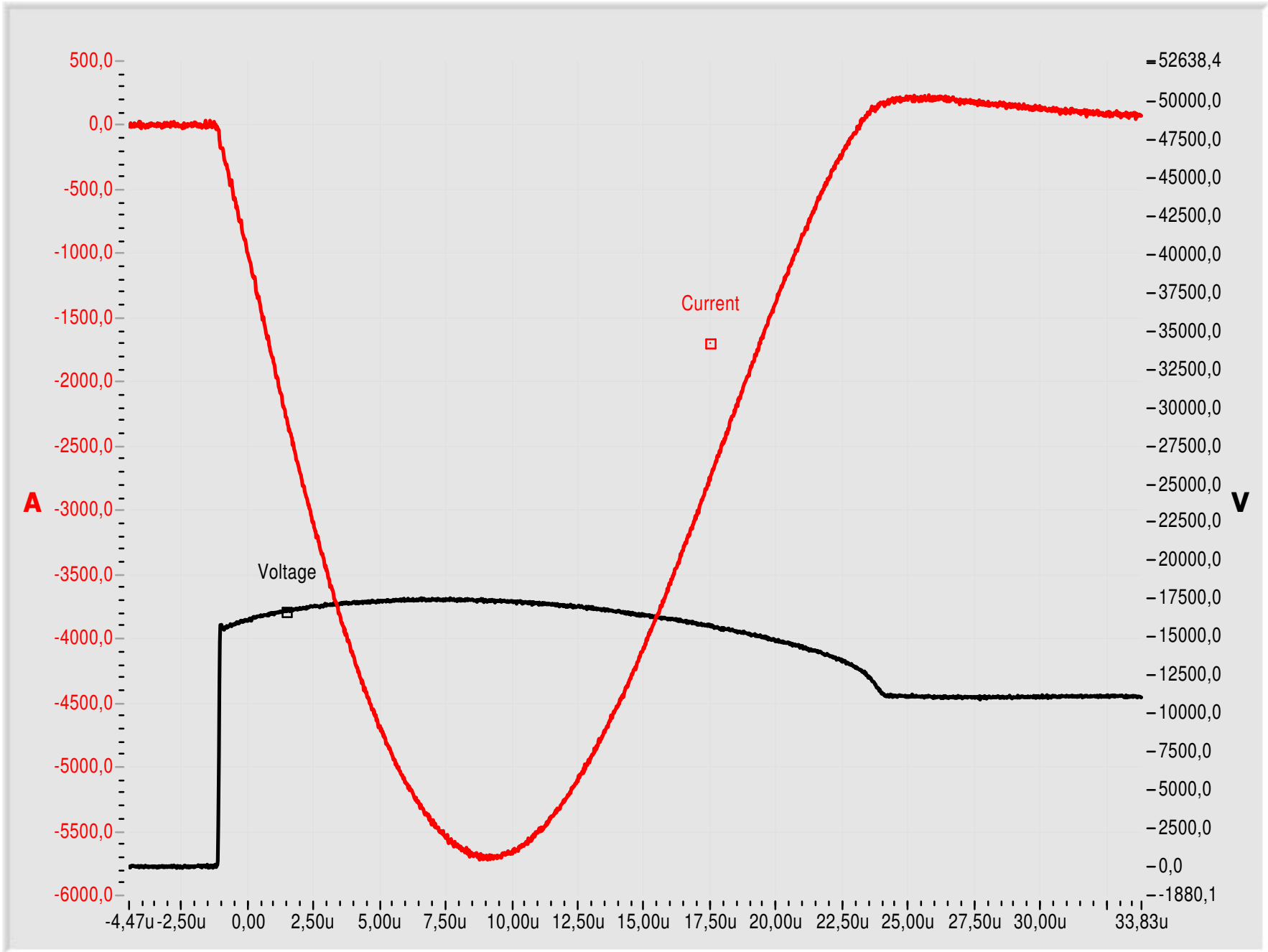


CESI C1004957 Oscillogram n. 71



Test Report

Document No.	C1011283	Copy No.	1	Number of pages	110
Apparatus	Varistors Balestro ZNO Protege +				
Designation	P + 363610				
Serial Number	---				
Manufacturer	Industria Eletromecânica Balestro Ltda				
Client	Industria Eletromecânica Balestro Ltda Rua Santa Cruz, 1550 13800-911 Mogi Mirim (Brazil)				
Tested for	---				
Date(s) of tests	From June 28 to July 02, 2021				
Tested by	CESI S.p.A. Via Rubattino, 54 20134 Milano – Italy				
Test performed	Test to verify the repetitive charge transfer rating, Qrs				

PAD C1011283 (2897912) - CONFIDENTIAL USE

The apparatus, constructed in accordance with the description, drawings and photographs incorporated in this document has been subjected to the series of proving tests in accordance with:

IEC 60099-4 – Edition 3.0 (2014-06)

The results are shown in the record of proving tests and the oscillograms attached hereto. The ratings assigned by the Manufacturer are listed on the ratings page.
The document applies only to the apparatus tested. The responsibility for conformity of any apparatus having the same designations with that tested rests with the Manufacturer.

September 15, 2021

Date	Gregori Marco C1011283 3059 AUT Test Engineer in charge	The Manager - Verhoeven Bas C1011283 3482248 APP Approved by

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测思 Centro Elettrotecnico Sperimentale Italiano

CESI

Shaping a Better Energy Future

Notes

STL-Member

CESI Group members are founder members of the SHORT-CIRCUIT TESTING LIAISON (STL) which has been established in 1969. STL is a forum for voluntary international cooperation of testing organizations.

CESI Group Test Documents description

STL Type Test Certificate of .....

Issued for type tests of high voltage products (> 1 kV_{ac}; > 1,5 kV_{dc}), which have successfully been carried out in full compliance with the relevant specifications or standards and STL Guides valid at the time of the test. The STL Type Test Certificate consists of documents unequivocally identifying the test object and describes all conditions under which the tests were conducted. It gives evidence of the unobjectionable behavior of the test object during the tests in line with the normative documents applied as well as of the results of successful testing.

Type Test Certificate of .....

Issued for type tests of high voltage products (> 1 kV_{ac}; > 1,5 kV_{dc}), which have successfully been carried out in full compliance with the relevant specifications or standards valid at the time of the test. The Type Test Certificate consists of documents unequivocally identifying the test object and describes all conditions under which the tests were conducted. It gives evidence of the unobjectionable behavior of the test object during the tests in line with the normative documents applied as well as of the results of successful testing.

Test Certificate of (complete / selected) Type Tests

Issued if type tests of low voltage products (< 1 kV_{ac}; < 1,5 kV_{dc}) requested by the relevant product standard were passed. For these tests the equipment under test must be clearly identified by technical description, drawings, and additional specifications.

Certificate of Design Verification

Issued for passed design verification tests according to IEC 61439. For these tests the equipment under test must be clearly identified by technical description, drawings, and additional specifications.

Type Test Report

Issued for high and low voltage products if parts of selected type tests have been passed; those shall be carried out in full compliance with the relevant standards but (for high voltage products) do not fulfill all STL requirements for issuing a Type Test Certificate. For these tests the equipment under test must be clearly identified by technical description, drawings, and additional specifications.

Test Report

Issued for all other tests on high and low voltage products which have been carried out according to specifications, standards and/or client instructions

On-Site Test Record

Issued as a record of results acquired during the on-site tests / measurements

Test Award

Can be additionally issued for all named types of test documents above if the tests to be referenced were passed

Tests witnessed by:

--- ---

Identification of the object: Not requested

Test evaluation

Subclause	Test	Test result
IEC 60099-4 (2014-06) – clause 8.5	Repetitive charge transfer withstand	Passed
The decision rule in conformity assessment is based on the simple acceptance method without considering the measuring uncertainties.		

The reported expanded uncertainties are determined in accordance with the Publication JCGM 100 "Evaluation of measurement data – Guide to the expression of uncertainty in measurement" and are based on a standard uncertainty multiplied by a coverage factor K=2, which for a normal distribution provides a level of confidence of approximately 95%

- Voltage a.c. **: ± 3,0%**
- Residual peak voltage (impulse tests) **: ± 3,0%**
- Current a.c. **: ± 3,0%**
- Peak current (impulse tests) **: ± 3,0%**
- Time (impulse tests) **: ± 10,0%**
- Time (a.c. tests) **: ± 1,5%**

Laboratory information

Receipt date of the sample May 2021

Test location CESI – Via Rubattino 54 – Milan

CESI testing team Mr. L- Podavitte

Test laboratory P177 (Surge Arrester laboratory)

ODV SAP 70012718

The sampling of the apparatuses to be tested has been carried out by CESI according to the product Standard

content	page a	test date
Test object characteristics	5	
Photographs of the test samples	6	
Reference standard	7	
Test carried out	7	
Test object identification	7	
Test procedure	8	
Summary of the test result	9	
Residual voltage test at nominal discharge current	10	June 28, 2021
Reference AC voltage test before the test	11 to 12	June 28, 2021
Residual voltage correction factor and Q_{rs} calculations	13	June 29, 2021
Application of 1,1 times Q_{rs}	14 to 30	June 29-July1, 2021
Test evaluation	31-33	July 1-2, 2021
Technical data of the test circuit	29 to 30	
Pages annexed:		
Oscillograms; n.80 pages		

Test object characteristics (assigned by the client)

Manufacturer's name	Industria Eletromecânica Balestro Ltda
Metal-oxide resistor type	P + 363610
Arrester class	Distribution
Designation	DH
Nominal discharge current - [kA]	10
Reference AC current - $I_{ref.}$ [mA]	1,7
Minimum reference voltage – $U_{ref.min}$ [mV]	6,20
Maximum residual voltage at 10 kA - [kV]	19,01
Repetitive charge transfer rating – Q_{rs} [C]	0,4
Flat surface area [cm^2]	10,37
Rated frequency - [Hz]	48÷62
Year of manufacture	2021

geometrical characteristics measured only on the metal-oxide resistor block

Total height [mm]	36,15
Diameter [mm]	36,35

Photograph of the test objects

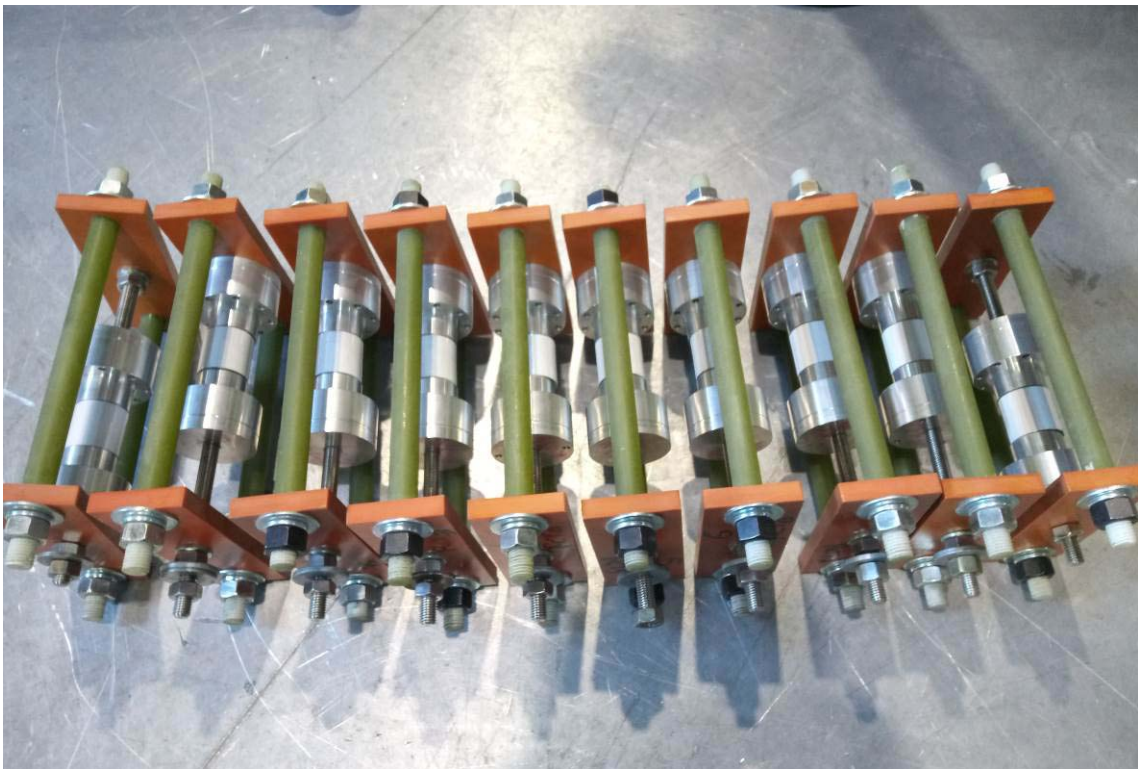


Photo no. 1

Varistors Balestro ZNO Protege + arranged by the Client in specified structure

Reference Standard

The test was carried out according on IEC 60099-4 – Edition 3.0 (2014-06) - Clause 8.5

“Metal-oxide surge arresters without gaps for a.c. system”

Test carried out

Test carried out	Number of sample tested
Test to verify the repetitive charge transfer rating, Qrs	10

Test object identification

Test object name	Identification of test sample (given by CESI)
Varistors Balestro ZNO Protege + arranged by the Client in specified structure	RCT1
	RCT 2
	RCT3
	RCT 4
	RCT 5
	RCT 6
	RCT 7
	RCT 8
	RCT 9
	RCT 10

Test procedure

The test consisted of the following steps:

a) Measurement of the lightning impulse residual voltage at the nominal discharge current.

b) Measurement of the power frequency reference voltage at the reference current.

c) Calculation of the corrected values of Q_{rs} associated to each test sample according to clause 7.3.1 of the reference standard.

d) Application of twenty lightning impulses 8/20 µs delivered in ten groups of two operations each.
The interval between consecutive impulses of the same group has been about 60 seconds.
Between different groups the samples have been let to cool down to near ambient temperature.

e) Measurement of the power frequency reference voltage at the reference current for comparison with initial value.

f) Measurement of the lightning impulse residual voltage at the nominal discharge current for comparison with initial value.

g) Application of a current impulse 8/20 µs of an amplitude resulting in a current density of 0,5 kA/cm^2 (withstand capability)

h) Visual inspection

Test result

The first test sequence has been performed on 10 MO resistors without any failure.
The variation of the reference voltage at the reference current measured before and after the test was less than 5% (the maximum allowed variation according to reference standard is 5%).
The variation of lightning impulse residual voltage before and after the test was less than 5% (maximum allowed variation according to reference standard is 5%).
After final application of a current impulse 8/20 µs no mechanical damage has been revealed by visual inspection.

The acceptance criteria are fulfilled and therefore the test result is positive.
The assigned repetitive charge transfer rating Q_{rs} equal to 0,4 C is proved.

Summary of test results

Variation of residual voltage at the nominal discharge current

sample	before test		after test		variation
	discharge current	discharge voltage	discharge current	discharge voltage	
	kA	kV	kA	kV	%
RCT 1	10,00	18,14	10,04	18,26	+0,66
RCT 2	10,10	18,23	10,04	18,27	+0,22
RCT 3	10,10	18,21	10,07	18,28	+0,38
RCT 4	10,16	18,13	10,06	18,27	+0,77
RCT 5	10,16	18,17	10,20	18,27	+0,55
RCT 6	10,15	18,17	10,09	18,29	+0,66
RCT 7	10,18	18,14	10,18	18,19	+0,28
RCT 8	10,15	18,17	10,10	18,28	+0,61
RCT 9	10,15	18,18	10,17	18,28	+0,55
RCT 10	10,19	18,14	10,15	18,24	+0,55

Variation of the reference AC voltage at the reference current

sample	reference AC voltage before test	reference AC voltage after test	variation
	kV	kV	%
RCT 1	6,50	6,38	-1,85
RCT 2	6,53	6,43	-1,53
RCT 3	6,56	6,47	-1,37
RCT 4	6,49	6,40	-1,39
RCT 5	6,54	6,44	-1,53
RCT 6	6,58	6,42	-2,43
RCT 7	6,50	6,39	-1,69
RCT 8	6,57	6,44	-1,98
RCT 9	6,53	6,35	-2,76
RCT 10	6,46	6,37	-1,39

Withstand capability to one 8/20 µs current impulse of at least 0,5 kA/cm^{2}peak current density after the test

sample	discharge current	discharge voltage	Note
	kA	kV	
RCT 1	5,35	17,11	no mechanical damage
RCT 2	5,37	17,12	no mechanical damage
RCT 3	5,33	17,13	no mechanical damage
RCT 4	5,38	17,09	no mechanical damage
RCT 5	5,35	17,08	no mechanical damage
RCT 6	5,43	17,07	no mechanical damage
RCT 7	5,38	17,12	no mechanical damage
RCT 8	5,30	17,09	no mechanical damage
RCT 9	5,41	17,08	no mechanical damage
RCT 10	5,47	17,11	no mechanical damage

Repetitive charge transfer withstand.

Residual voltage test at nominal discharge current before the test.

Test circuit: A0120

Date: June 28, 2021

Sample	Requested current	Charging Voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.	kA	kV	No.	µs	kA	kV
RCT 1	10	28,4	1	8,5/18,2	10,00	18,14
RCT 2		28,5	2		10,10	18,23
RCT 3		28,5	3		10,10	18,21
RCT 4		28,5	4		10,16	18,13
RCT 5		28,4	5		10,16	18,17
RCT 6		28,5	6		10,15	18,17
RCT 7		28,5	7		10,18	18,14
RCT 8		28,5	8		10,15	18,17
RCT 9		28,5	9		10,15	18,18
RCT 10		28,5	10		10,19	18,14

Notes:

Test to verify the repetitive charge transfer rating, Qrs.

Reference voltage test at reference current before the test.

Test circuit: A0019

Date: June 28, 2021
Ambient temperature: 21 °C

Sample No. RCT 1						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
11	6,50	1,67	1,70	0,782	3,78	---

Sample No. RCT 2						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
12	6,50	1,63	1,70	0,78	3,79	---

Sample No. RCT 3						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
13	6,50	1,65	1,71	0,78	3,80	---

Sample No. RCT 4						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
14	6,49	1,67	1,70	0,78	3,79	---

Sample No. RCT 5						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
15	6,54	1,63	1,70	0,77	3,75	---

continued

continued

Date: June 28, 2021

Sample No. RCT 6						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
16	6,58	1,67	1,70	0,774	3,74	---

Sample No. RCT 7						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
17	6,50	1,57	1,70	0,788	3,83	---

Sample No. RCT 8						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
18	6,57	1,67	1,70	0,782	3,81	---

Sample No. RCT 9						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
19	6,53	1,66	1,70	0,778	3,77	---

Sample No. RCT 10						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
20	6,46	1,67	1,70	0,785	3,79	---

Test to verify the repetitive charge transfer rating, Qrs.

Date: June 29, 2021

Residual voltage correction factor and Q_{rs} calculations

Sample	$U_{res.}$	Lenght	$U_{res.stress}$	Max $U_{res.stress}$	0,97 x Max $U_{res.stress}$	Correction factor	Q_{rs} rating	Corrected Q_{rs}	Applicable range for Q_{rs}
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
No.	kV	mm	kV/mm	kV/mm	kV/mm	kV	C	C	C
RCT 1	18,14	36,18	0,501	0,535	0,519	1,068	0,4	0,427	0,470÷0,512
RCT 2	18,23	36,21	0,503			1,064		0,426	0,469÷0,511
RCT 3	18,21	36,20	0,503			1,064		0,426	0,469÷0,511
RCT 4	18,13	36,26	0,500			1,070		0,428	0,471÷0,514
RCT 5	18,17	36,22	0,502			1,066		0,426	0,469÷0,511
RCT 6	18,17	36,23	0,502			1,066		0,426	0,469÷0,511
RCT 7	18,14	36,26	0,500			1,070		0,428	0,471÷0,514
RCT 8	18,17	36,21	0,502			1,066		0,426	0,469÷0,511
RCT 9	18,18	36,23	0,502			1,066		0,426	0,469÷0,511
RCT 10	18,14	36,32	0,499			1,072		0,428	0,471÷0,514

[1] $U_{res.}$: residual voltage at 10 kA measured on each sample

[2] Lenght : length measured on each sample

[3] $U_{res.stress}$: residual voltage stress calculated for each sample [3] = [1] / [2]

[4] Max $U_{res.stress}$: Max residual voltage stress claimed by the manufacturer for the surge arrester design (Maximum residual voltage at 10 kA / minimum thickness h)

[5] 0,97 x Max $U_{res.stress}$: Lowest limit of the residual voltage stress without applying any correction factor

[6] Correction factor : Correction factor is calculated for each sample
- no correction factor applied if the [3] ≥[5]
- correction factor applied if the [3] < [5]
- correction factor calculated [3] = [4] / [3]

[7] Q_{rs} rating : charge transfer rating selected from the list on the Reference Standard clause 8.5.4 by the manufacturer

[8] corrected Q_{rs} : corrected Q_{rs} [8] = [6] x [7]

[9] Applicable range for Q_{rs} : the lower value is calculated as 1,1 times [8],the higher value of the range is calculated as 1,2 times [8]

Note :

Max $U_{res.}$ declared by the manufacturer : 19,01 kV

Minimum lenght declared by the manufacturer : 35,5 mm

Test configuration for application of 1,1 times Q_{rs}

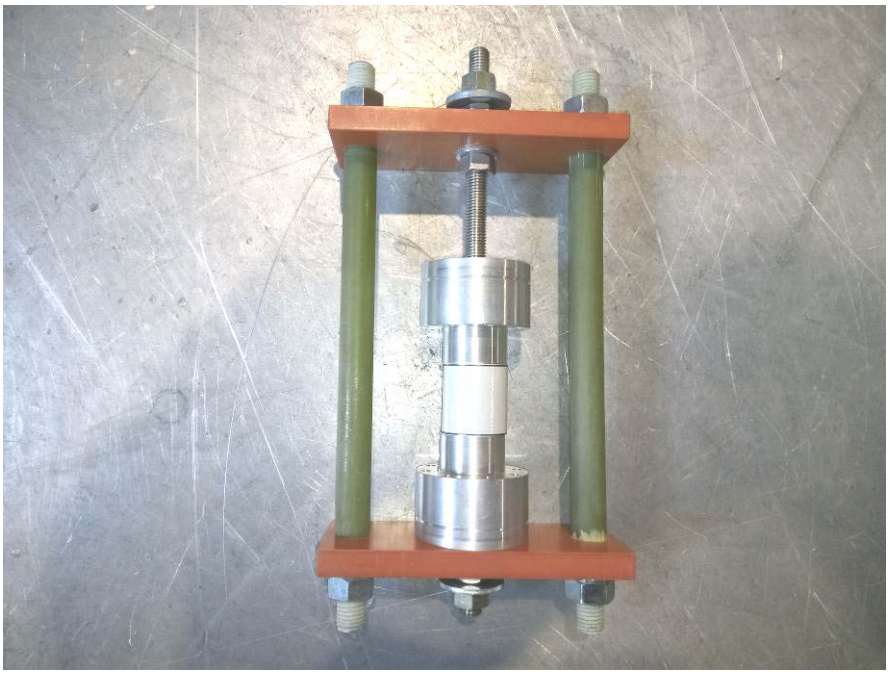


Photo no. 2

Test to verify the repetitive charge transfer rating, Qrs.

Application of twenty operations in ten groups of two 8/20 lightning current impulses.

Test circuit: A0120

Date: June 29&30, 2021

Sample No.	Impulse No.	Charging voltage kV	Oscillogram No.	Peak current kA	Residual voltage kV	Charge C
RCT 1	1	65,0		35,30	---	0,510
	2	64,5	21	34,90	---	0,500
	3	64,0		33,60	---	0,490
	4	64,0		33,30	---	0,487
	5	64,0		33,80	---	0,490
	6	64,0		33,50	---	0,490
	7	64,0		33,30	---	0,490
	8	64,0		33,40	---	0,490
	9	64,0		33,80	---	0,490
	10	64,0	31	33,35	---	0,490
	11	64,0		33,60	---	0,490
	12	64,0		33,50	---	0,490
	13	64,0		33,50	---	0,490
	14	64,0		33,45	---	0,490
	15	64,0		33,30	---	0,485
	16	63,8		32,80	---	0,480
	17	64,0		33,45	---	0,485
	18	64,0		33,55	---	0,490
	19	64,0		33,70	---	0,490
	20	64,0	41	33,55	---	0,490

Current impulse waveshape
8,9/18,5 µs

Note:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 2	1	64,5		35,0	---	0,510
	2	64,5	22	34,9	---	0,500
	3	64,0		33,50	---	0,490
	4	64,0		33,40	---	0,490
	5	64,0		33,70	---	0,490
	6	64,0		33,20	---	0,490
	7	64,0		33,60	---	0,490
	8	64,0		33,20	---	0,490
	9	64,0		33,50	---	0,490
	10	64,0	32	33,50	---	0,490
	11	64,0		33,50	---	0,490
	12	64,0		33,80	---	0,495
	13	64,0		33,60	---	0,490
	14	64,0		33,70	---	0,490
	15	64,0		33,40	---	0,485
	16	64,0		33,55	---	0,490
	17	64,0		33,65	---	0,490
	18	64,0		33,20	---	0,485
	19	64,0		33,40	---	0,490
	20	64,0	42	33,60	---	0,490

Current impulse waveshape
8,9/18,5 µs

Notes:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 3	1	64,0		34,05	---	0,500
	2	64,0	23	34,20	---	0,500
	3	64,0		33,60	---	0,490
	4	64,0		33,20	---	0,485
	5	64,0		33,40	---	0,490
	6	64,0		33,45	---	0,485
	7	64,0		33,45	---	0,495
	8	64,0		33,40	---	0,490
	9	64,0		33,95		0,490
	10	64,0	33	33,60		0,490
	11	64,0		33,60	---	0,490
	12	64,0		33,30	---	0,485
	13	64,0		33,50	---	0,490
	14	64,0		33,40	---	0,490
	15	64,0		33,35	---	0,485
	16	64,0		33,30	---	0,485
	17	64,0		33,65	---	0,490
	18	64,0		33,60	---	0,490
	19	64,0		33,85	---	0,495
	20	64,0	43	33,80	---	0,495

Current impulse waveshape
8,9/18,5 µs

Notes:

continued

continued

Date: Junee 29&30, 2021

Sample No.	Impulse No.	Charging voltage kV	Oscillogram No.	Peak current kA	Residual voltage kV	Charge C
RCT 4	1	64,5		33,95	---	0,500
	2	64,5	24	34,20	---	0,500
	3	64,0		33,60	---	0,490
	4	64,0		33,30	---	0,490
	5	64,0		33,60	---	0,490
	6	64,0		33,40	---	0,485
	7	64,0		33,60	---	0,490
	8	64,0		33,30	---	0,490
	9	64,0		33,70	---	0,495
	10	64,0	.34	33,45	---	0,485
	11	64,0		33,70	---	0,490
	12	64,0		33,55	---	0,490
	13	64,0		33,60	---	0,490
	14	64,0		33,60	---	0,490
	15	64,0		33,45	---	0,490
	16	64,0		33,35	---	0,485
	17	64,0		33,80	---	0,495
	18	64,0		33,50	---	0,490
	19	64,0		33,60		0,490
	20	64,5	44	34,10		0,500

Current impulse waveshape
8,9/18,5 µs

Notes:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 5	1	64,5		34,20	---	0,500
	2	64,0	25	33,10	---	0,480
	3	64,0		33,70	---	0,490
	4	64,0		33,50	---	0,485
	5	64,0		33,70	---	0,495
	6	64,0		33,70	---	0,490
	7	64,0		33,60	---	0,490
	8	64,0		33,50	---	0,490
	9	64,0		33,60	---	0,490
	10	64,0	35	33,65		0,495
	11	64,0		33,50		0,490
	12	64,0		33,70	---	0,495
	13	64,0		33,40	---	0,490
	14	64,0		33,50	---	0,490
	15	64,0		33,50	---	0,490
	16	64,0		33,30	---	0,485
	17	64,0		33,45	---	0,490
	18	64,0		33,70	---	0,490
	19	64,0		33,85	---	0,495
	20	64,0	45	33,75	---	0,495

Current impulse waveshape
8,9/18,5 µs

Notes:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 6	1	64,0		34,20	---	0,500
	2	64,0	26	33,75	---	0,490
	3	64,0		33,50	---	0,490
	4	64,0		33,20	---	0,485
	5	64,0		33,40	---	0,485
	6	64,0		33,10	---	0,485
	7	64,0		33,30	---	0,485
	8	64,0		33,40	---	0,485
	9	64,0		33,75	---	0,495
	10	64,0	36	33,50	---	0,490
	11	64,0		33,85	---	0,495
	12	64,0		33,50	---	0,490
	13	64,0		33,75	---	0,490
	14	64,0		33,70	---	0,490
	15	64,0		33,75	---	0,490
	16	64,0		33,60	---	0,490
	17	64,0		33,75	---	0,490
	18	64,0		33,60	---	0,490
	19	64,0		33,95	---	0,495
	20	64,0	46	33,85	---	0,495

Current impulse waveshape
8,9/18,5 µs

Notes:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 7	1	64,0		34,00	---	0,500
	2	64,0	27	33,40	---	0,490
	3	64,0		33,45	---	0,490
	4	64,0		33,15	---	0,485
	5	64,0		33,70	---	0,490
	6	64,0		33,60	---	0,490
	7	64,0		33,70	---	0,490
	8	64,0		33,60	---	0,490
	9	64,0		33,50	---	0,490
	10	64,0	37	33,60	---	0,495
	11	64,0		33,65	---	0,490
	12	64,0		33,65	---	0,490
	13	64,0		33,60	---	0,490
	14	64,0		33,60	---	0,490
	15	64,0		33,60	---	0,490
	16	64,0		33,65	---	0,490
	17	64,0		33,90	---	0,495
	18	64,0		33,75	---	0,490
	19	64,0		33,80	---	0,490
	20	64,0	47	33,70	---	0,495

Current impulse waveshape
8,9/18,5 µs

Notes:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 8	1	64,0		33,80	---	0,490
	2	64,0	28	33,30	---	0,490
	3	64,0		33,70	---	0,490
	4	64,0		33,60	---	0,495
	5	64,0		33,60	---	0,490
	6	64,0		33,45	---	0,490
	7	64,0		33,80	---	0,495
	8	64,0		33,80	---	0,495
	9	64,0		33,70	---	0,490
	10	64,0	38	33,50	---	0,490
	11	64,0		33,70	---	0,490
	12	64,0		33,40	---	0,485
	13	64,0		33,40	---	0,485
	14	64,0		33,35	---	0,485
	15	64,0		33,60	---	0,490
	16	64,0		33,30	---	0,485
	17	64,0		33,80	---	0,495
	18	64,0		33,60	---	0,490
	19	64,0		33,60	---	0,490
	20	64,0	48	33,70		0,490

Current impulse waveshape
8,9/18,5 µs

Notes:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 9	1	64,0		34,10	---	0,500
	2	64,0	29	33,50	---	0,490
	3	64,0		33,50	---	0,490
	4	64,0		33,35	---	0,490
	5	64,0		33,95	---	0,495
	6	64,0		33,50		0,490
	7	64,0		33,58	---	0,490
	8	64,0		33,65	---	0,490
	9	64,0		33,70	---	0,485
	10	64,0	39	33,75	---	0,490
	11	64,0		33,50	---	0,490
	12	64,0		33,40	---	0,490
	13	64,0		33,60	---	0,485
	14	64,0		33,70	---	0,490
	15	64,0		33,60	---	0,490
	16	64,0		33,55	---	0,490
	17	64,0		33,60	---	0,490
	18	64,0		33,55	---	0,490
	19	64,0		33,50	---	0,490
	20	64,0	49	33,60	---	0,490

Current impulse waveshape
8,9/18,5 µs

Notes
:

continued

continued

Date: June 29&30, 2021

Sample	Impulse	Charging voltage	Oscillogram	Peak current	Residual voltage	Charge
No.	No.	kV	No.	kA	kV	C
RCT 10	1	64,0		34,00	---	0,500
	2	64,0	30	33,50	---	0,490
	3	64,0		33,50	---	0,490
	4	64,0		33,50	---	0,490
	5	64,0		33,80	---	0,490
	6	64,0		33,70	---	0,490
	7	64,0		33,75	---	0,490
	8	64,0		33,60	---	0,490
	9	64,0		34,20	---	0,500
	10	64,0	40	33,63	---	0,490
	11	64,0		33,50	---	0,490
	12	64,0		33,45	---	0,490
	13	64,0		33,50	---	0,490
	14	64,0		33,40	---	0,485
	15	64,0		33,50	---	0,490
	16	64,0		33,65	---	0,490
	17	64,0		33,55	---	0,490
	18	64,0		33,50	---	0,485
	19	64,0		33,60	---	0,490
	20	64,0	50	33,60		0,490

Current impulse waveshape
8,9/18,5 µs

Notes:

Repetitive charge transfer withstand

Reference voltage test at reference current after the test.

Test circuit: A0019

Date: July 01, 2021
Ambient temperature: 21 °C

Sample No. RCT 1						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
51	6,38	1,39	1,71	0,735	3,46	---

Sample No. RCT 6						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
52	6,43	1,36	1,70	0,730	3,42	---

Sample No. RCT 7						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
53	6,47	1,39	1,70	0,732	3,46	---

Sample No. RCT 9						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
54	6,40	1,43	1,70	0,744	3,50	---

Sample No. RCT 9						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
55	6,44	1,41	1,70	0,733	3,46	---

continued

Date: July 01, 2021

Sample No. RCT 6						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
56	6,42	1,31	1,70	0,716	3,34	---

Sample No. RCT 7						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
57	6,39	1,46	1,70	0,750	3,54	---

Sample No. RCT 8						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
58	6,44	1,41	1,70	0,741	3,52	---

Sample No. RCT 9						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
59	6,35	1,39	1,71	0,741	3,49	---

Sample No. RCT 10						
oscillogram	voltage	current	current	current	power	Note
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
60	6,37	1,46	1,70	0,746	3,52	---

Repetitive charge transfer withstand.

Residual voltage test at nominal discharge current after the test.

Test circuit: A0120

Date: July 02, 2021

Sample	Requested current	Charging Voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.	kA	kV	No.	µs	kA	kV
RCT 1	10	28,4	61	8,3/18,2	10,04	18,26
RCT 2		28,4	62		10,04	18,27
RCT 3		28,4	63		10,07	18,28
RCT 4		28,4	64		10,06	18,27
RCT 5		28,4	65		10,20	18,27
RCT 6		28,4	66		10,09	18,29
RCT 7		28,4	67		10,18	18,19
RCT 8		28,4	68		10,10	18,28
RCT 9		28,4	69		10,17	18,28
RCT 10		28,4	70		10,15	18,24

Notes:

Repetitive charge transfer rating, Qrs.

Final application of a current impulse 8/20 µs (withstand capability)

Test circuit: A0120

Date: July 02, 2021

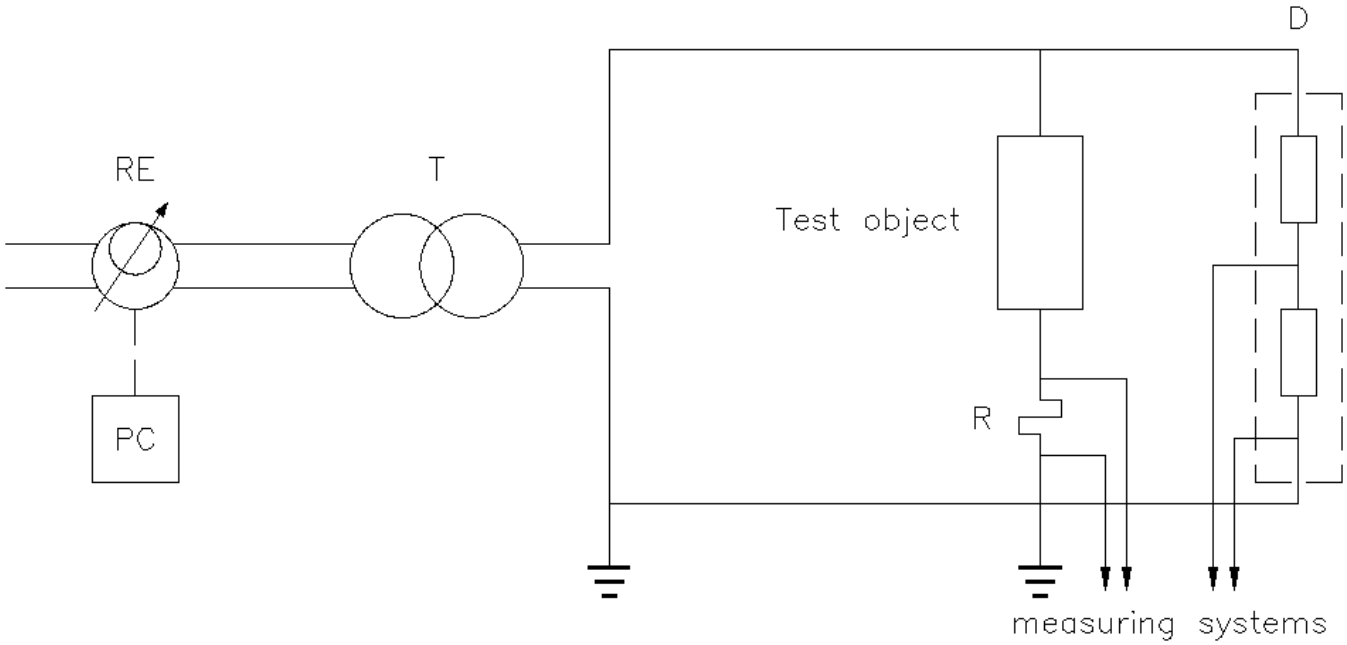
Sample	Requested current	Charging Voltage	Oscillogram	Current waveshape	Discharge current	Discharge voltage
No.	kA	kV	No.	µs	kA	kV
RCT 1	5,20(*)	22,6	71	8,3/18,6	5,35	17,11
RCT 2		22,6	72		5,37	17,12
RCT 3		22,6	73		5,33	17,13
RCT 4		22,6	74		5,38	17,09
RCT 5		22,6	75		5,35	17,08
RCT 6		22,6	76		5,43	17,07
RCT 7		22,6	77		5,38	17,12
RCT 8		22,6	78		5,30	17,09
RCT 9		22,6	79		5,41	17,08
RCT 10		22,6	80		5,47	17,11

Notes:

(*) Requested current = 0,5 kA/cm^2 x 10,37 cm^2 = 5,19 kA

- where 0,5 kA/cm^2 is peak current density
- where 13,29 cm^2 is surface area on the metal-oxide resistor used for this test declared by the manufacturer

Circuit A0019



Power frequency supply

RE - programmable supply type PACIFIC A.C. Power Source 140 ASX.; CESI no. 0560408
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system type HBM CESI No. 57986(Rx) – 57987 (Tx)

OSC
- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.1)

Voltage measuring system

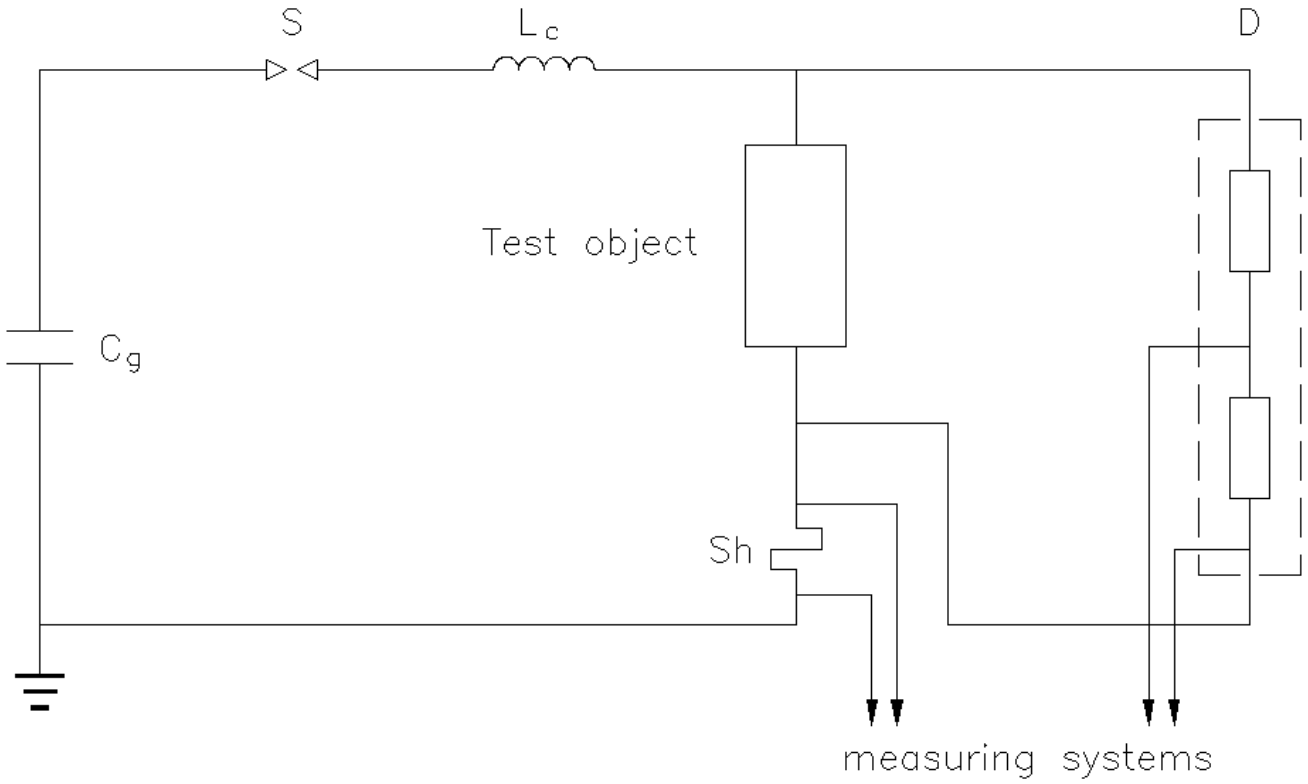
D - Voltage divider SAGI; CESI No.11120
- Electro optical system type HBM CESI No. 57986(Rx) – 57991 (Tx)

OSC
- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122;
- CESI No 056227- 0562226 (on channel No.2)

Software system:

SW - S.A.D. Surge arrester version 2.0

Circuit A0120



Impulse generator

No. of stages	1 (for residual voltage measurement at 10 kA)
Cg	6,64 µF
Lc	6 µH
No. of stages	2 (for Q_{rs} application)
Cg	3,32 µF
Lc	12 µH
S	- Spark-gap

Additional two blocks have been added

Voltage measuring system.

D	- Voltage divider SAGI; CESI No.11120
	- Electro optical system type HBM CESI No. 57986(Rx) – 57987 (Tx)
OSC	- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122; - CESI No 056227- 0562226 (on channel No.2)

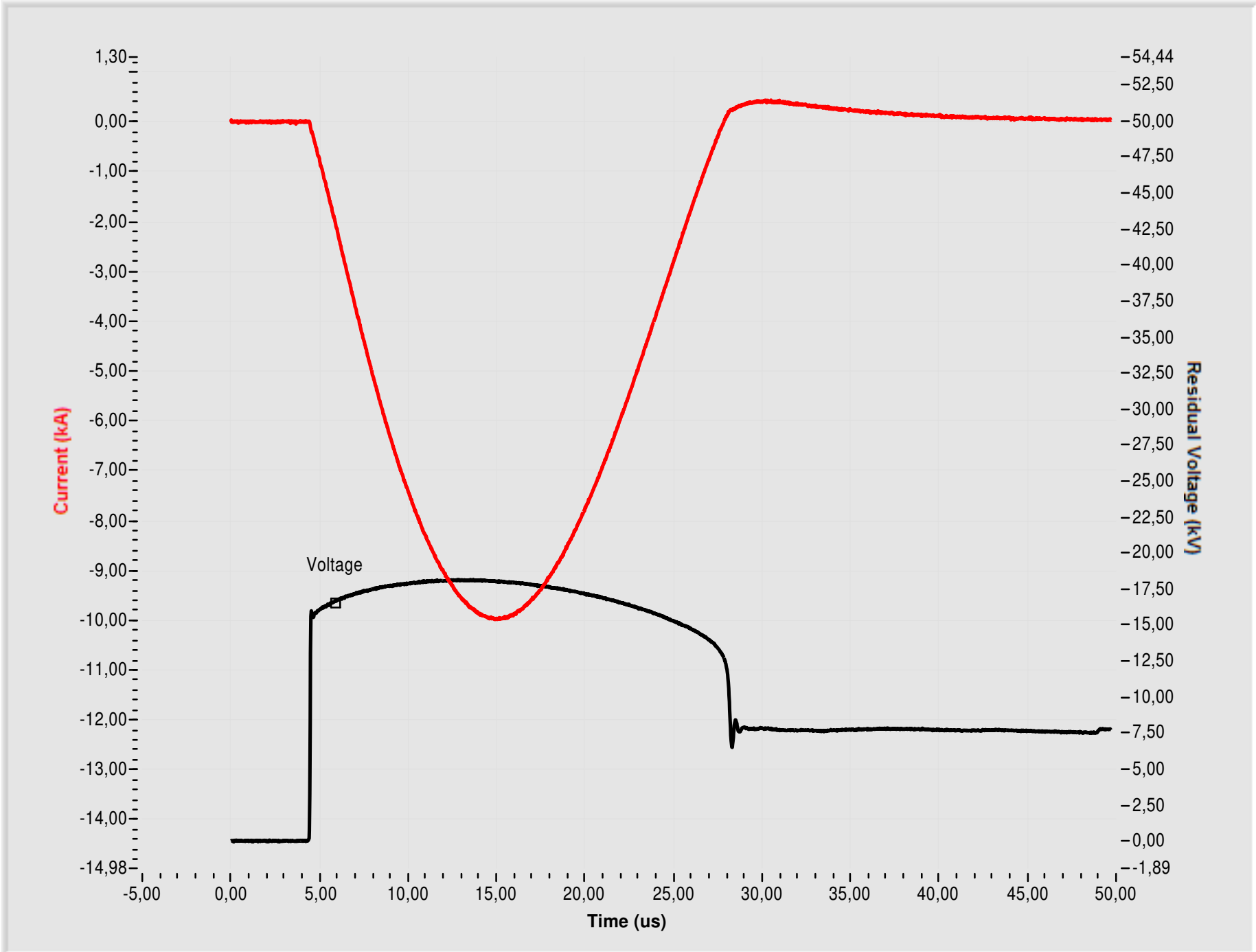
Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
	- Electro optical system type HBM CESI No. 57986(Rx) – 57987 (Tx)
OSC	- Oscilloscope type NATIONAL INSTRUMENT NI PXI-1031/NI-PXI 8108/NI-PXI 5122; - CESI No 056227- 0562226 (on channel No.1)

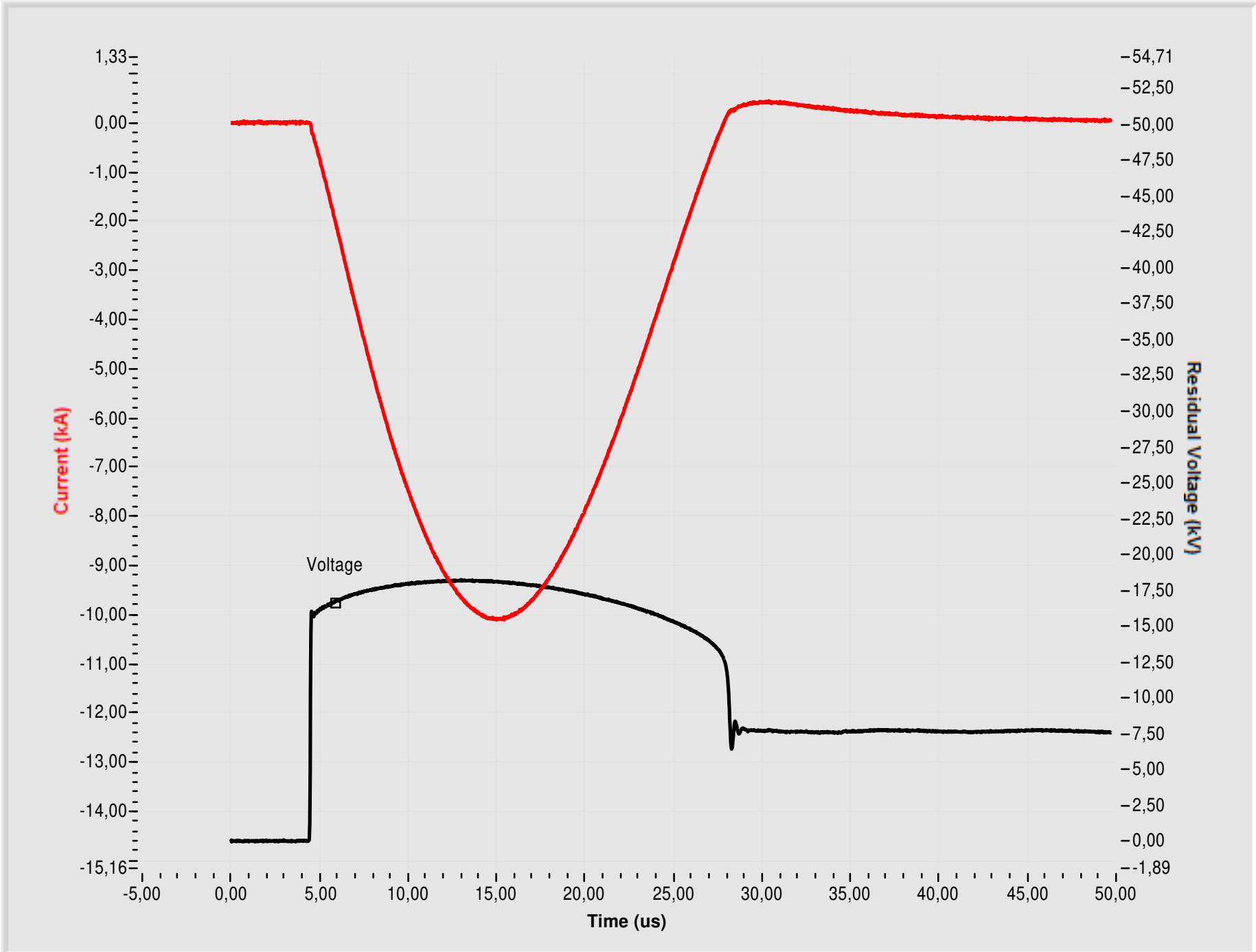
Software system:

SW - S.A.D. Surge arrester version 2.0

CESI C1011283 Oscillogram n. 1



CESI C1011283 Oscillogram n. 2



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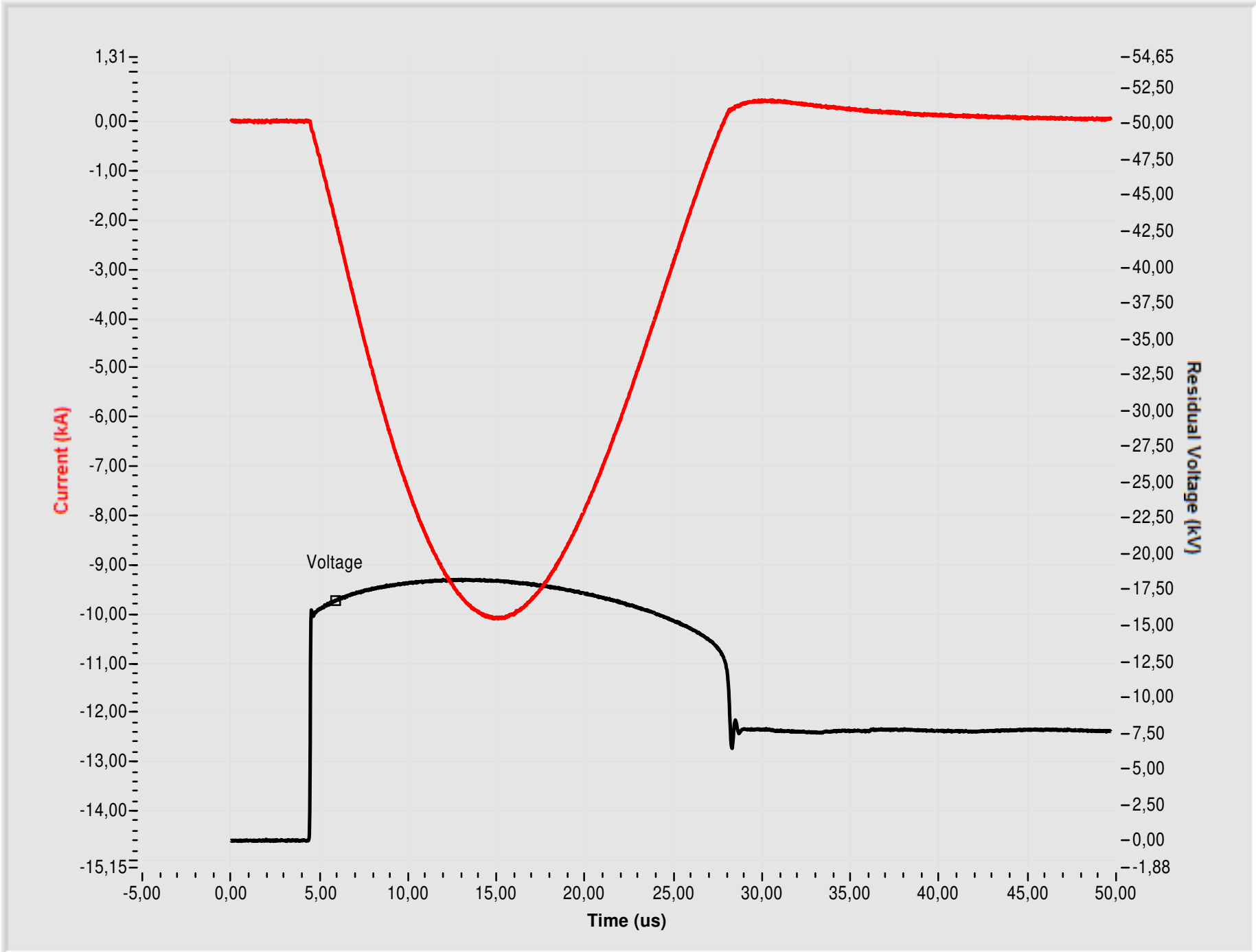
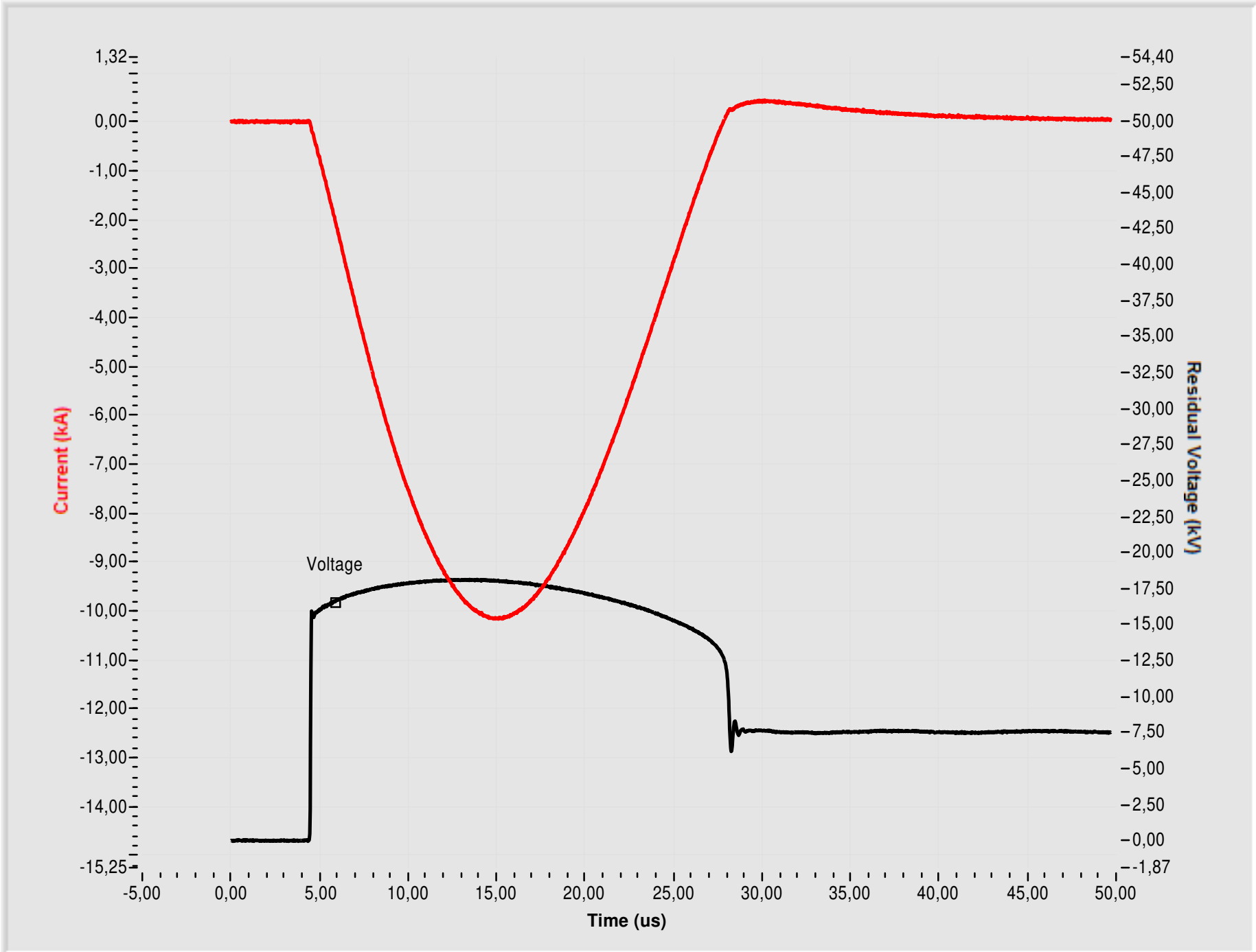
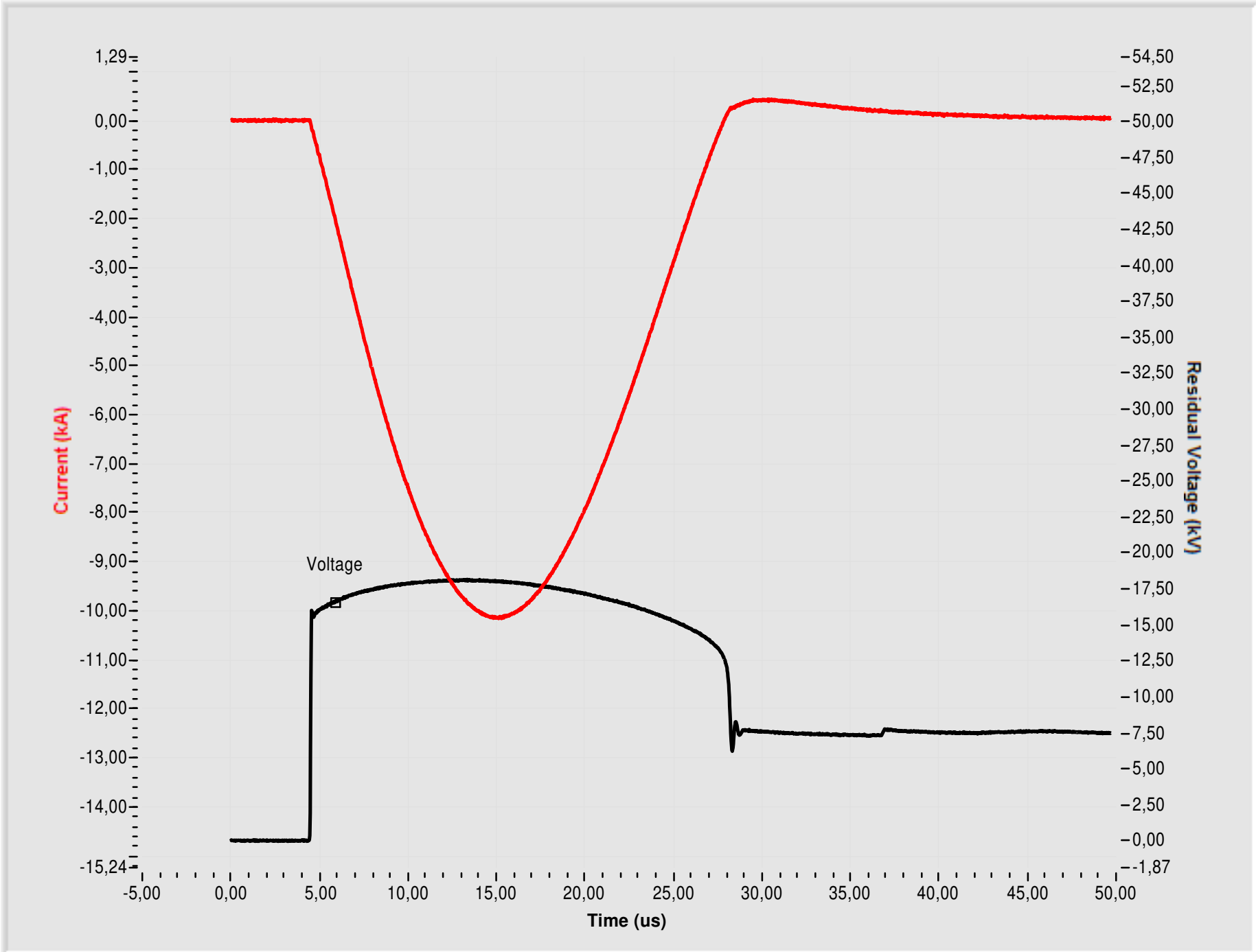


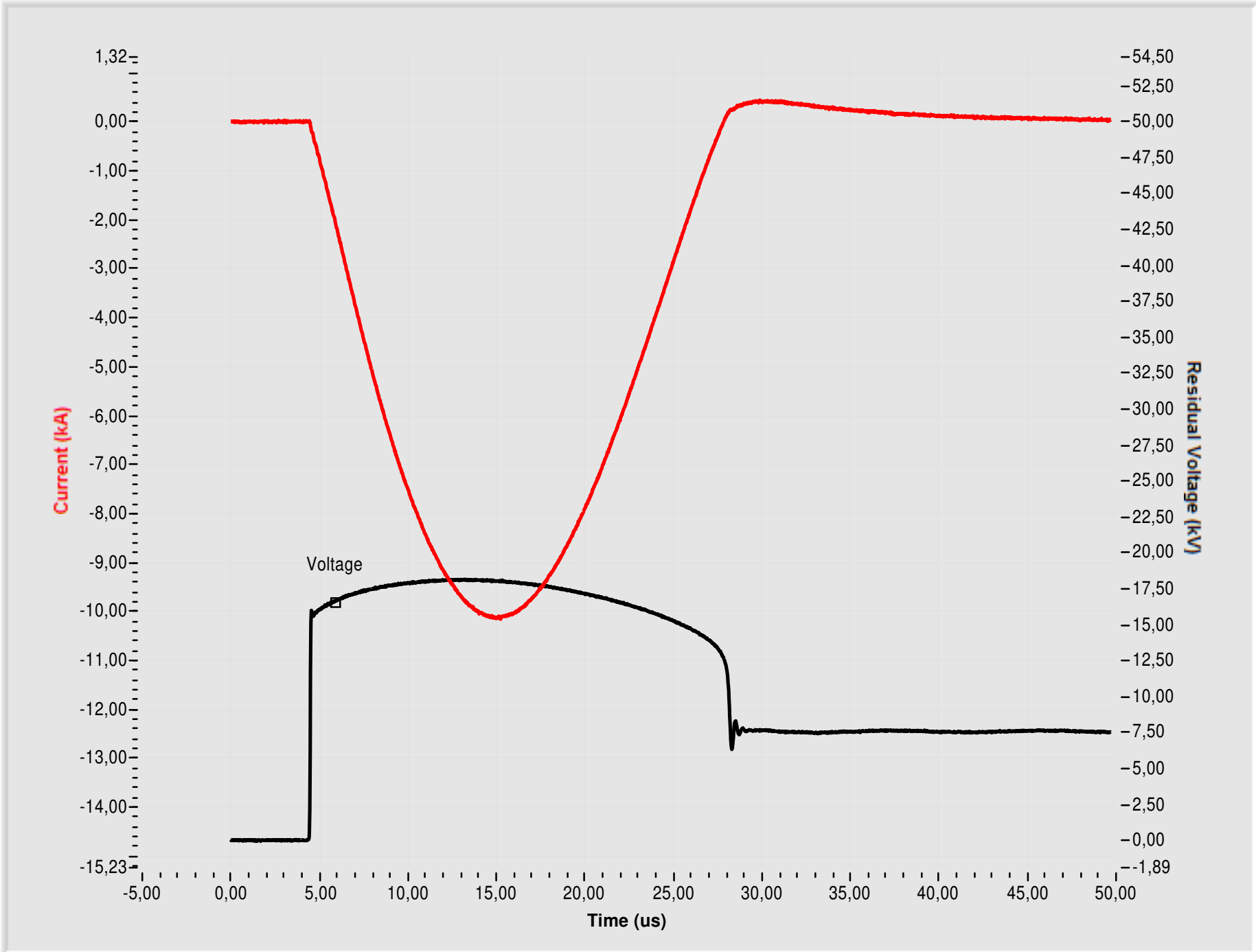
CESI C1011283 Oscillogram n. 4



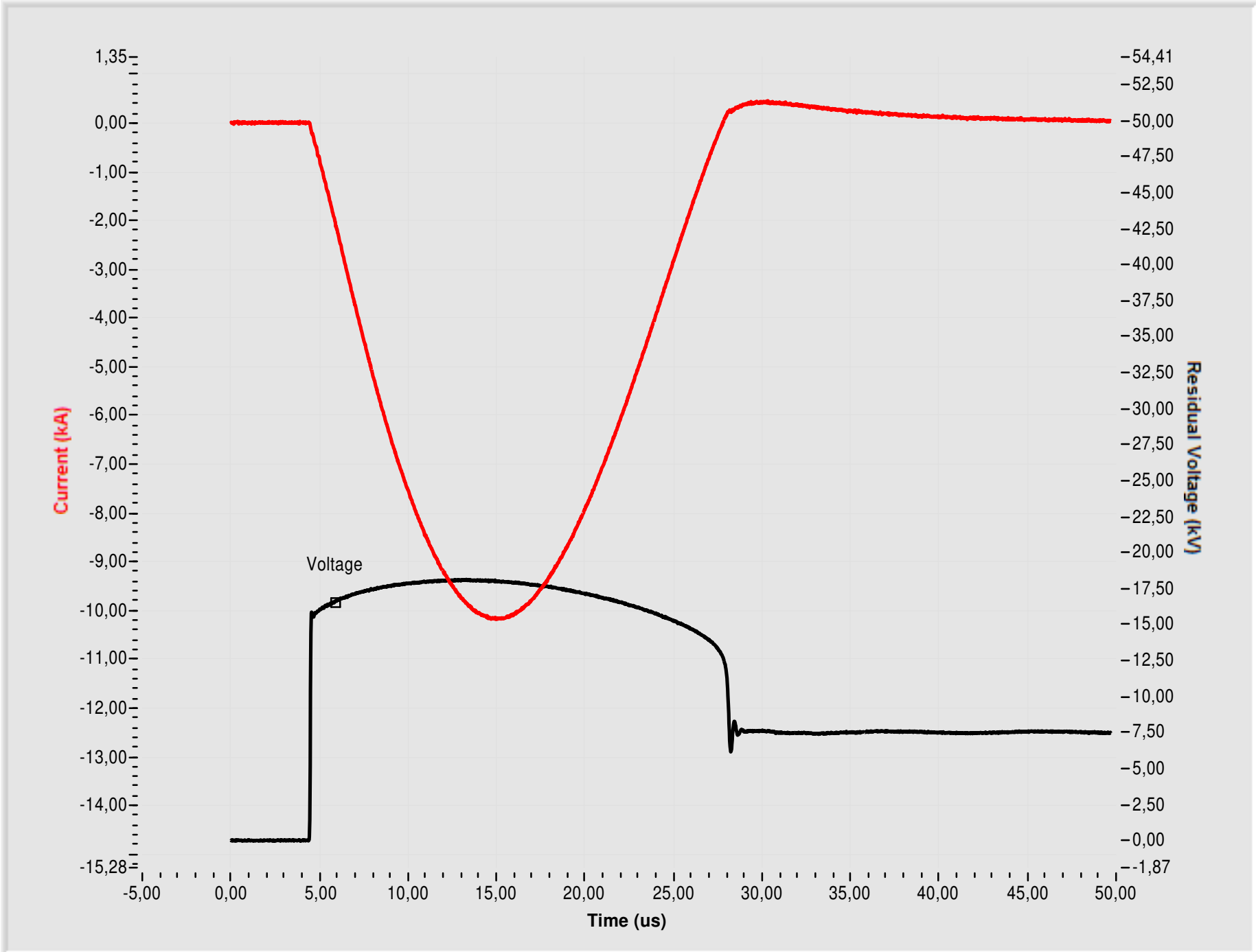
CESI C1011283 Oscillogram n. 5



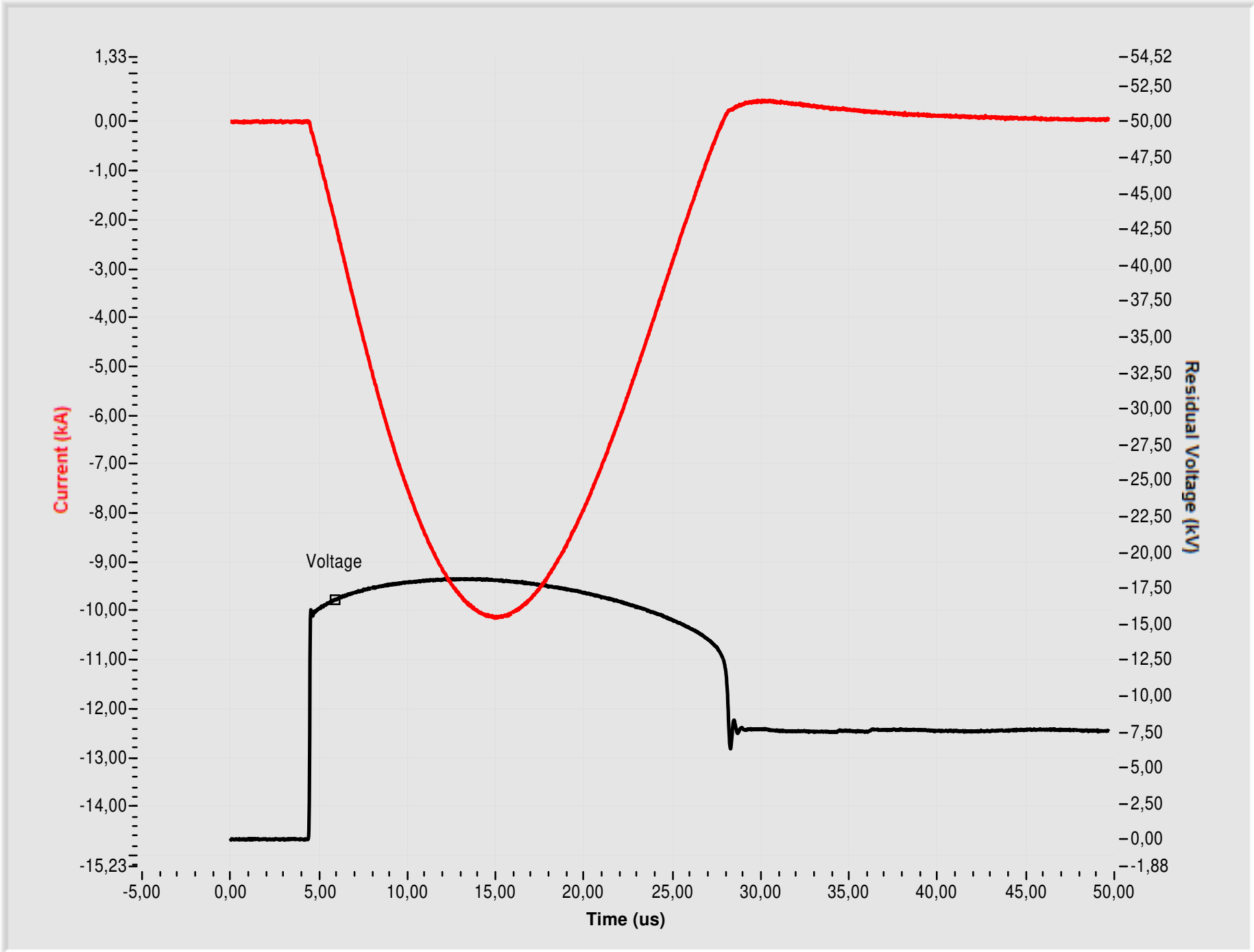
CESI C1011283 Oscillogram n. 6



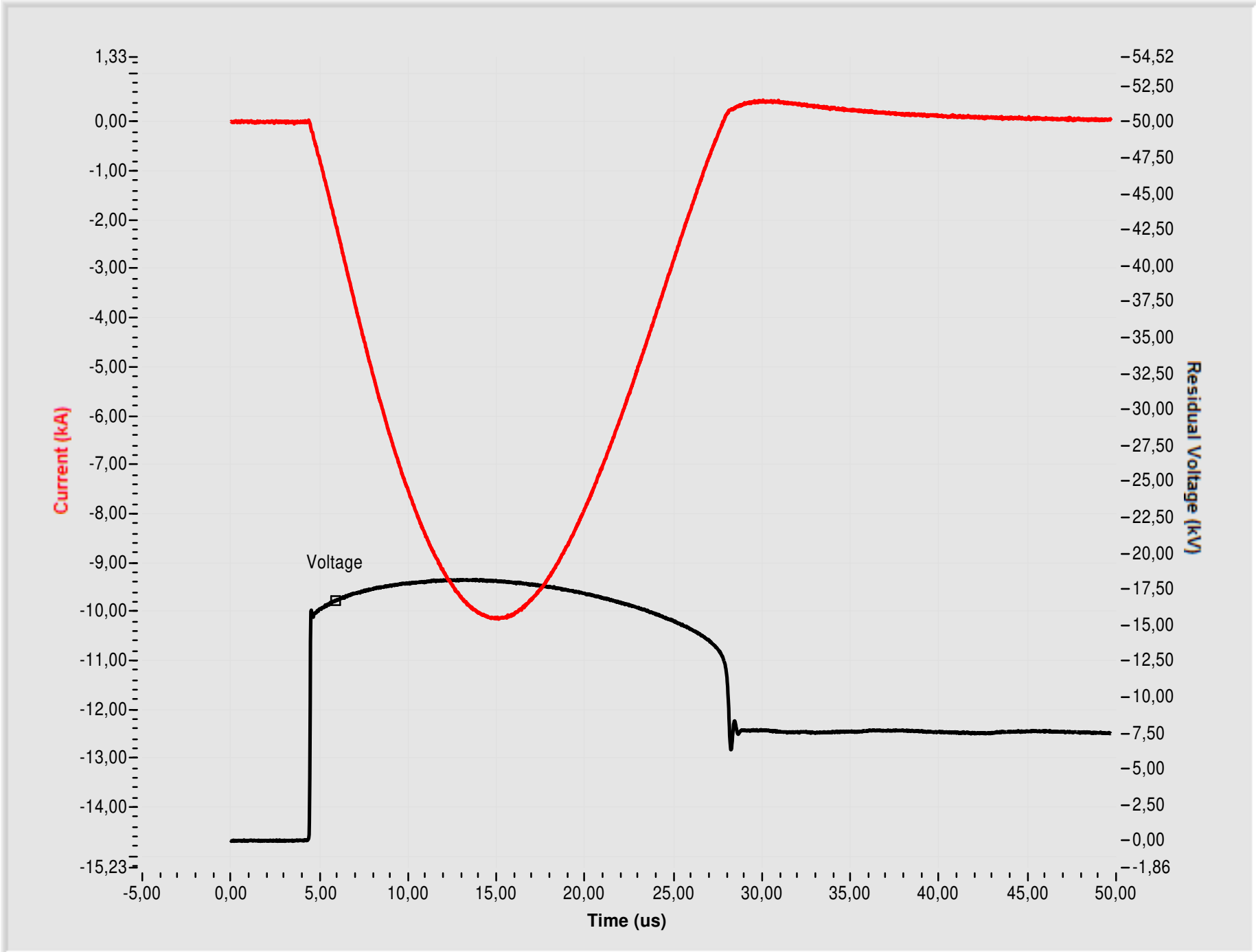
CESI C1011283 Oscillogram n. 7



CESI C1011283 Oscillogram n. 8



CESI C1011283 Oscillogram n. 9



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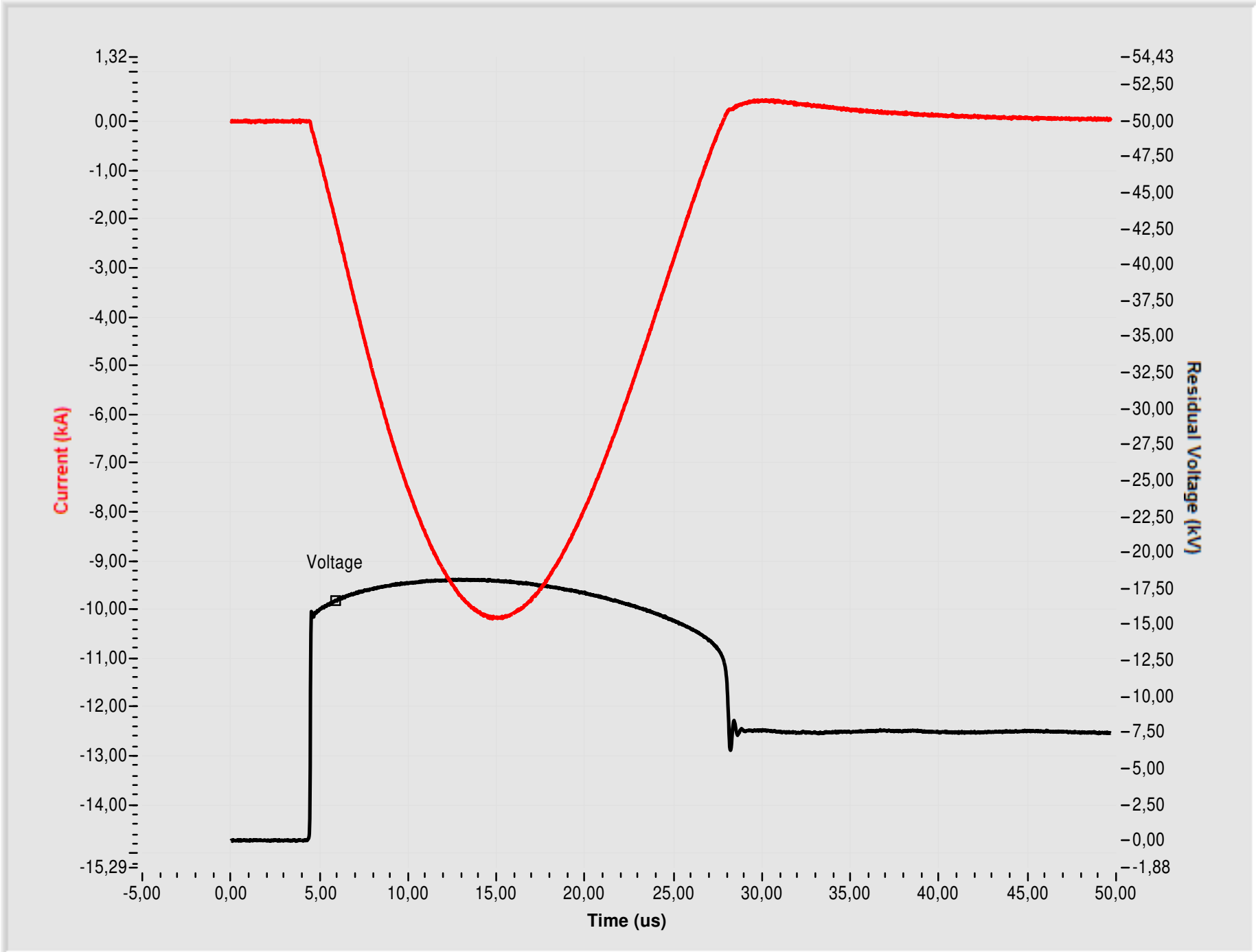

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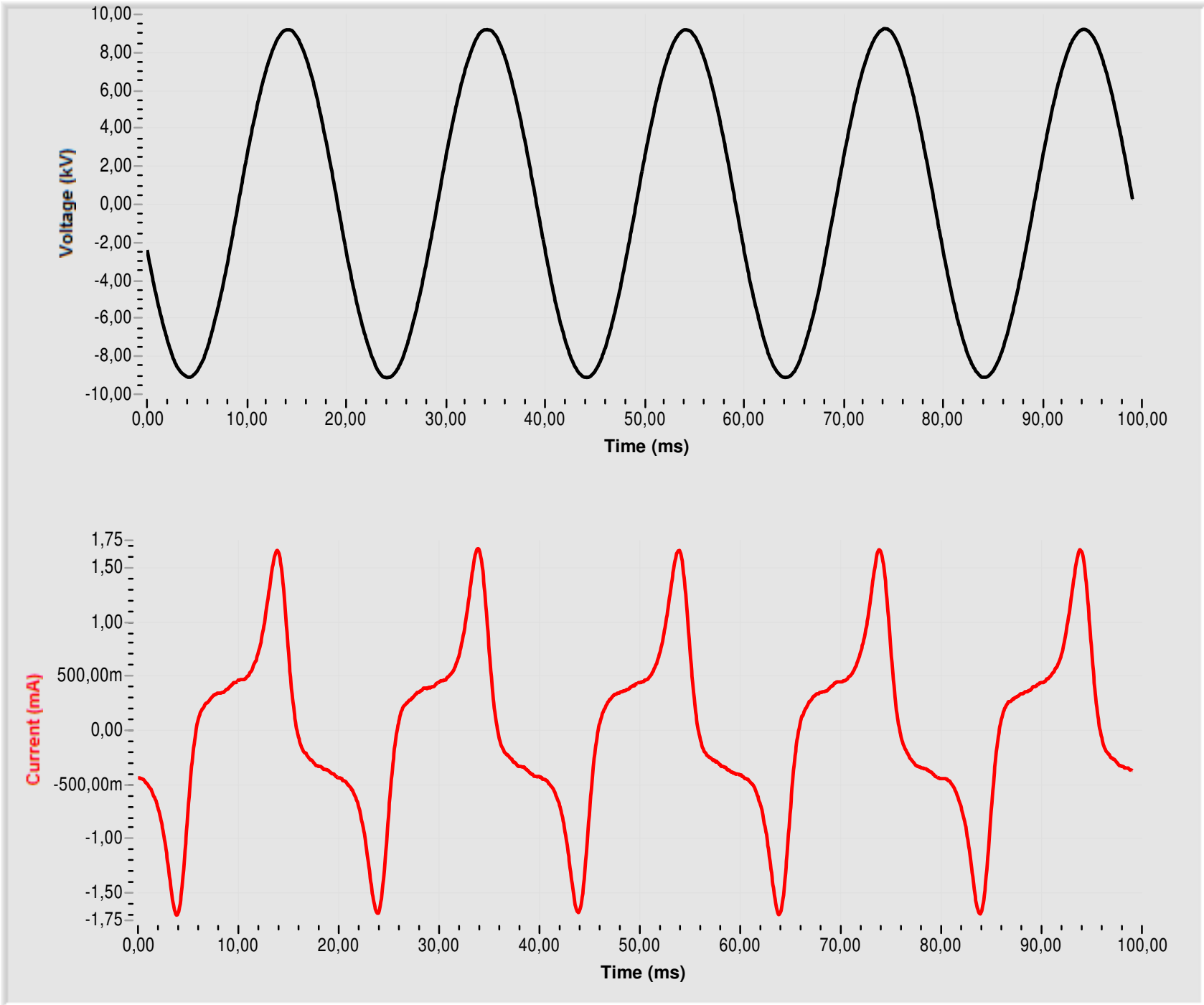

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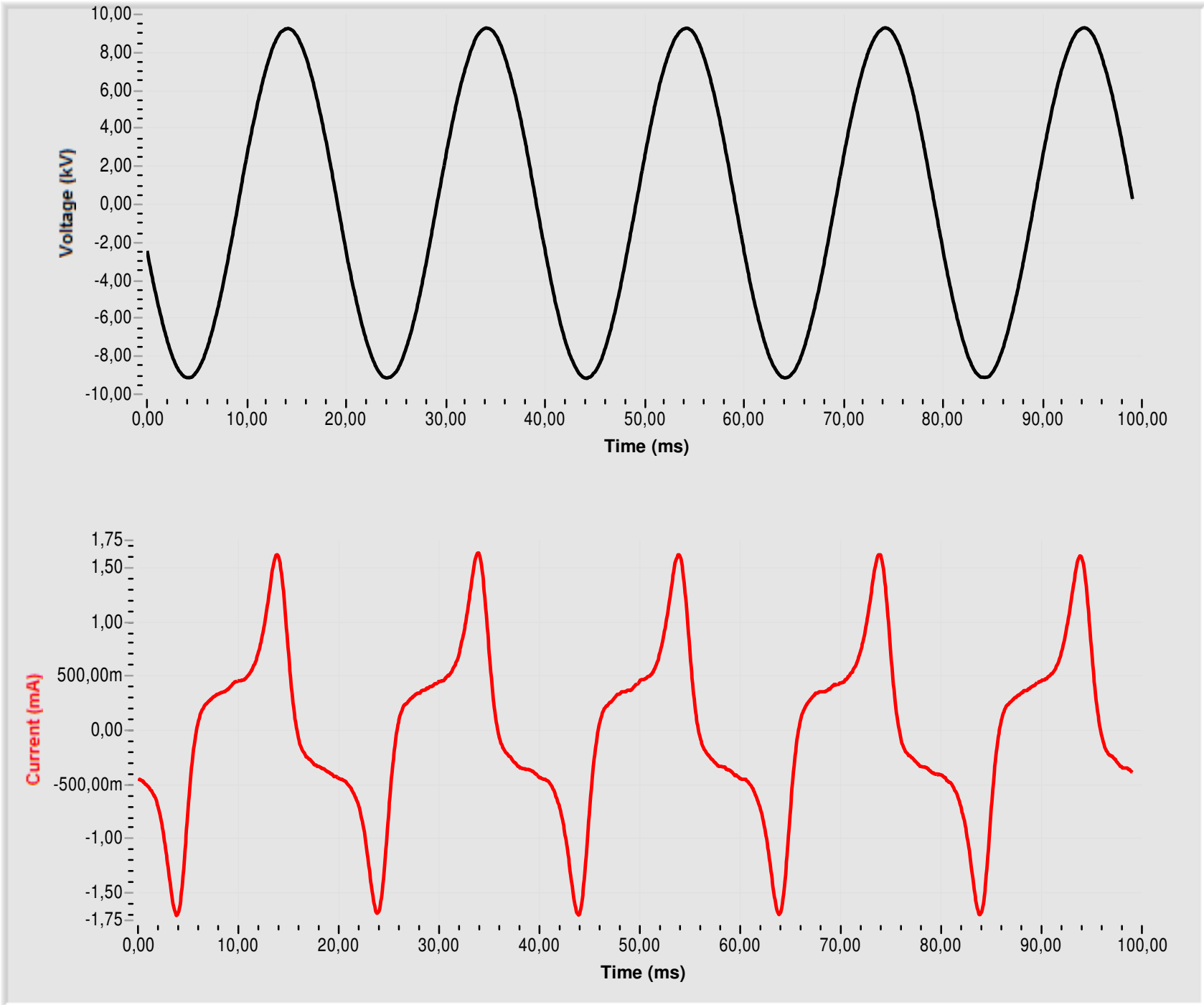
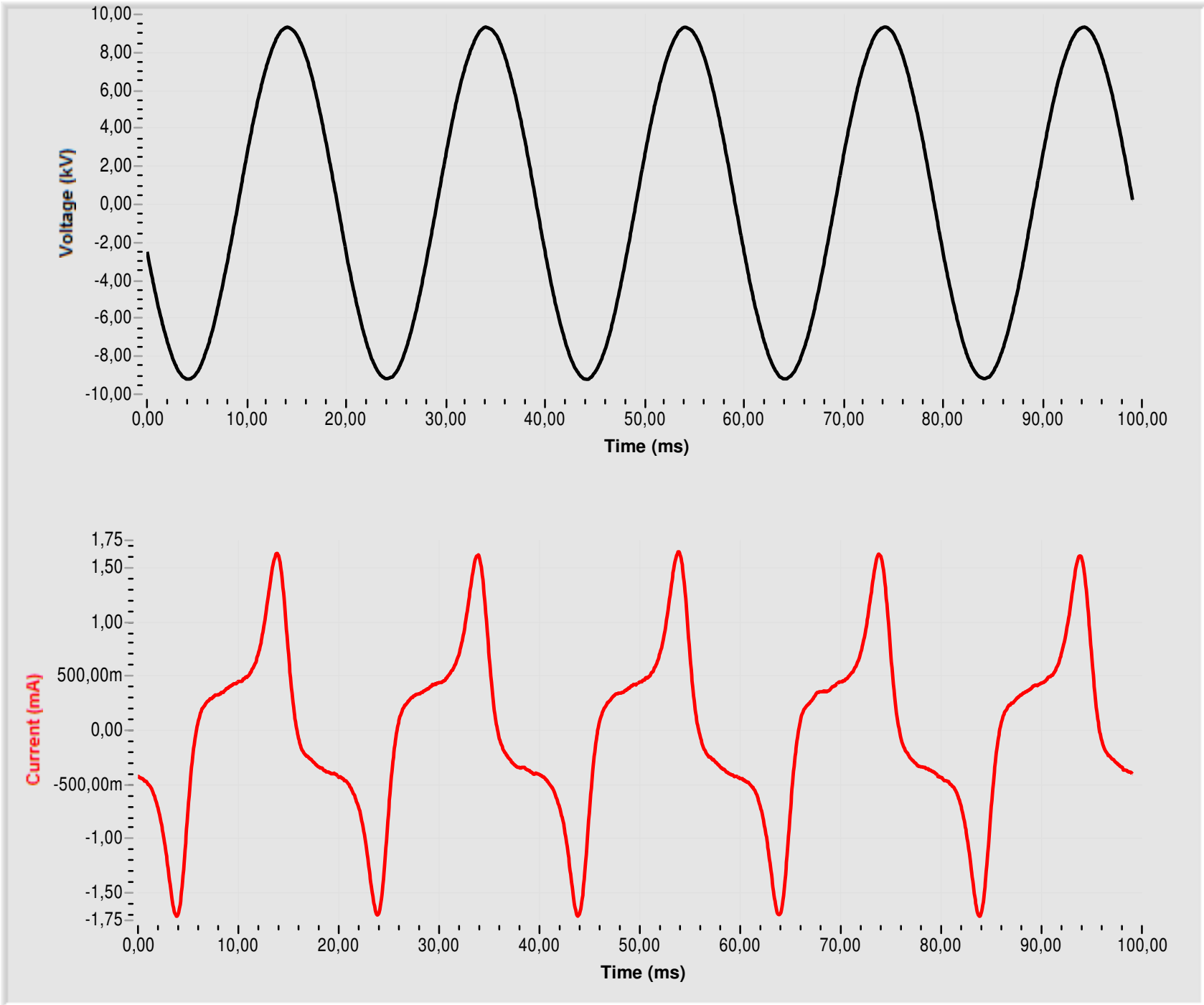
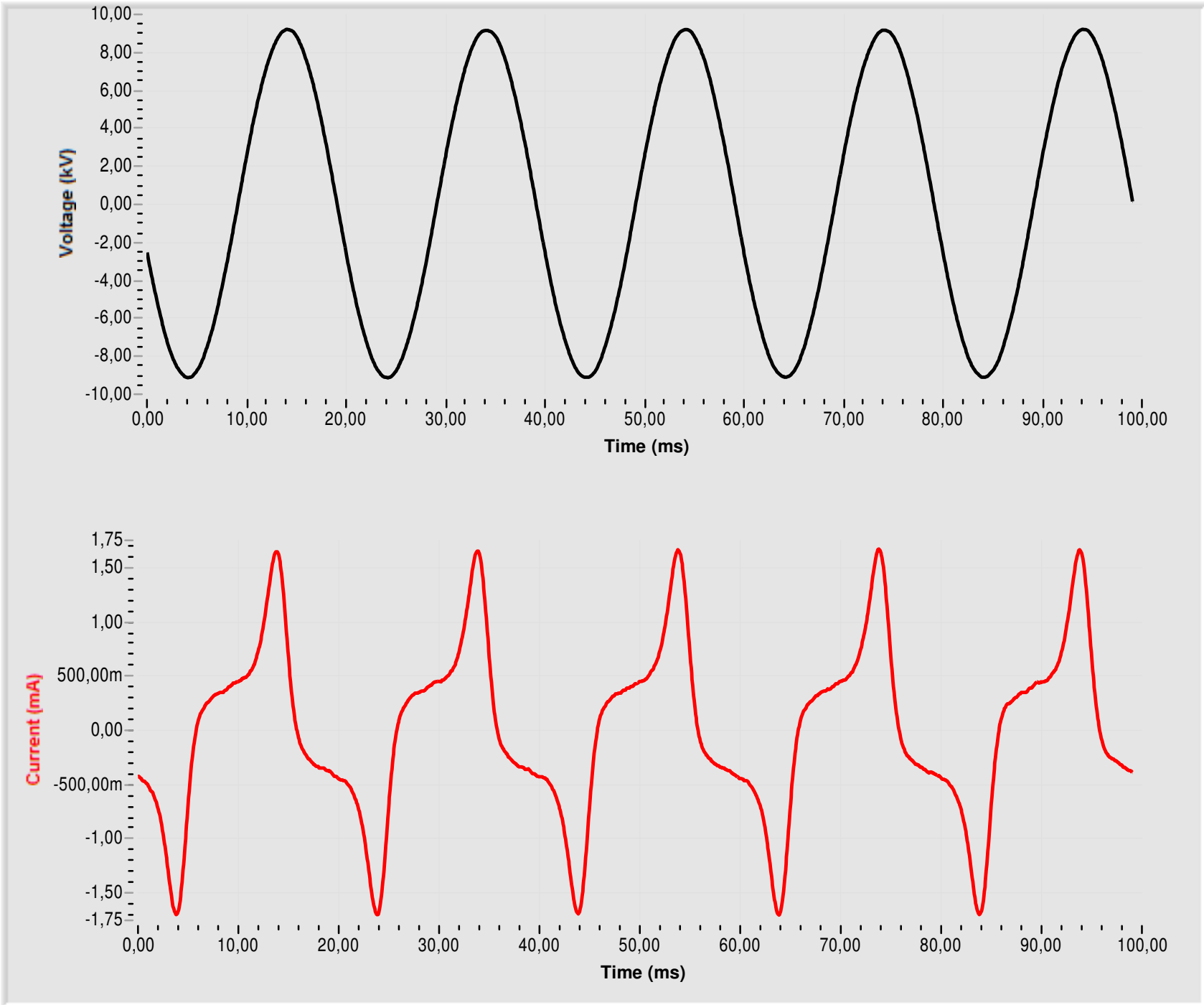


CESI C1011283 Oscillogram n. 13



CESI C1011283 Oscillogram n. 14



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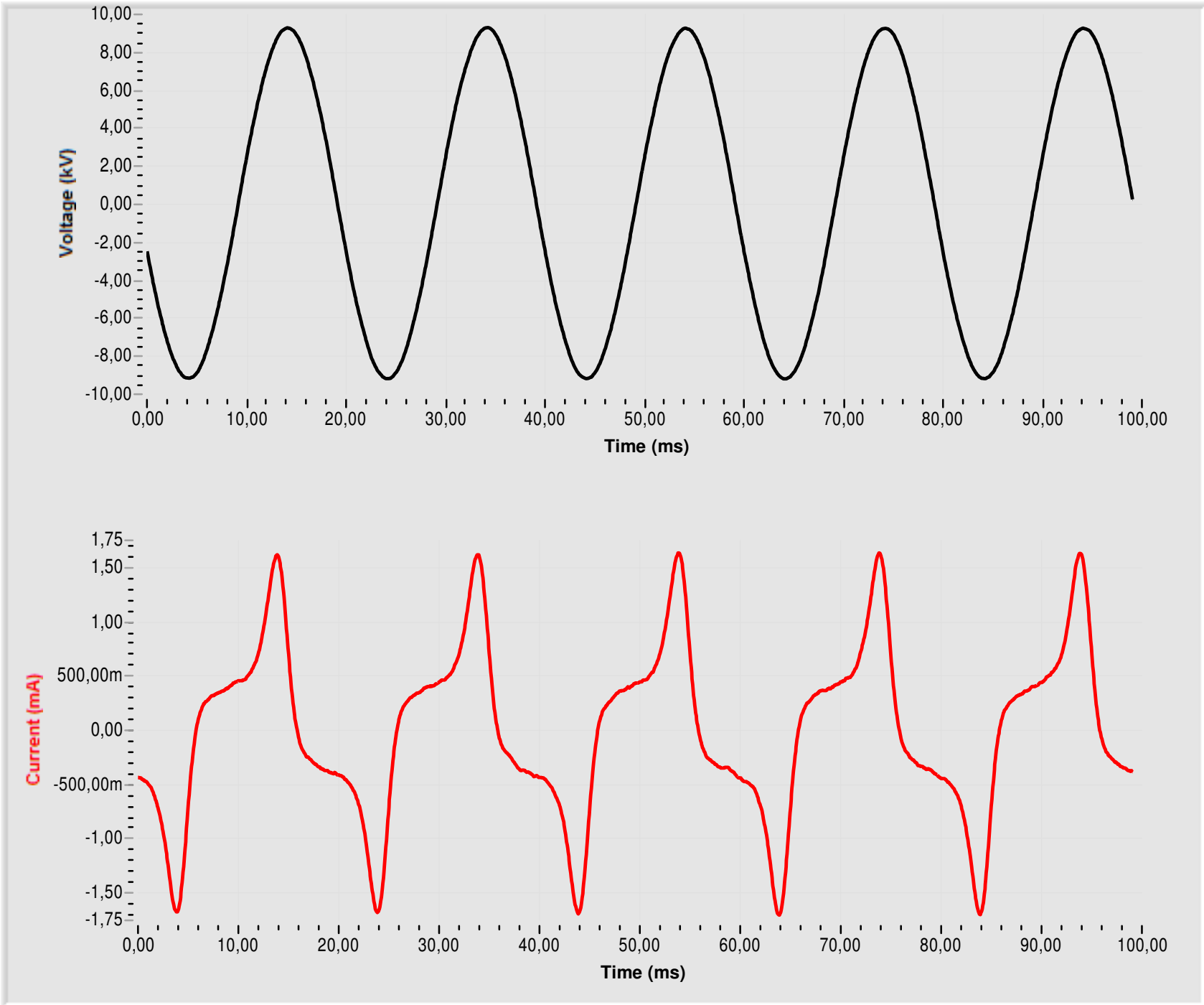
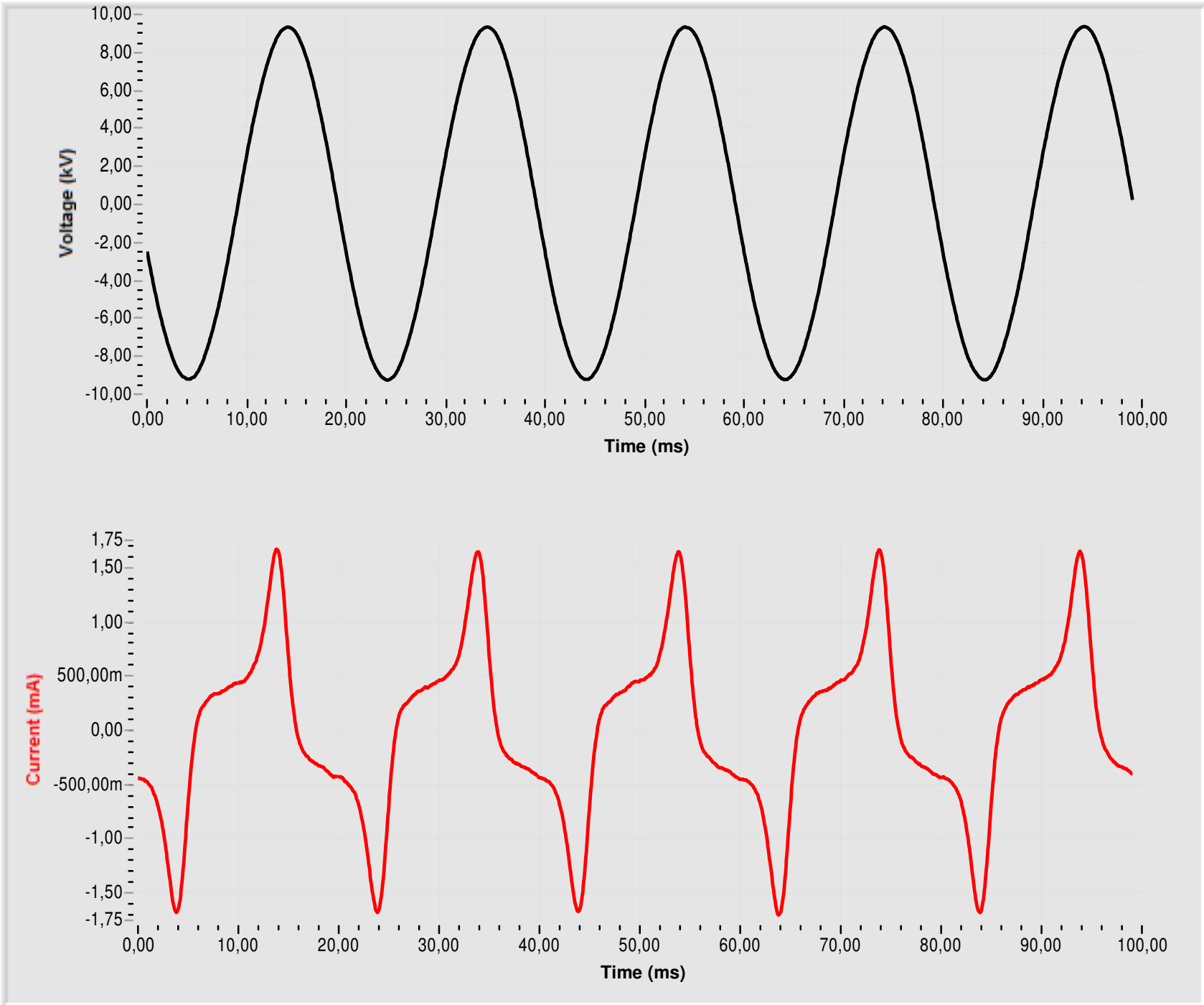


CESI C1011283 Oscillogram n. 16



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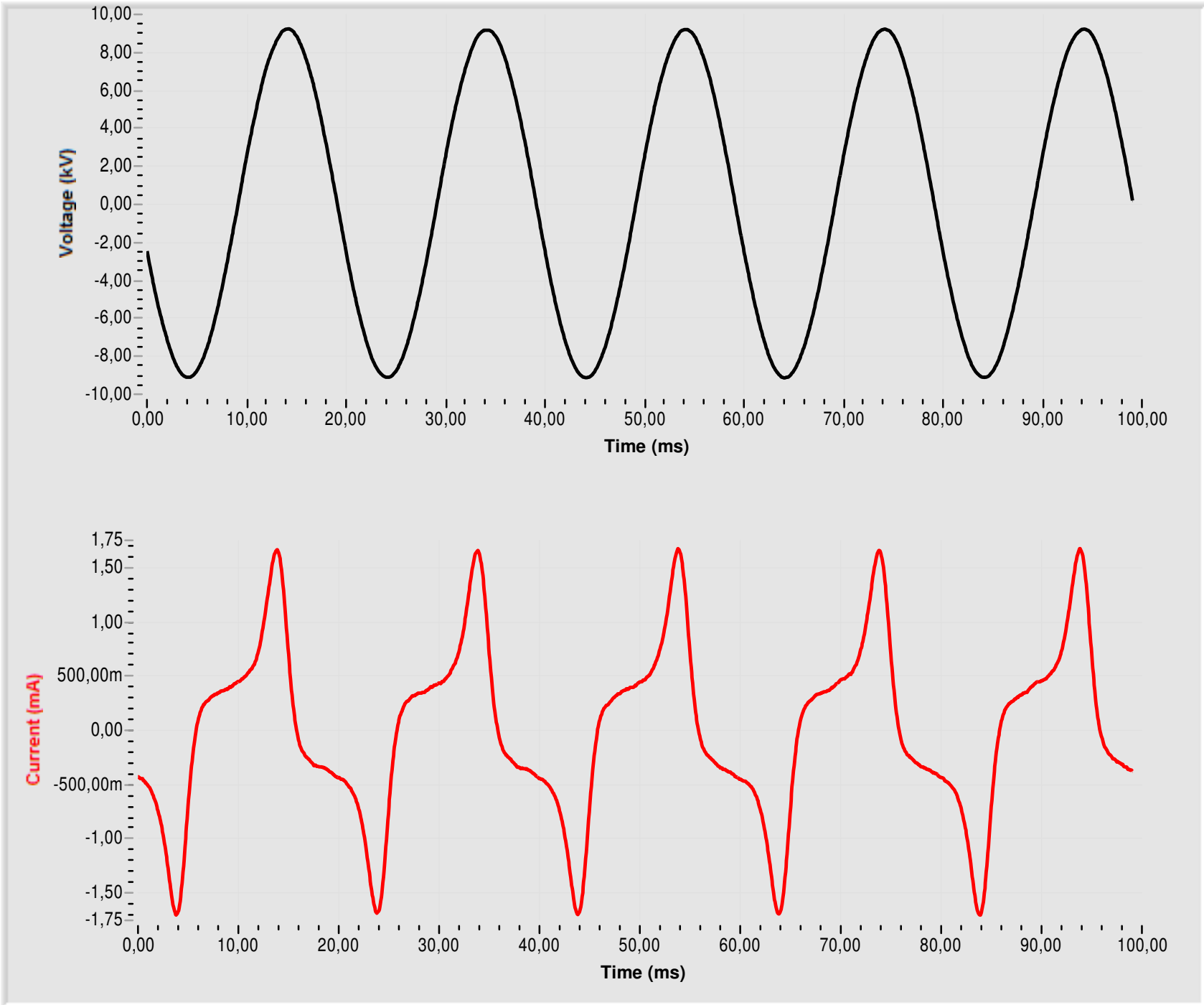

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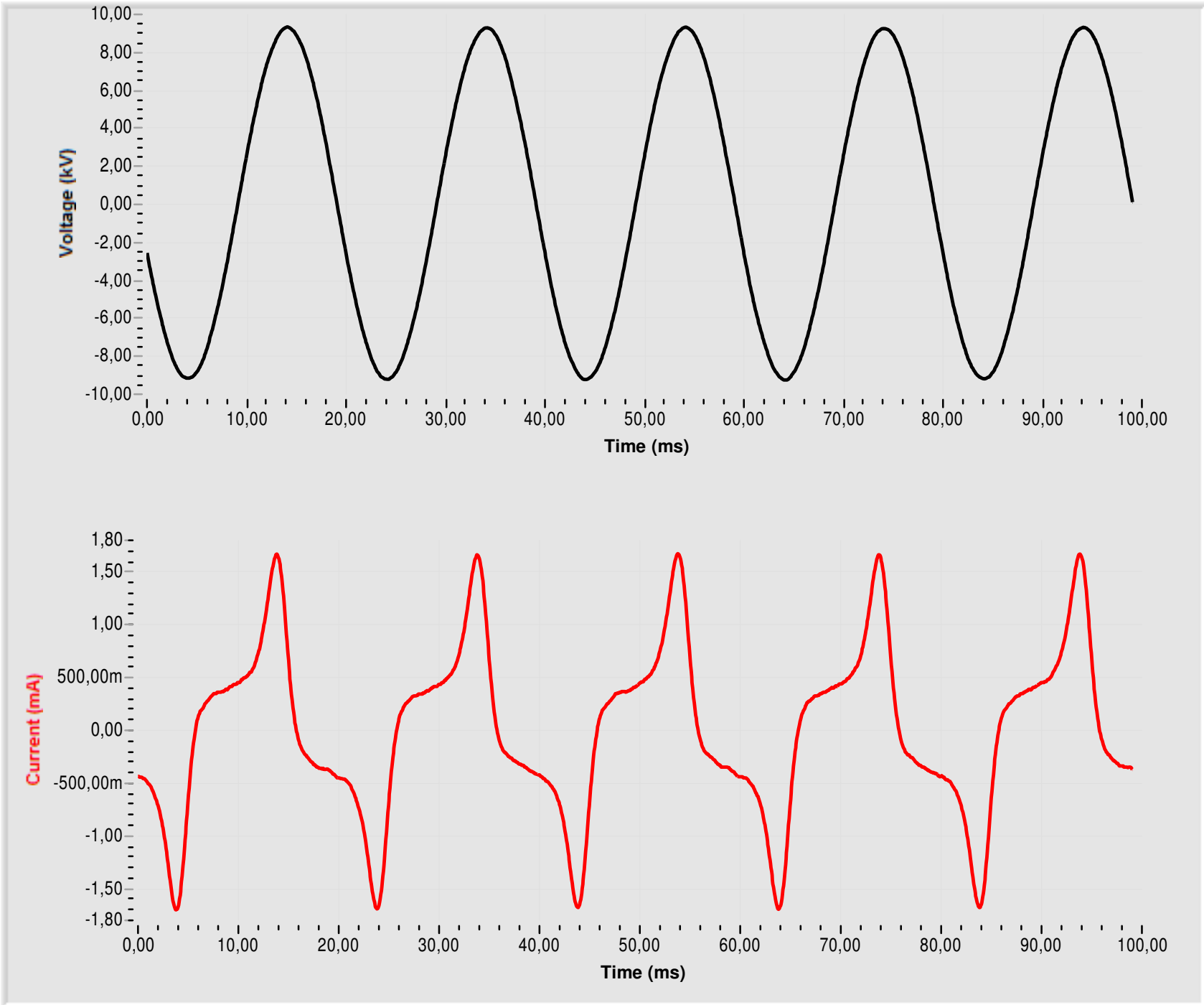

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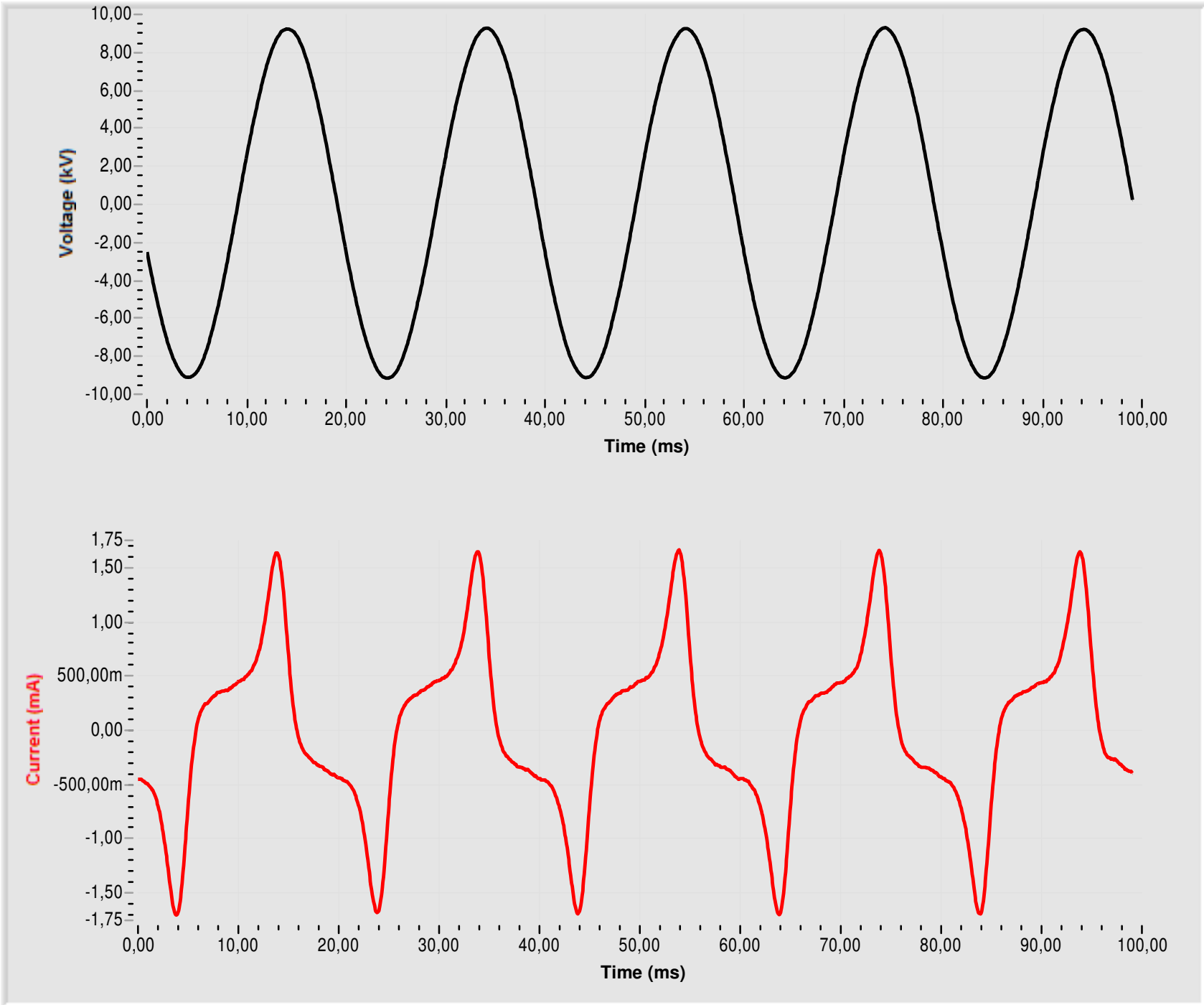

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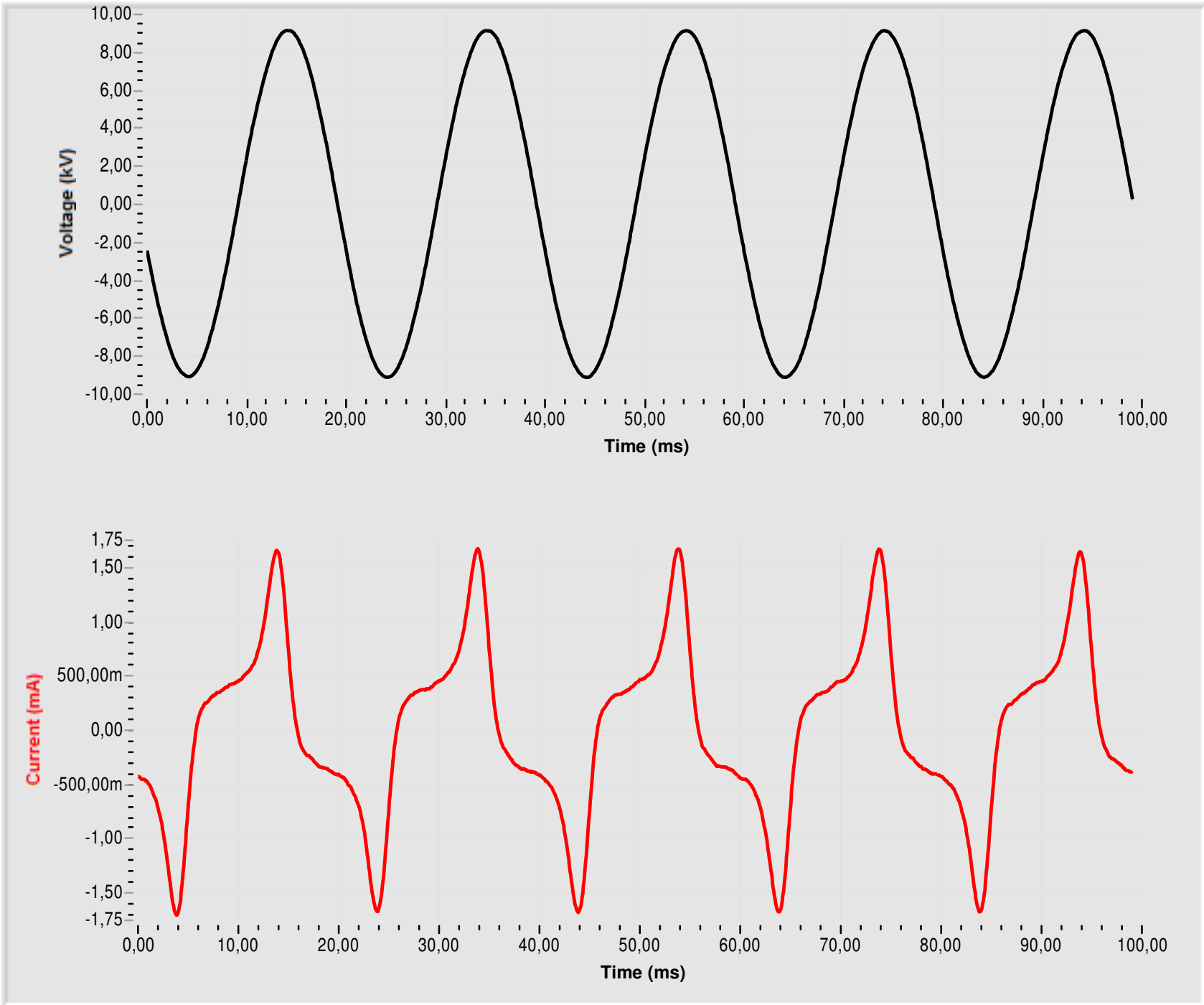

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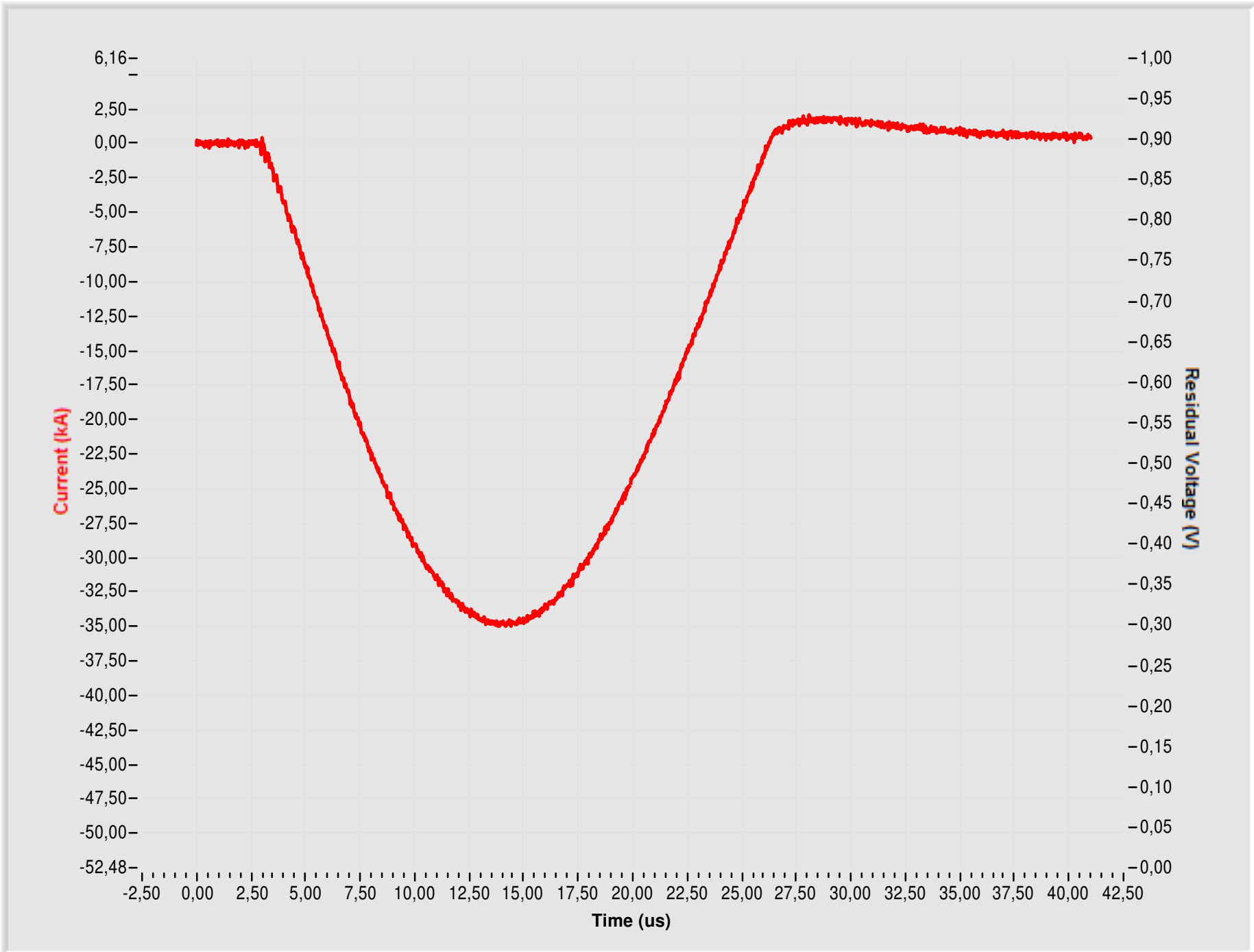

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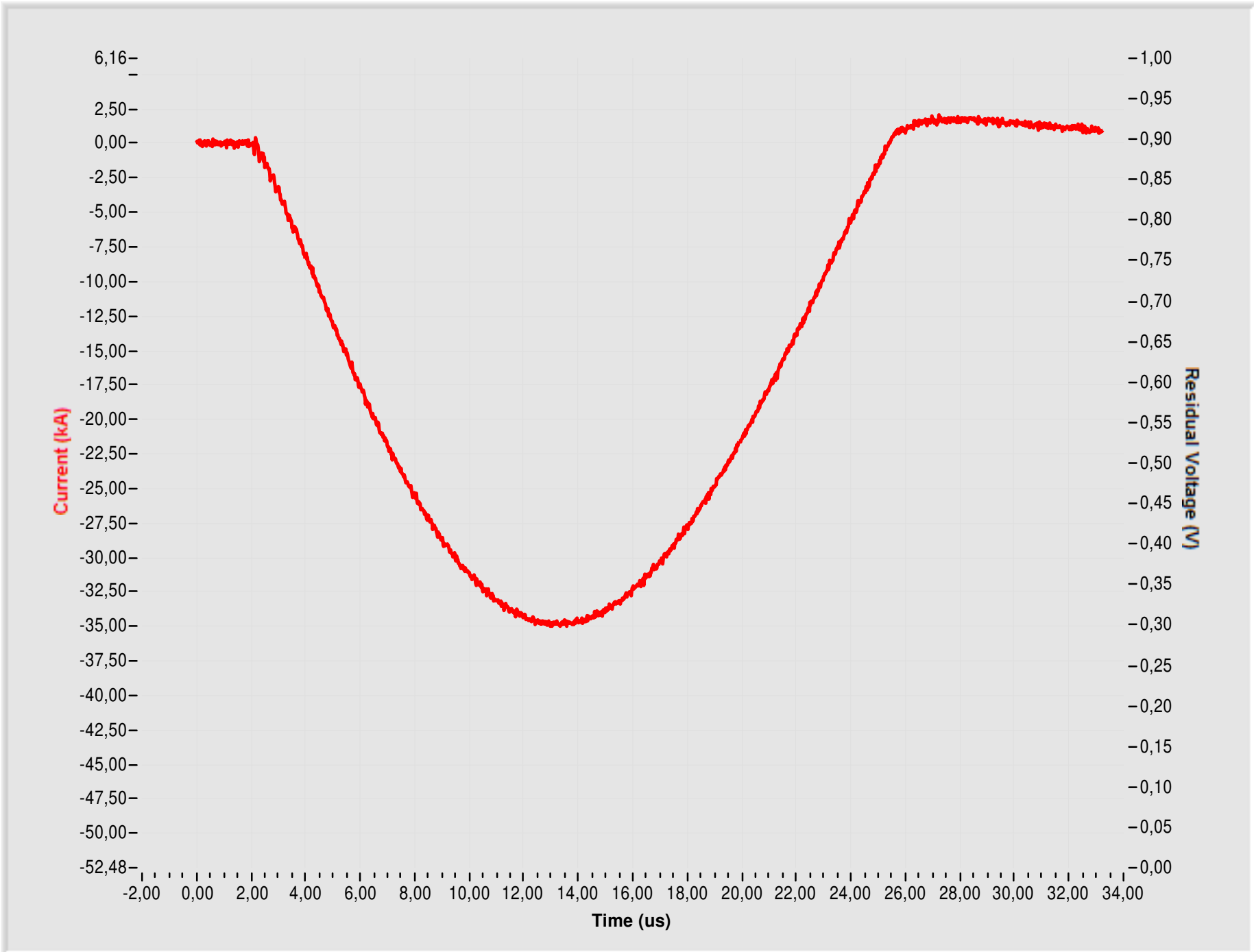

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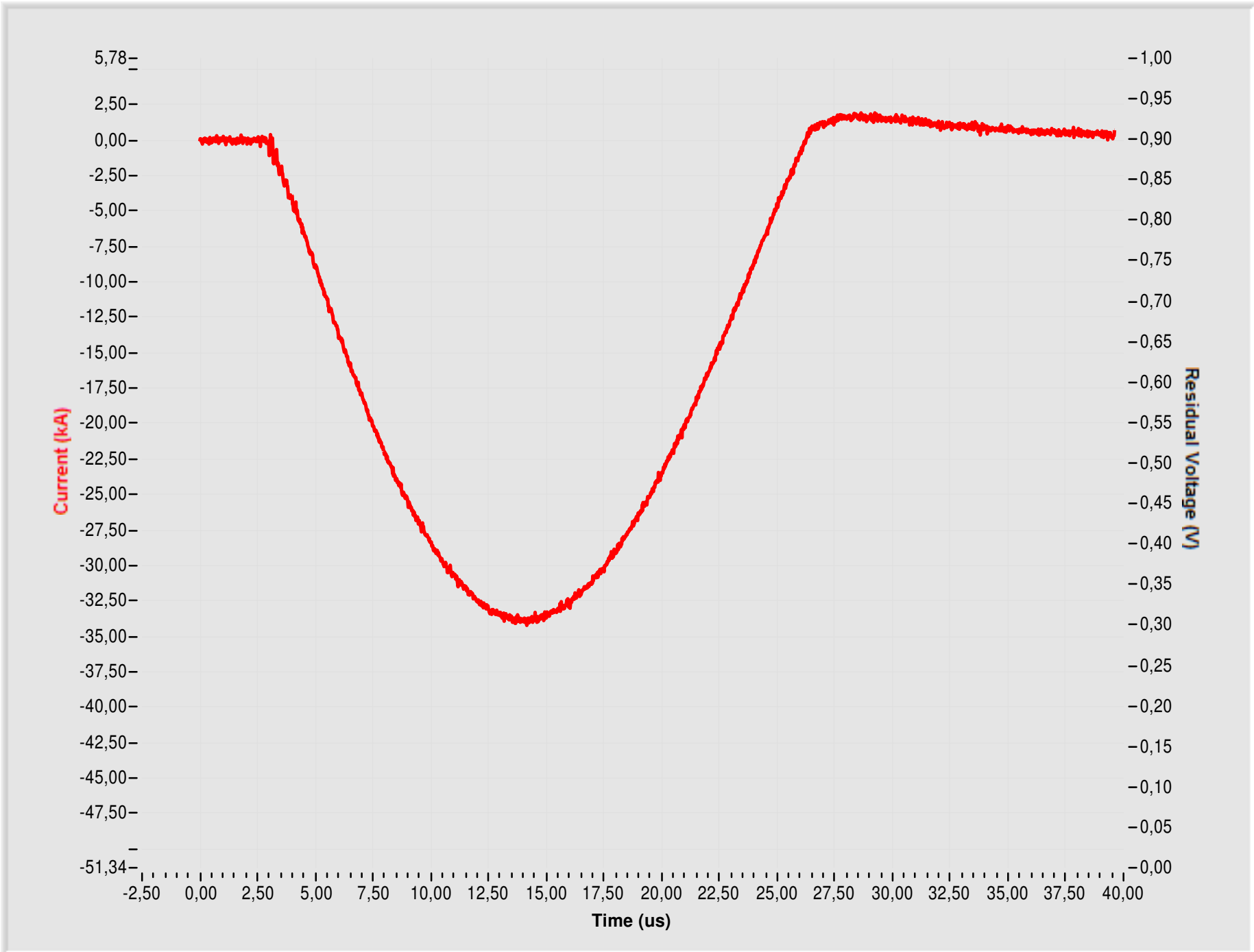

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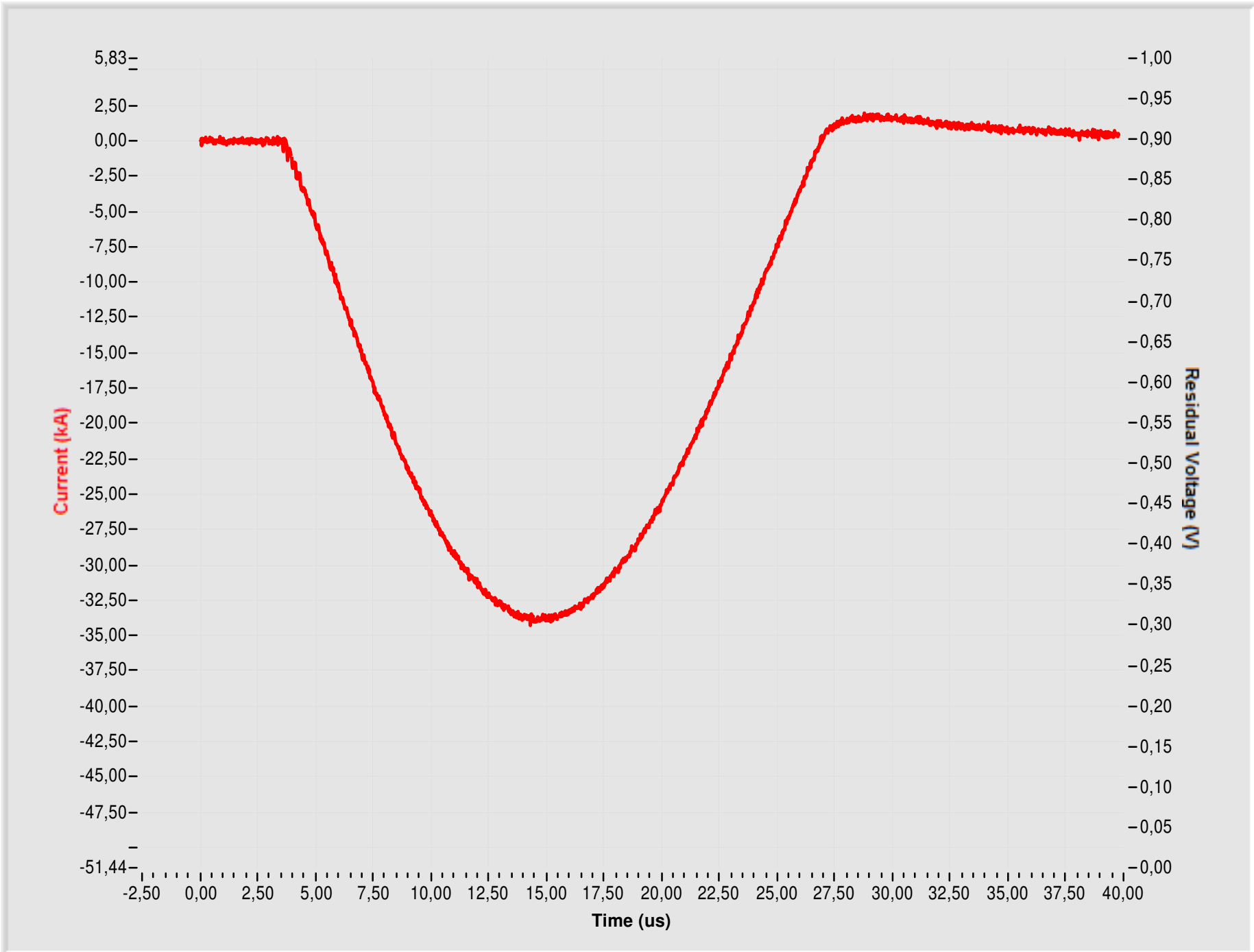

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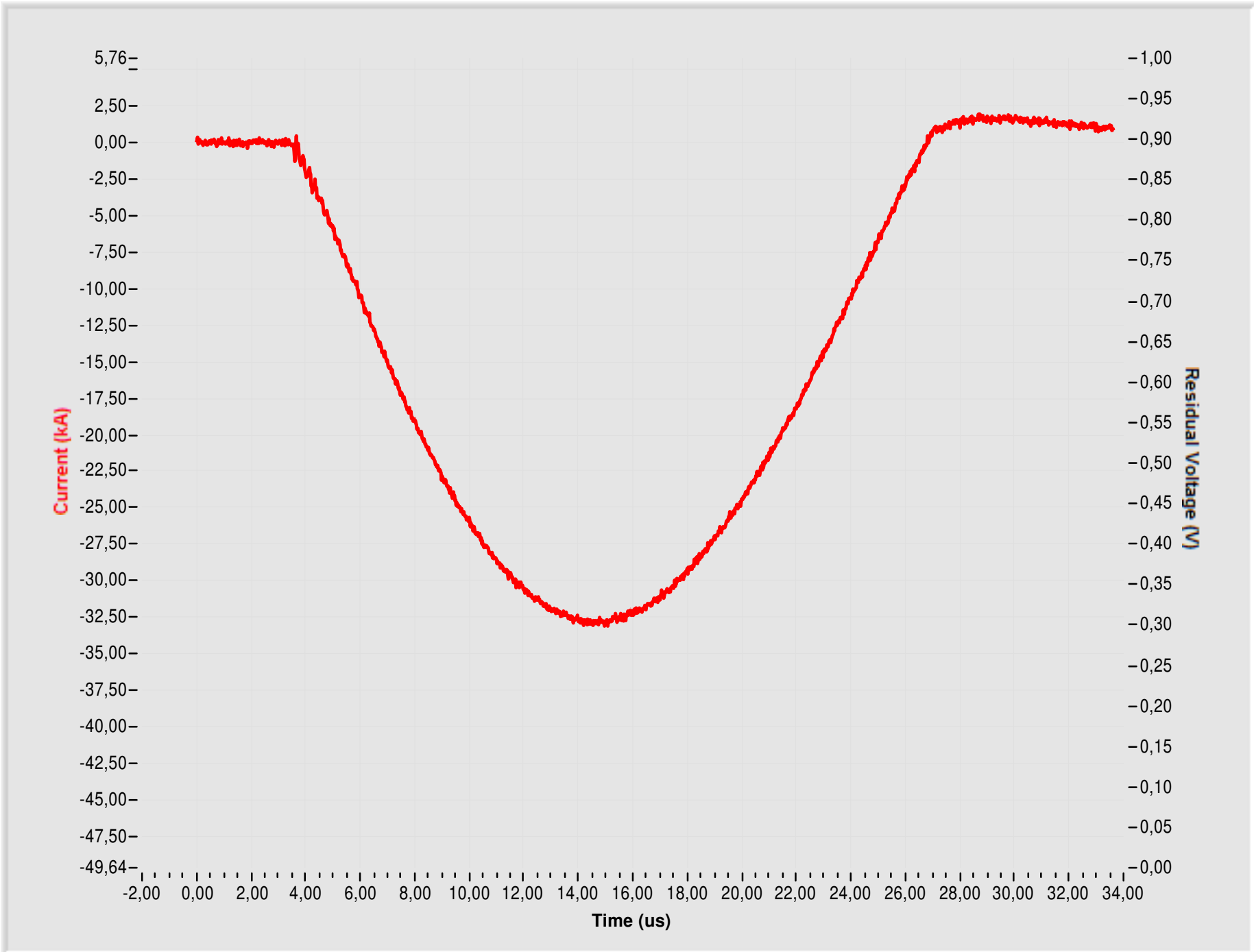

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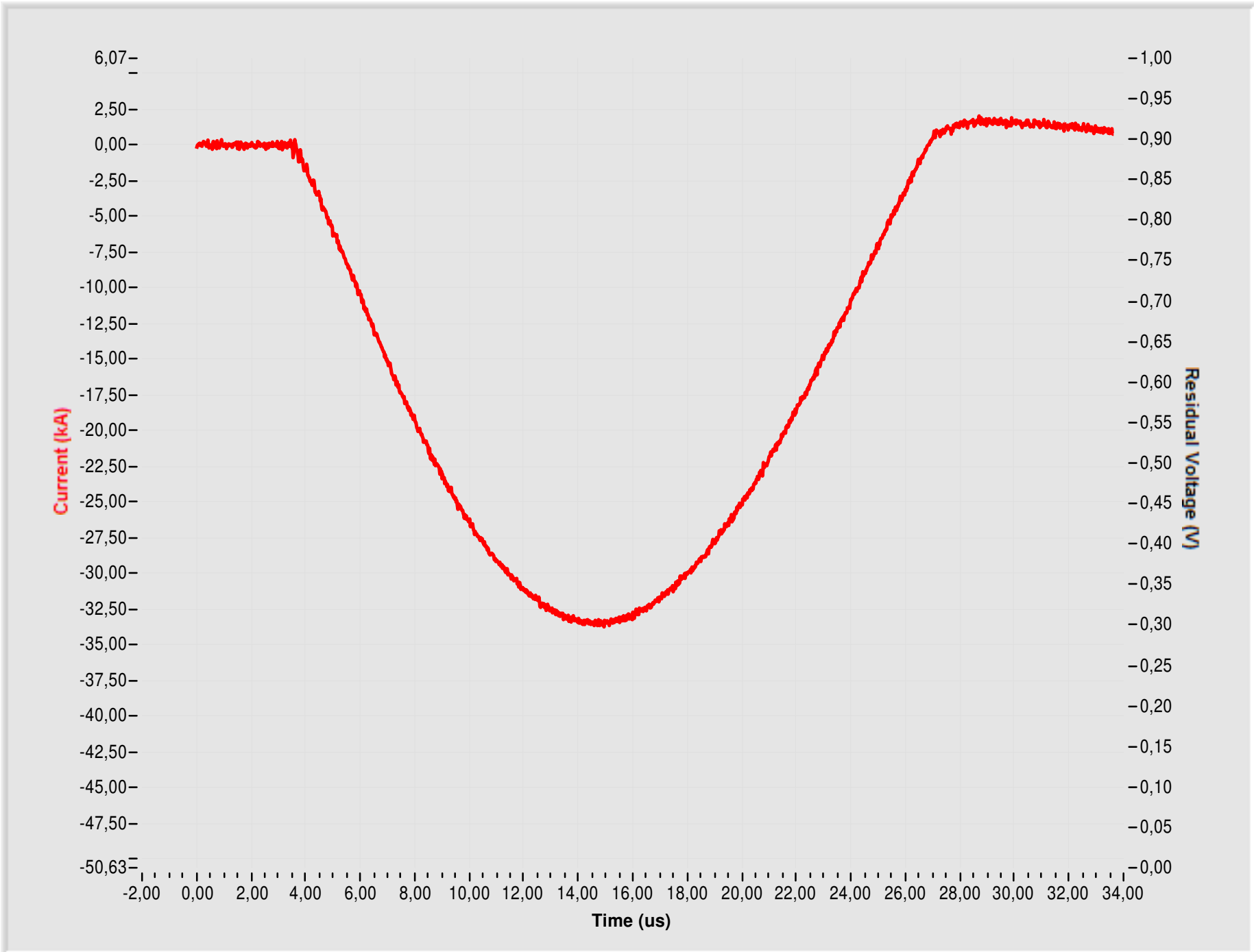

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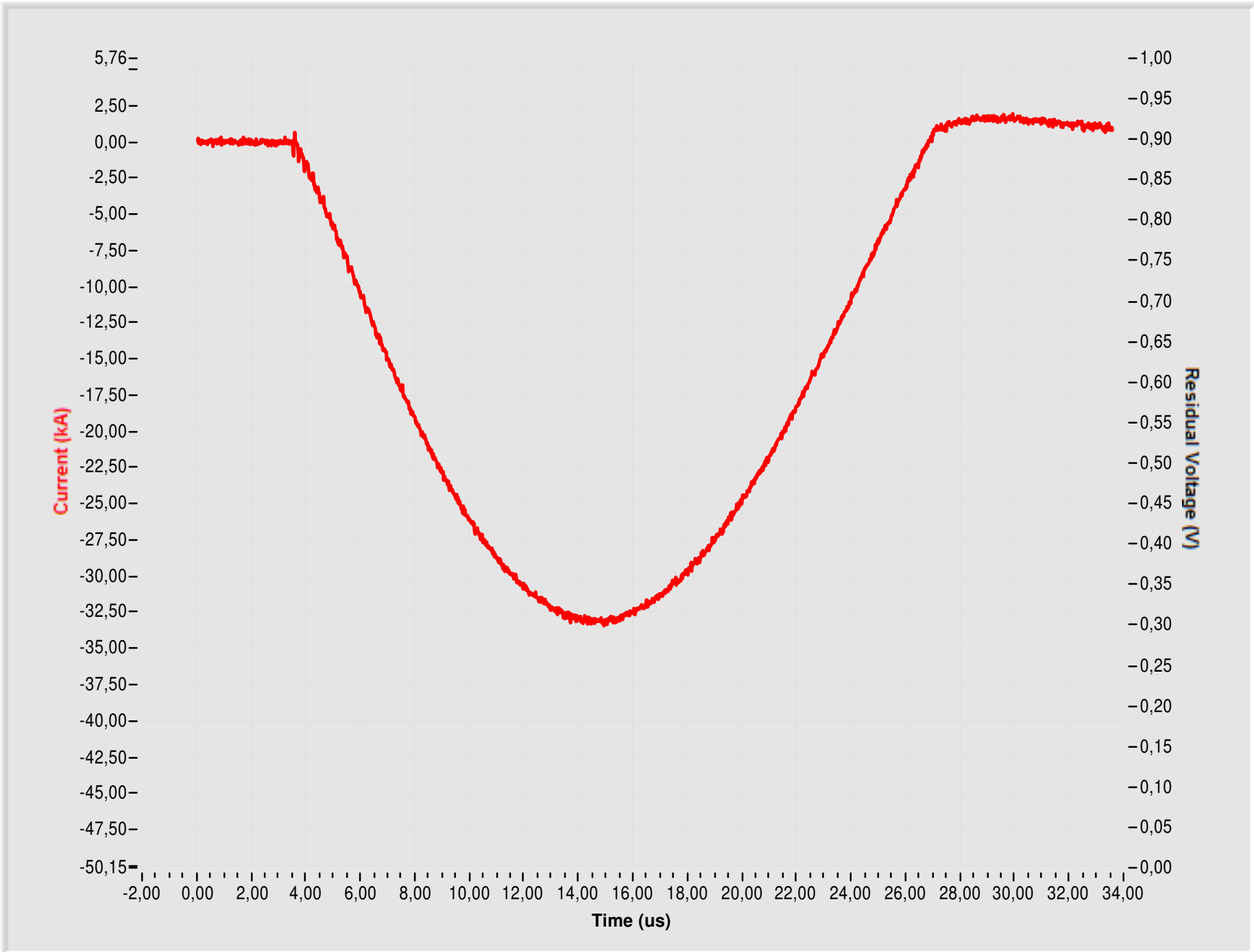

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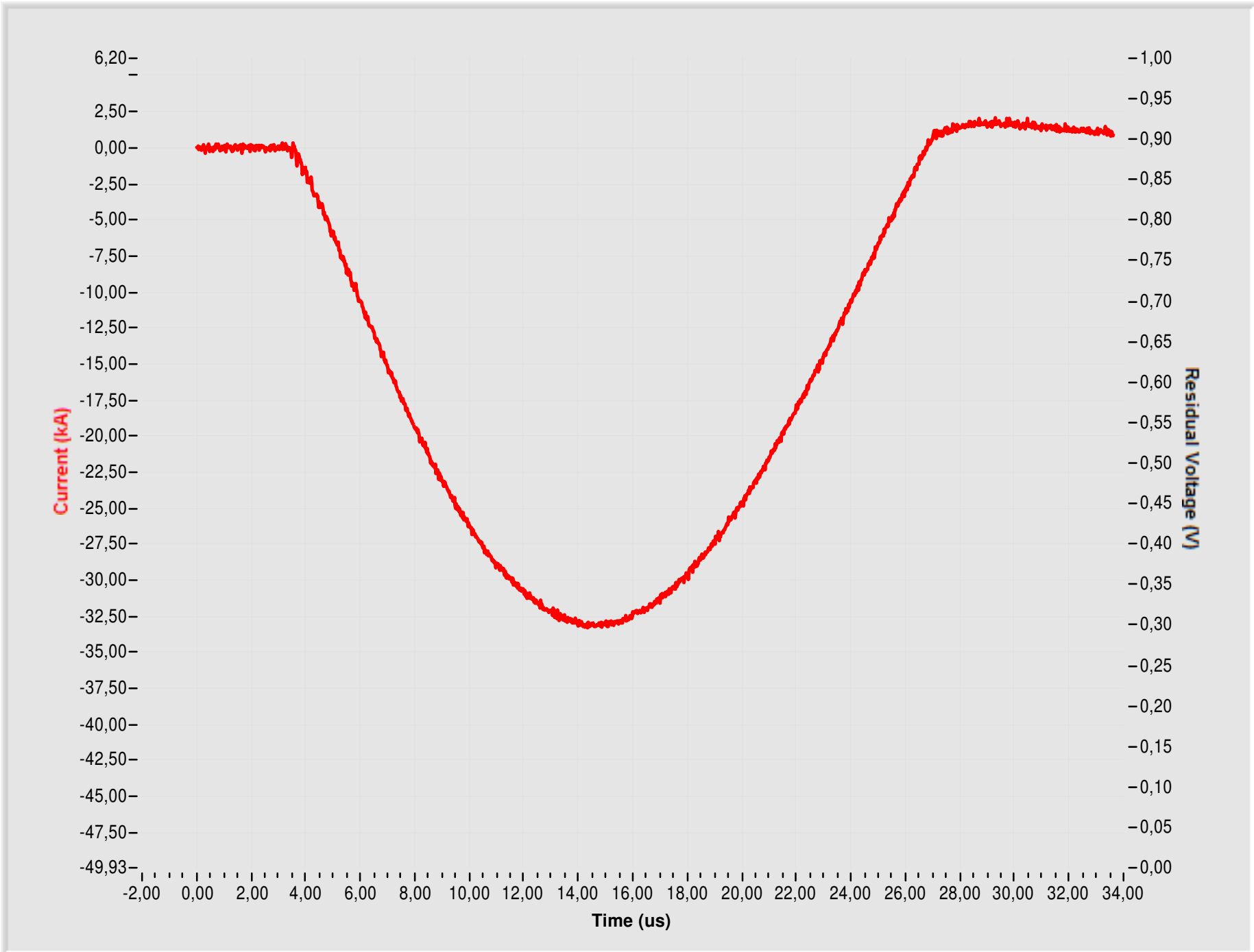

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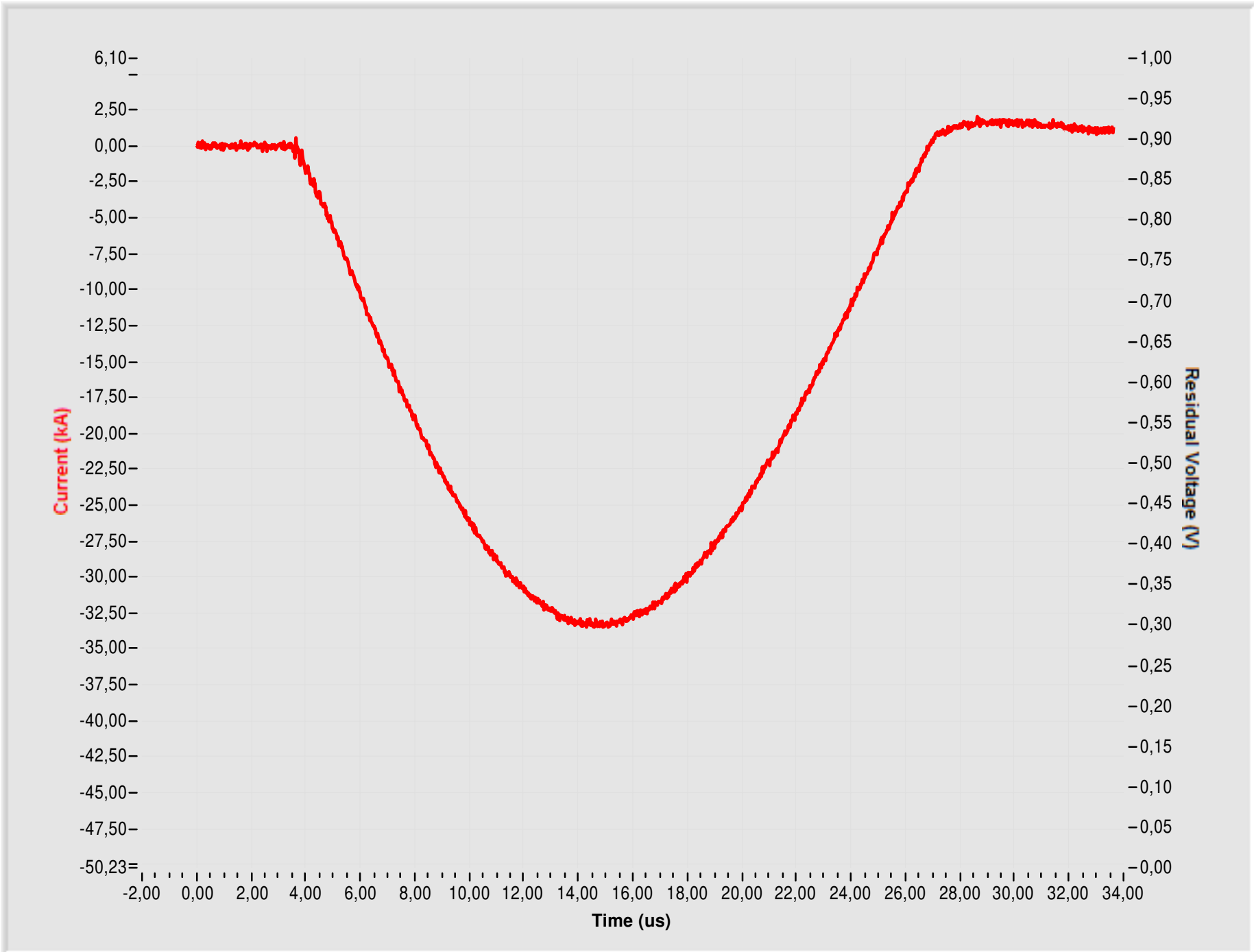

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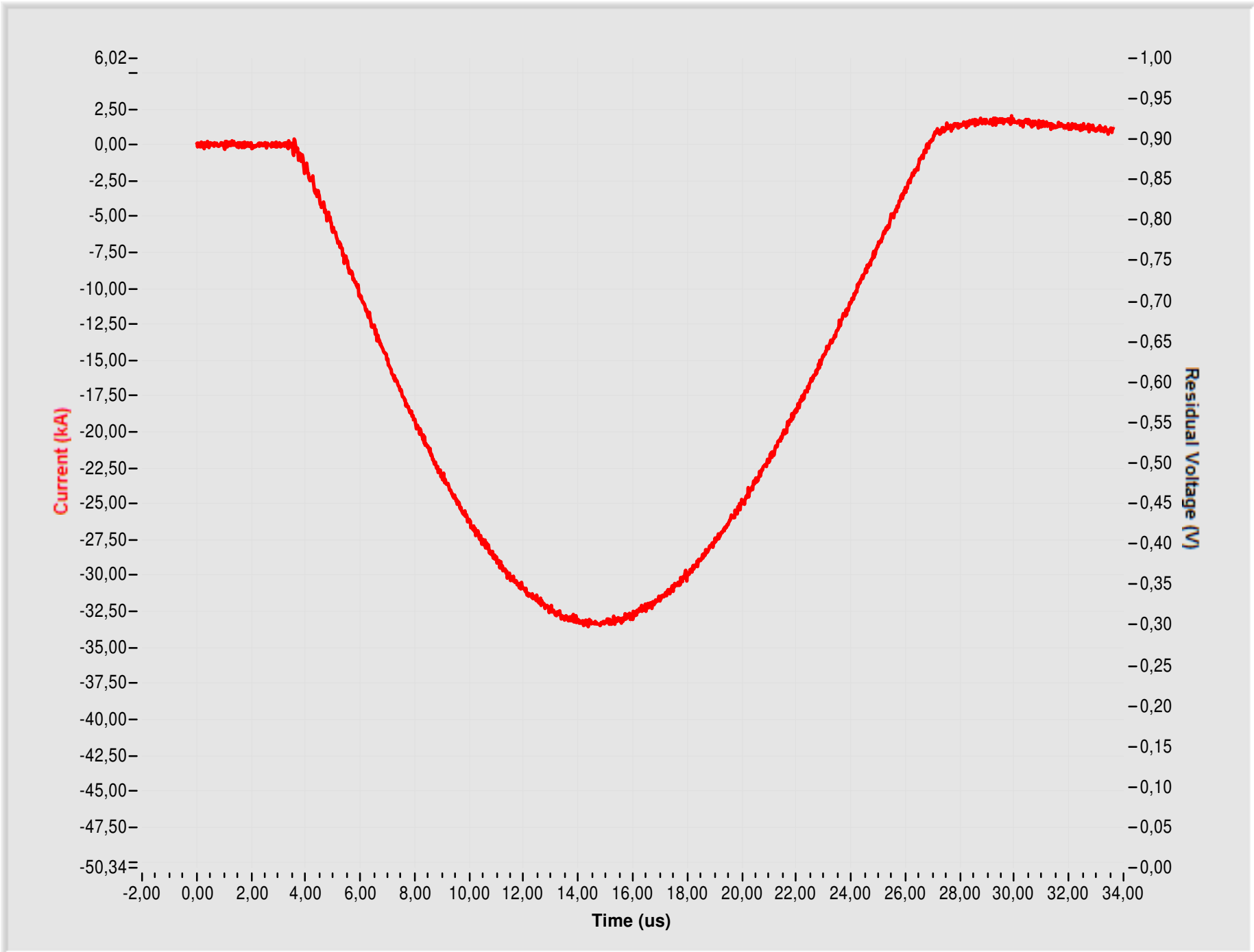

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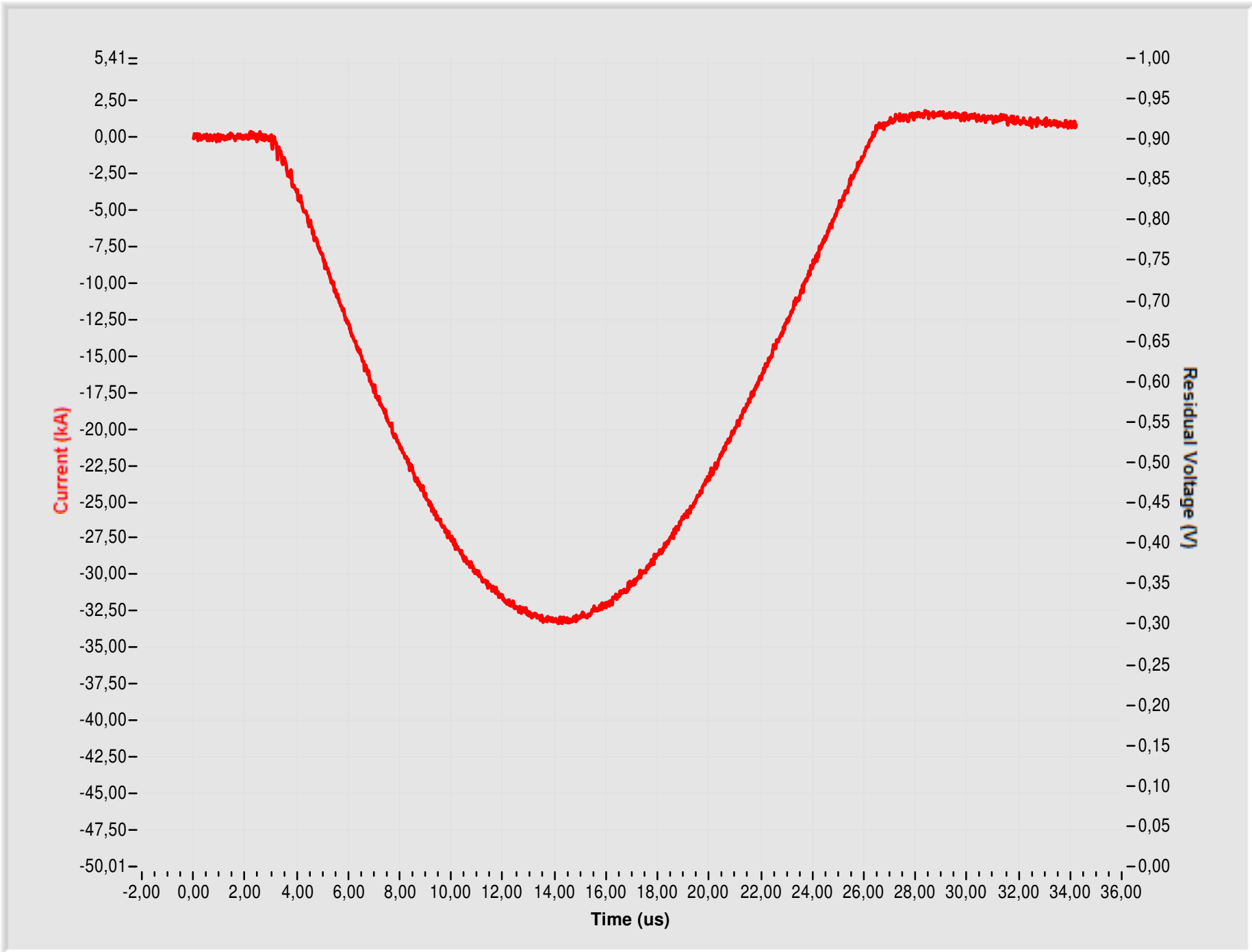

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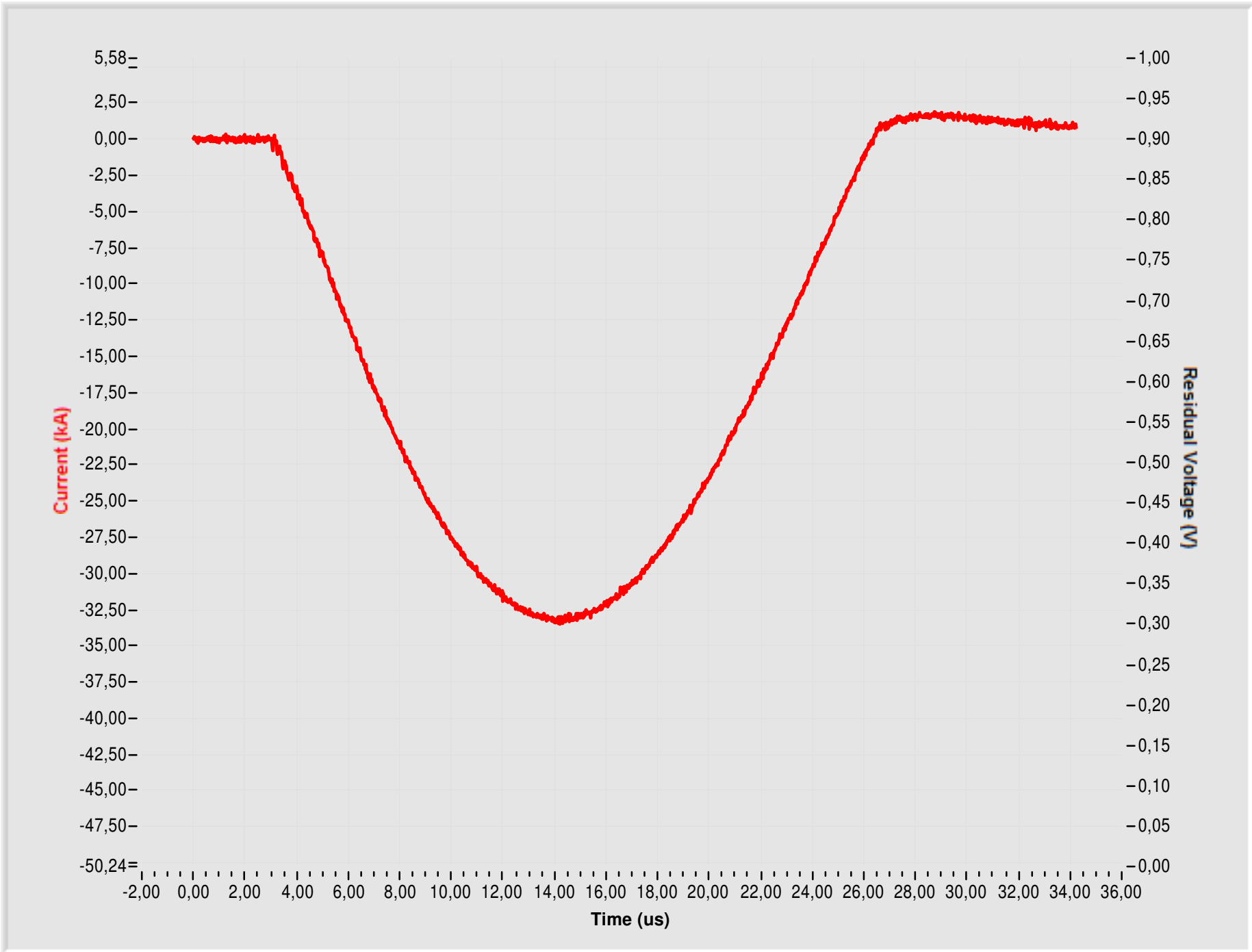

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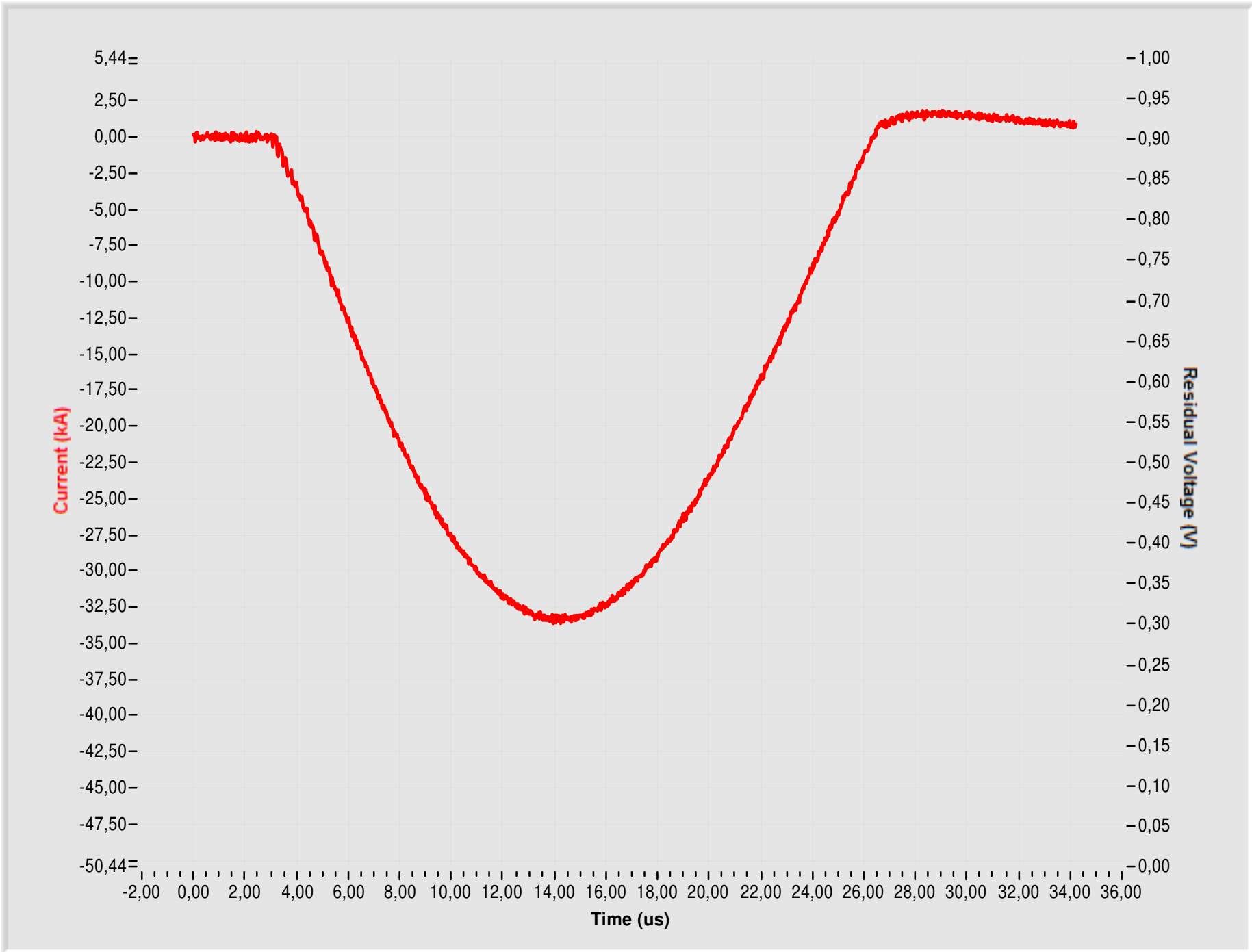

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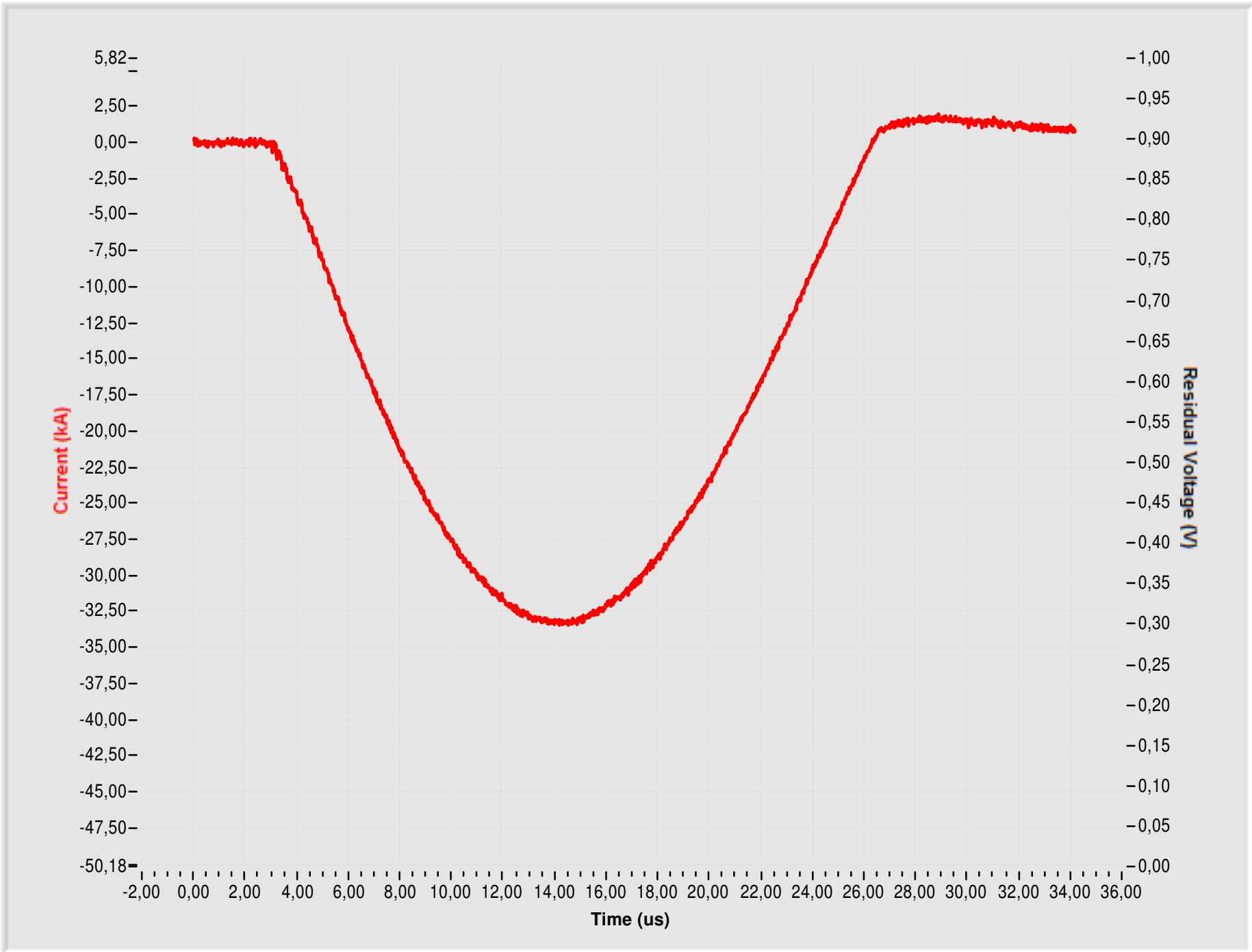

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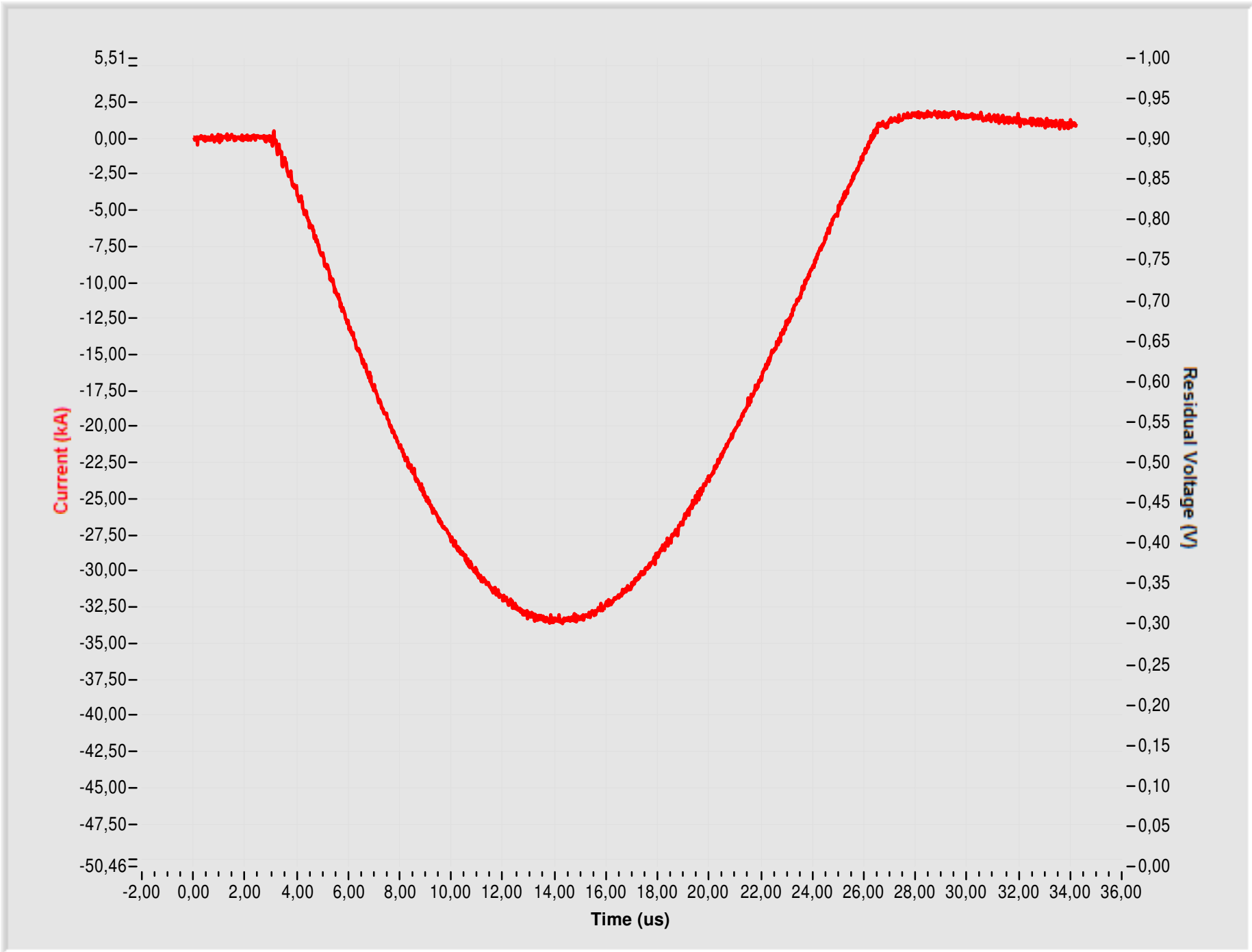

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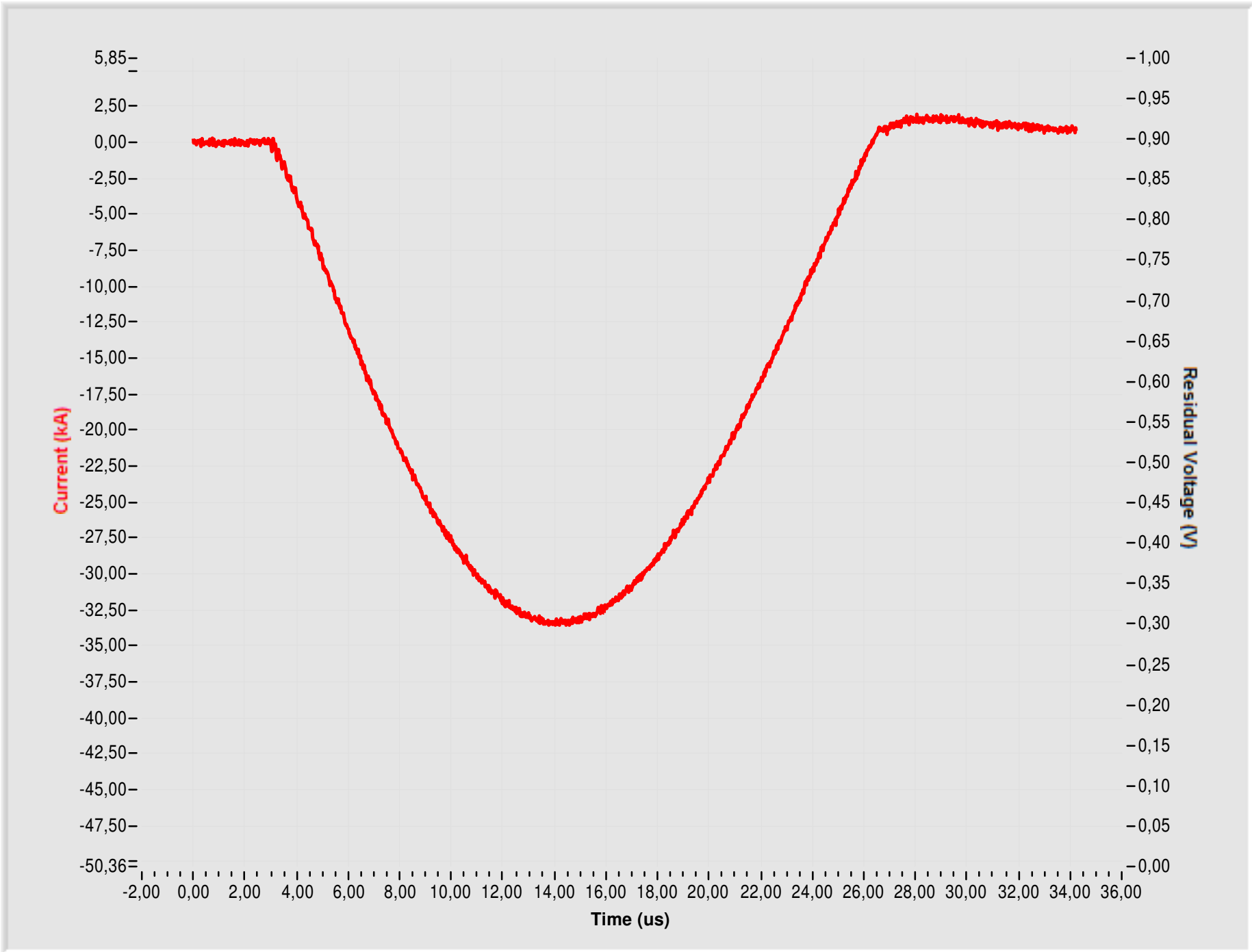

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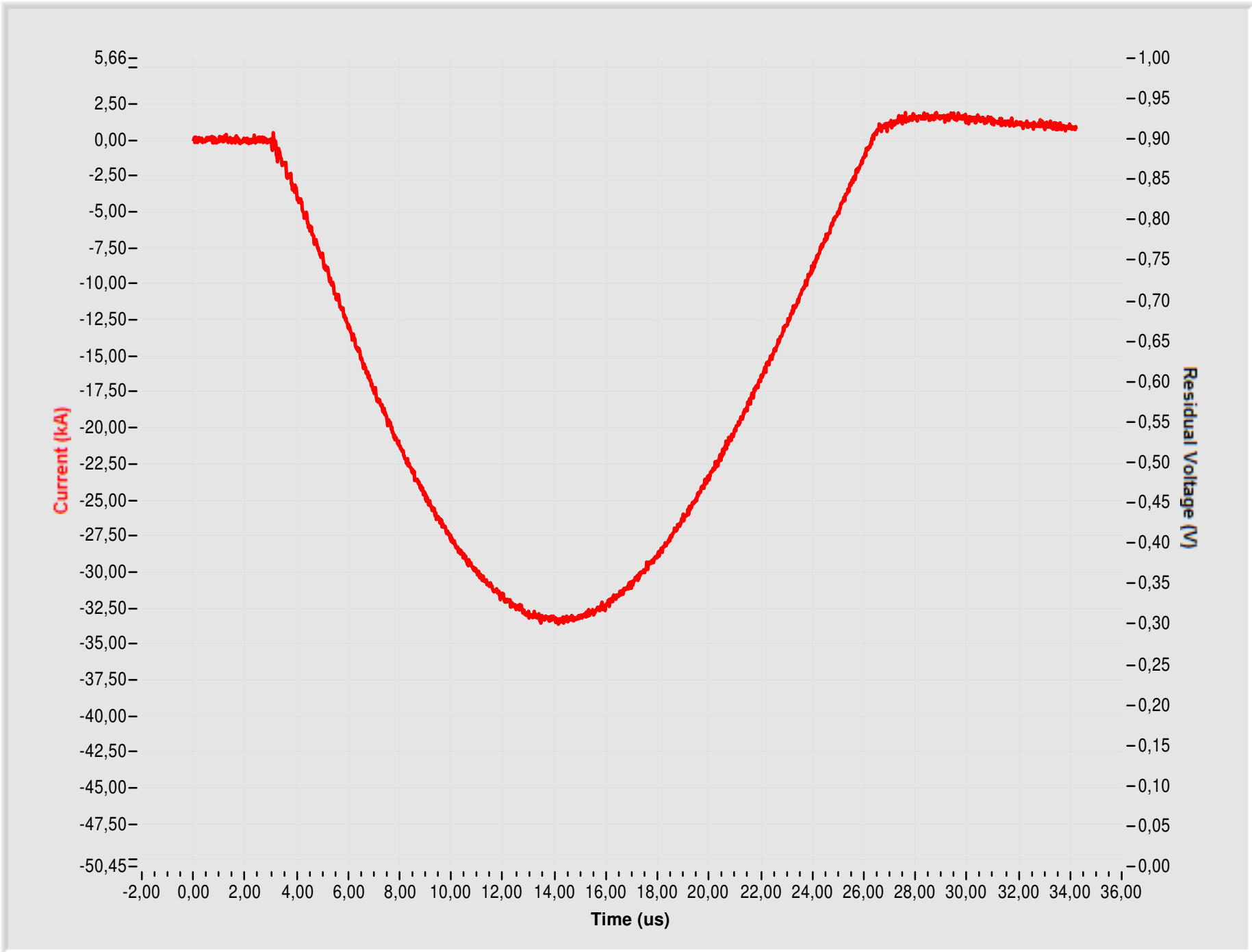

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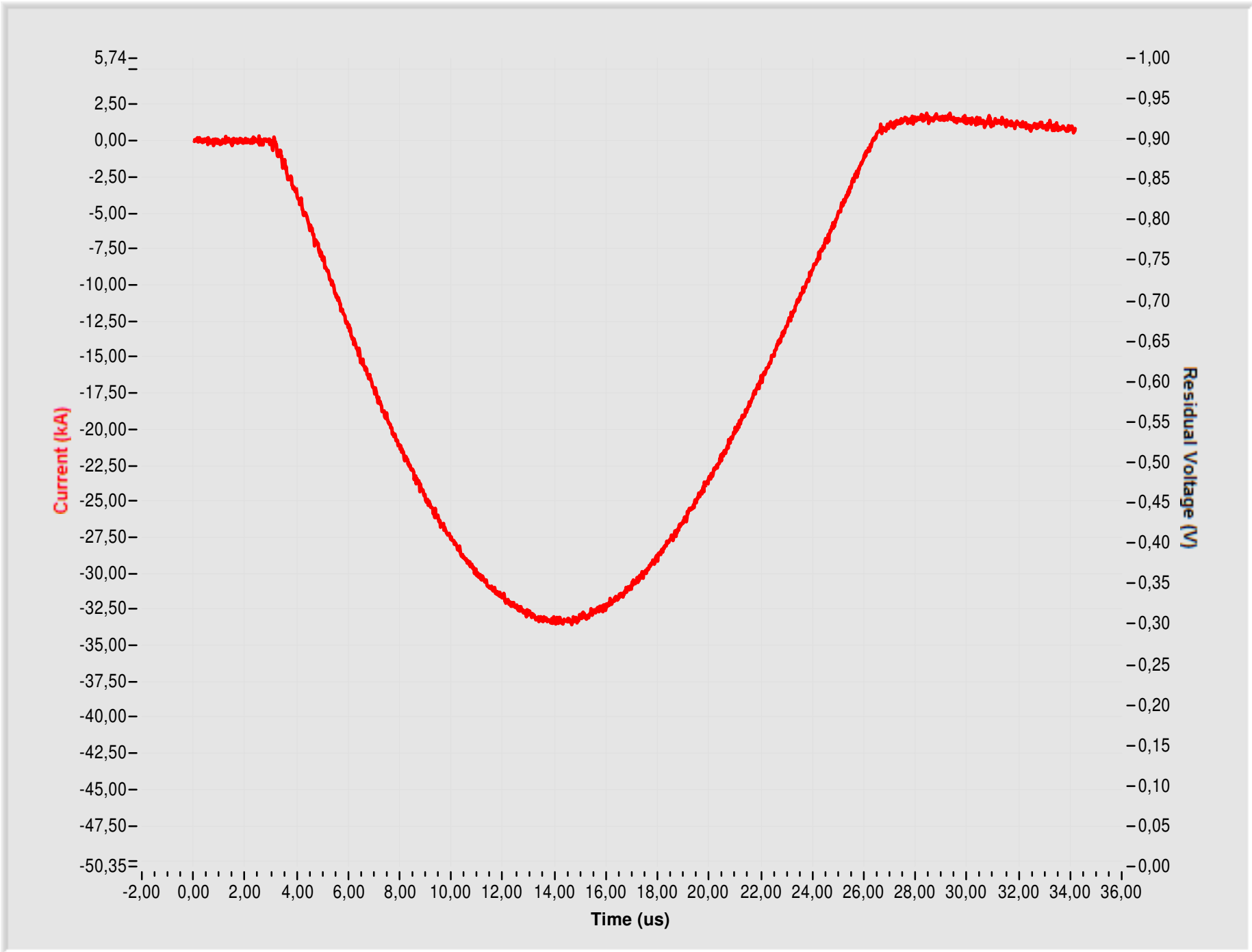

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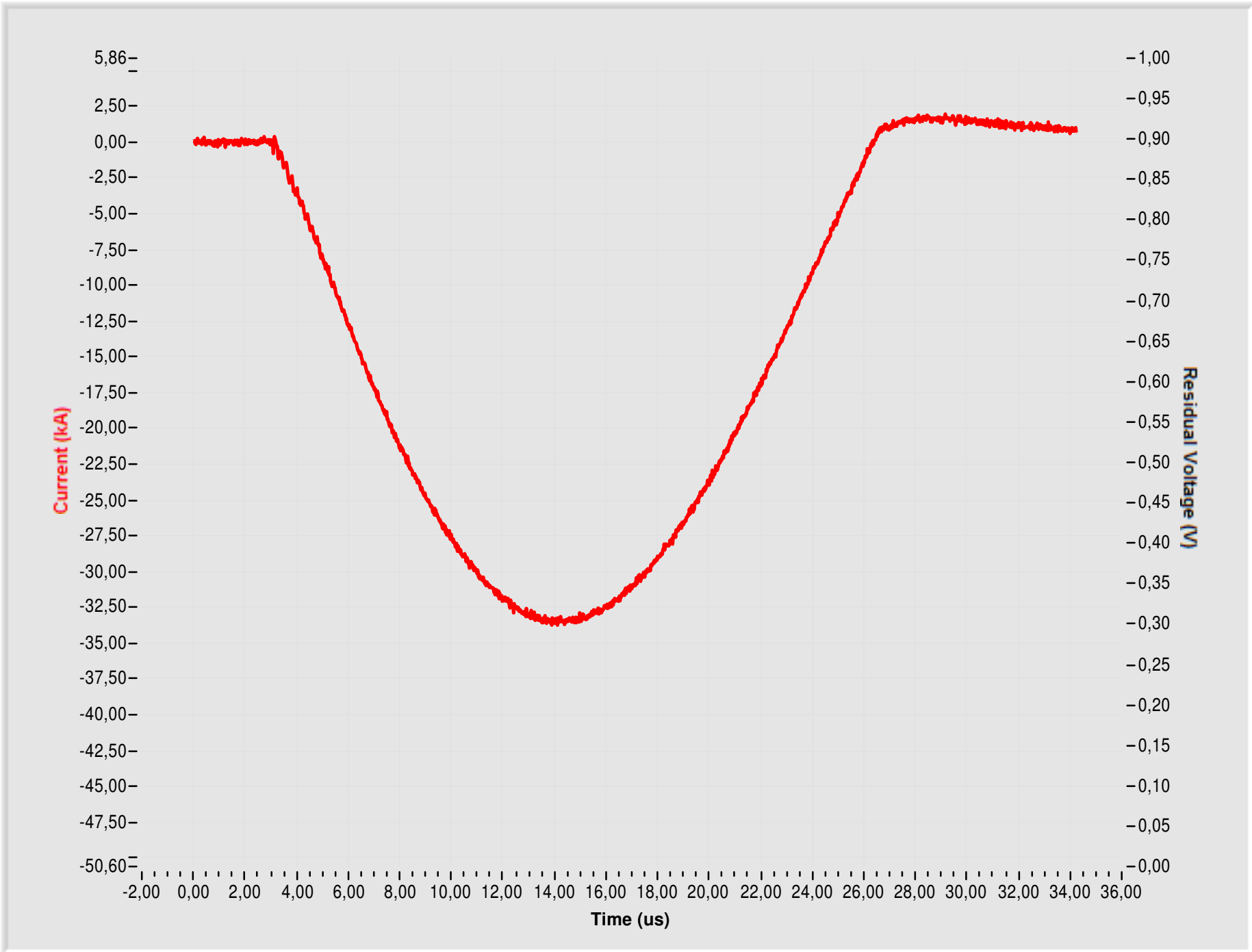

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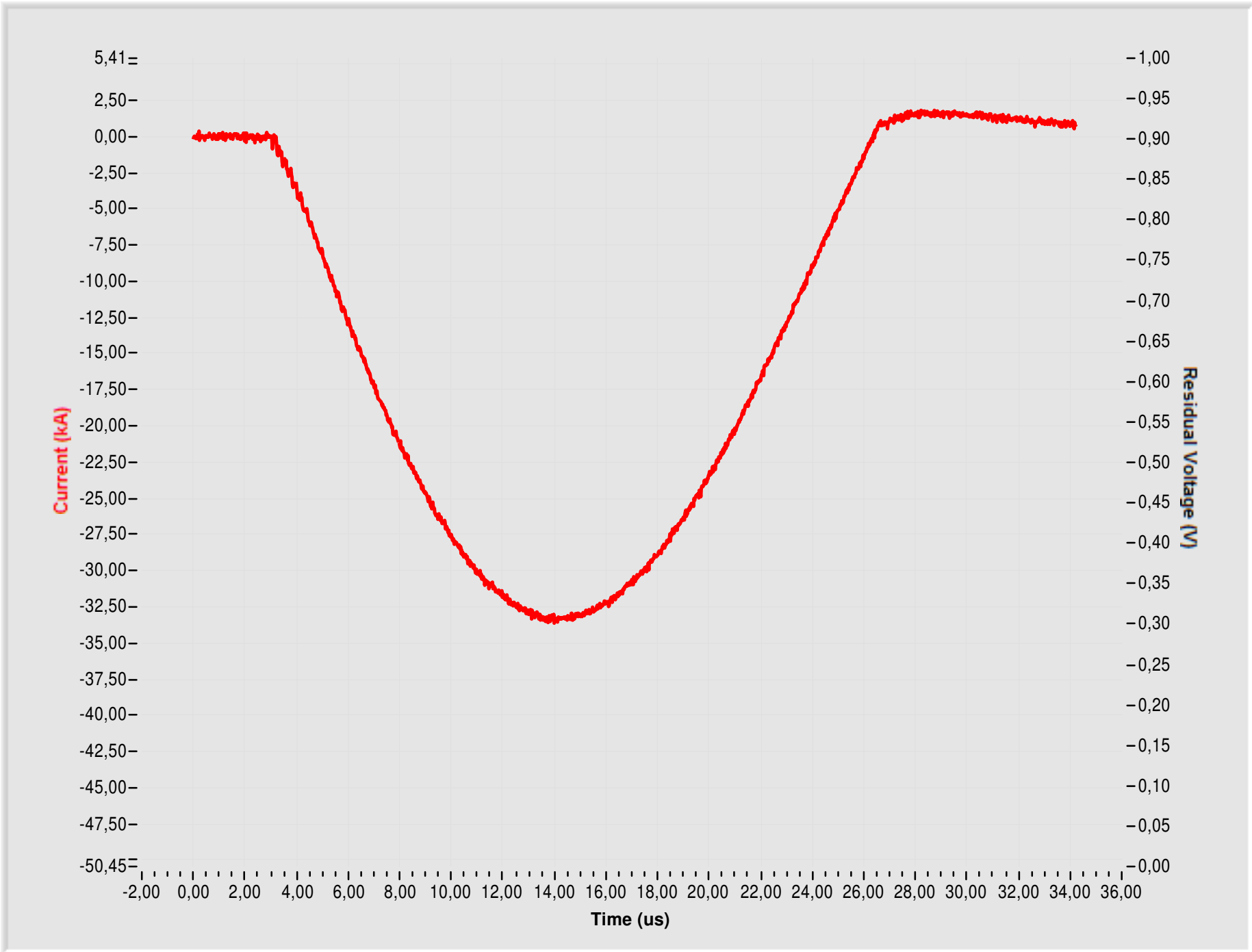
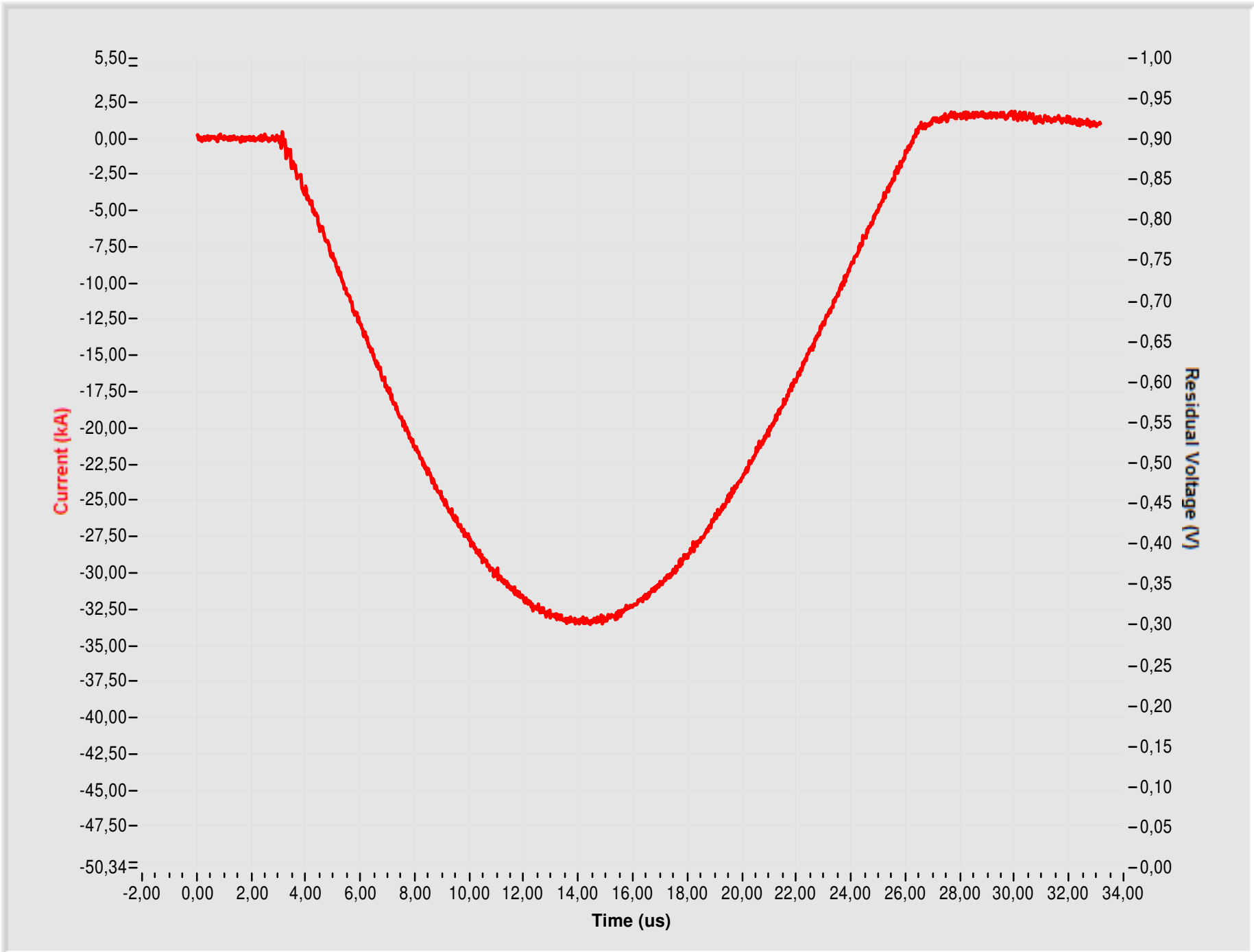


CESI C1011283 Oscillogram n. 41



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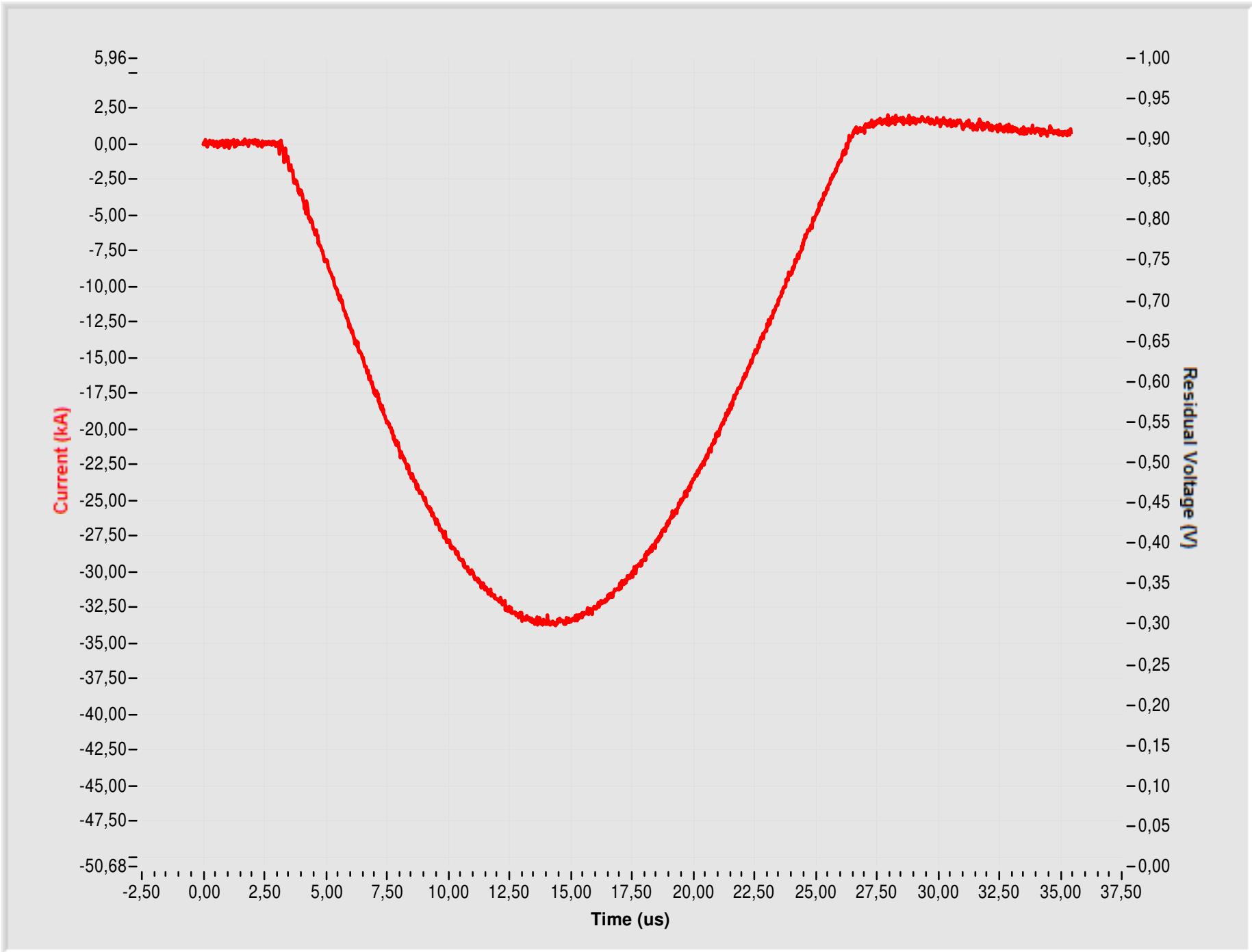

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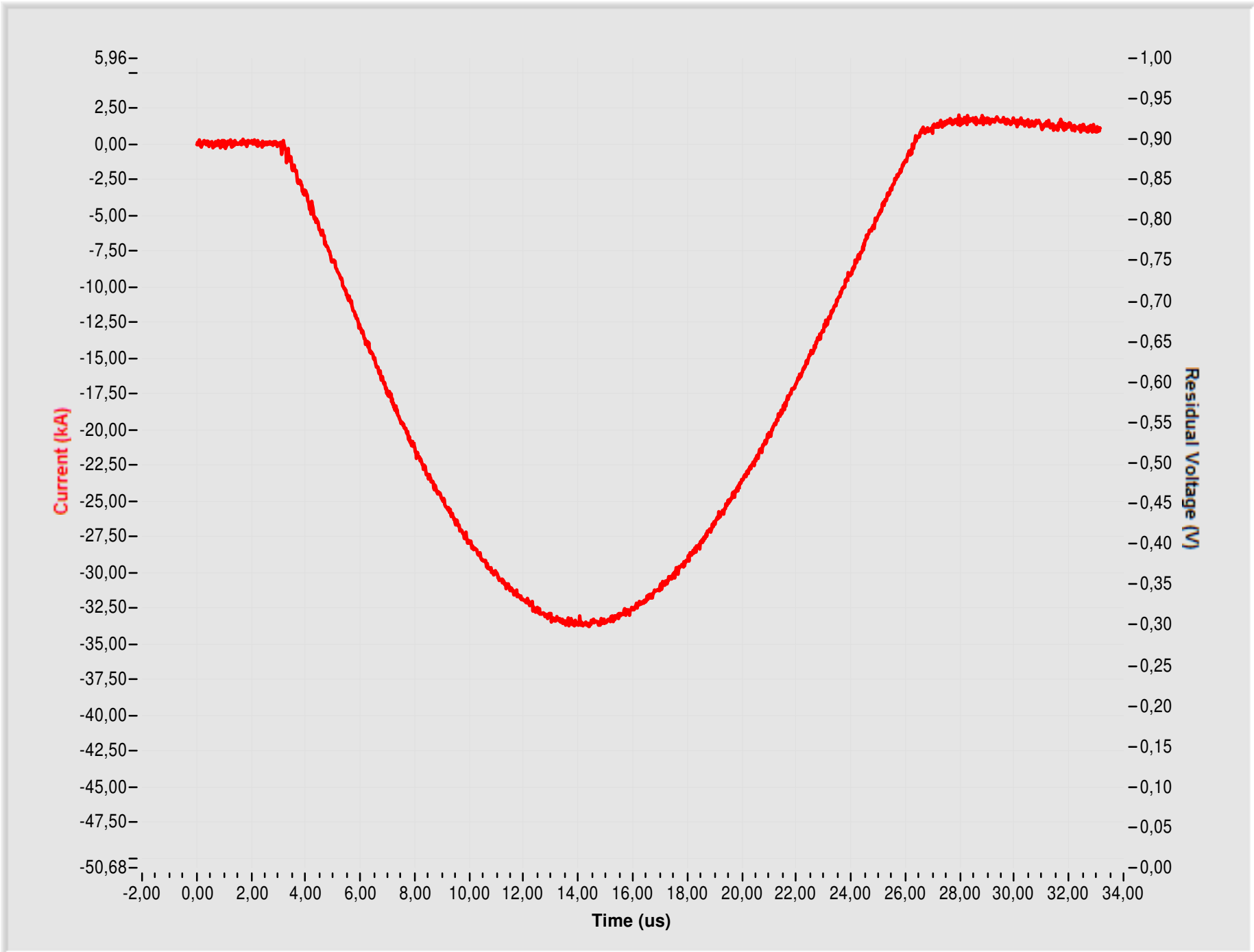
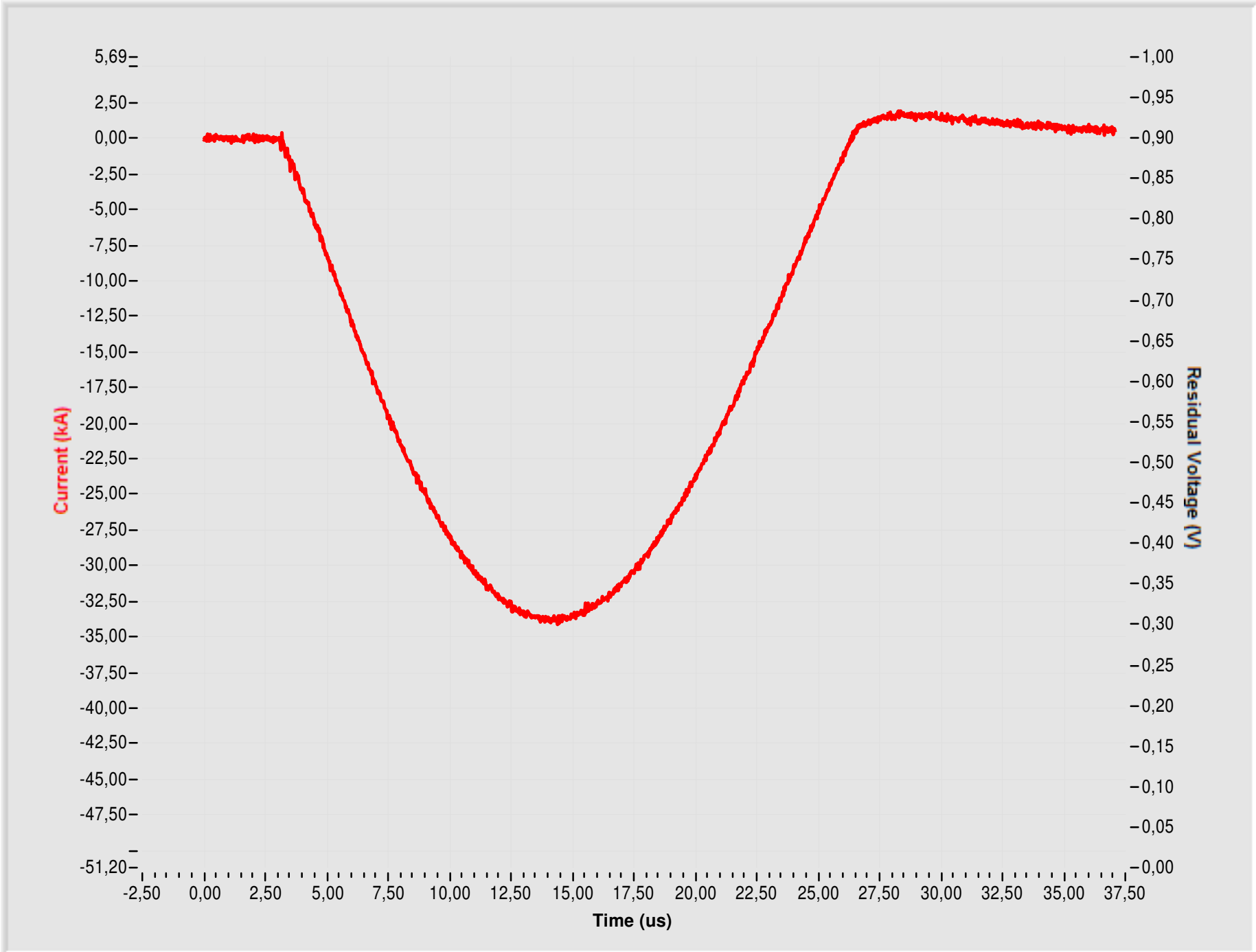
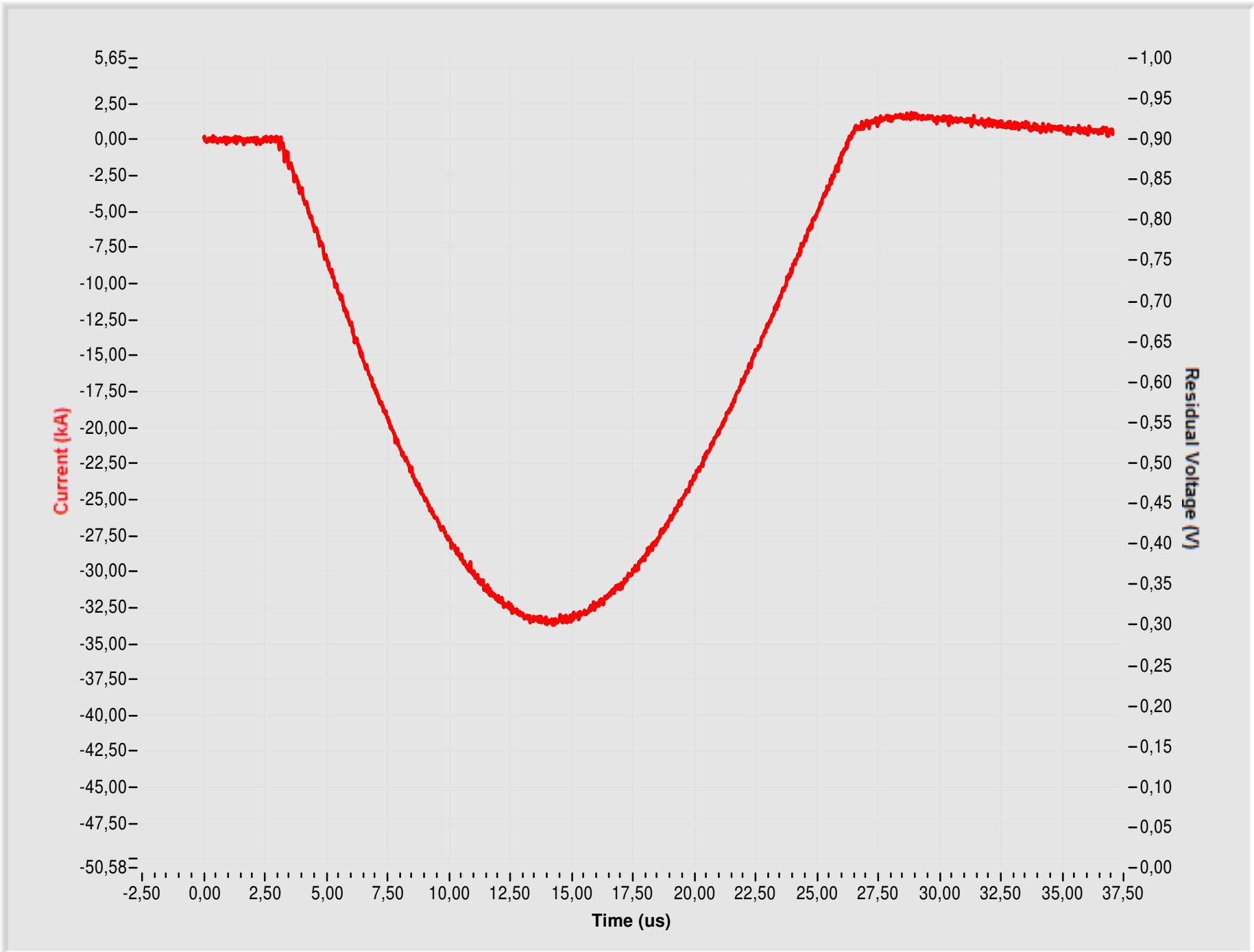


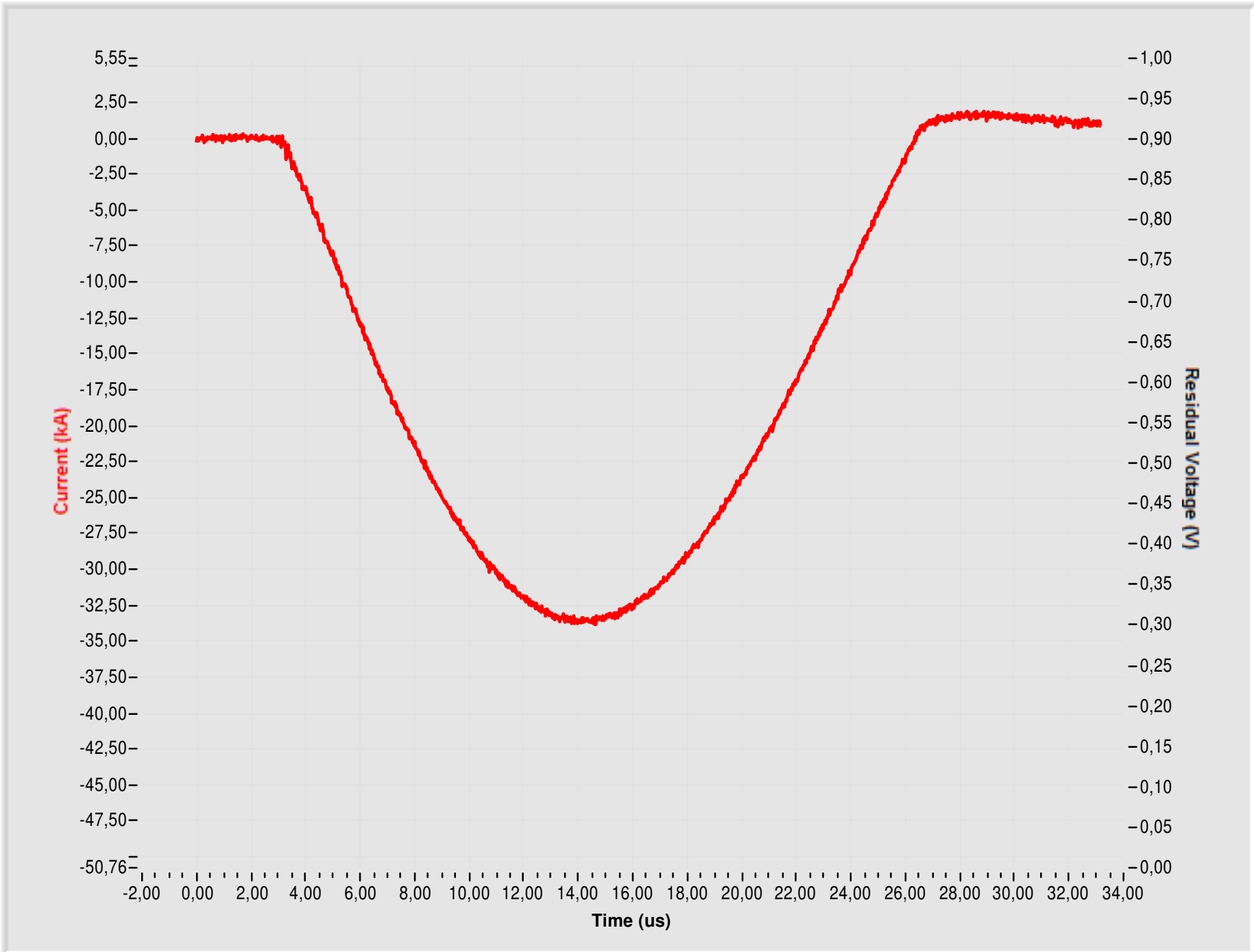
CESI C1011283 Oscillogram n. 44



CESI C1011283 Oscillogram n. 45



CESI C1011283 Oscillogram n. 46



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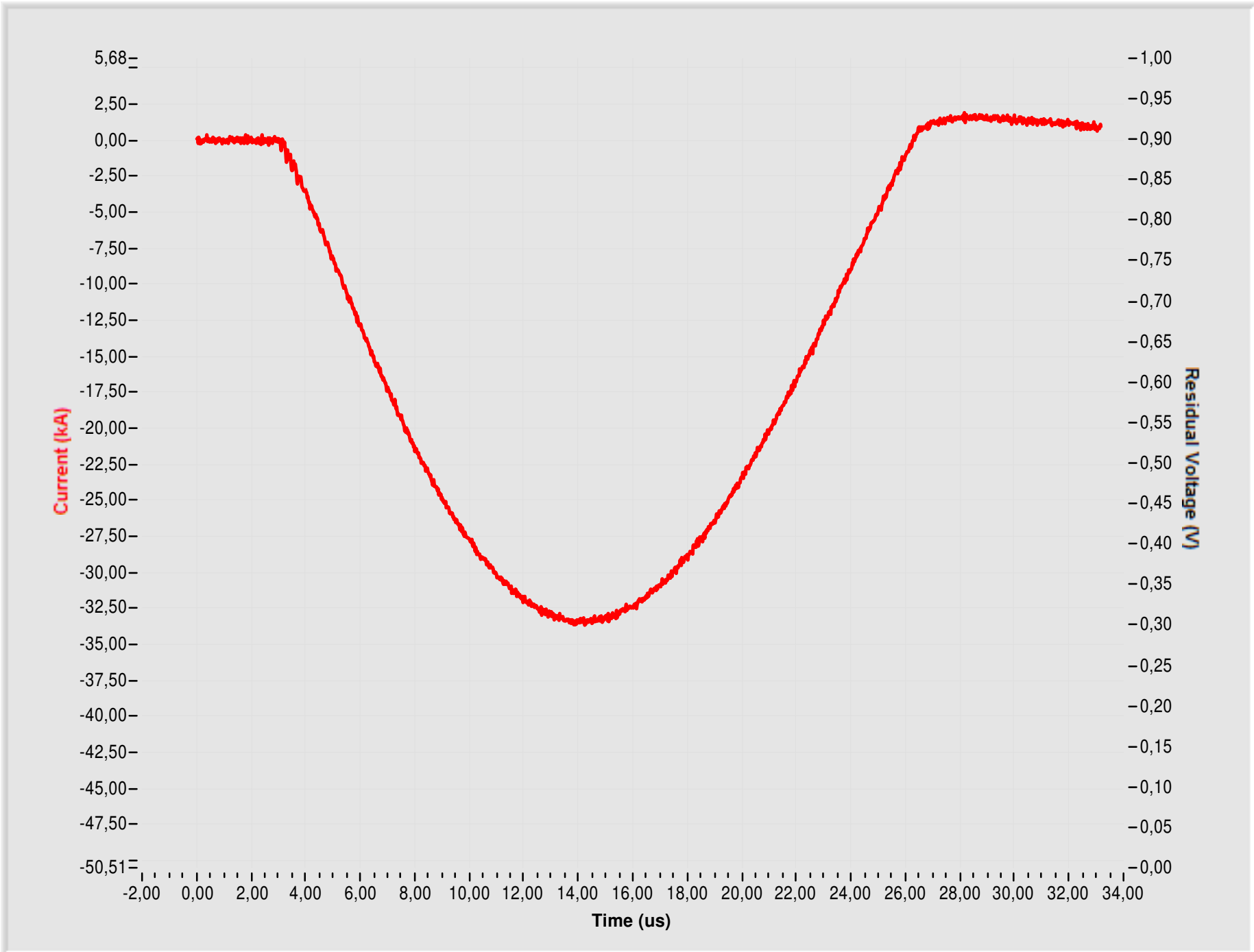
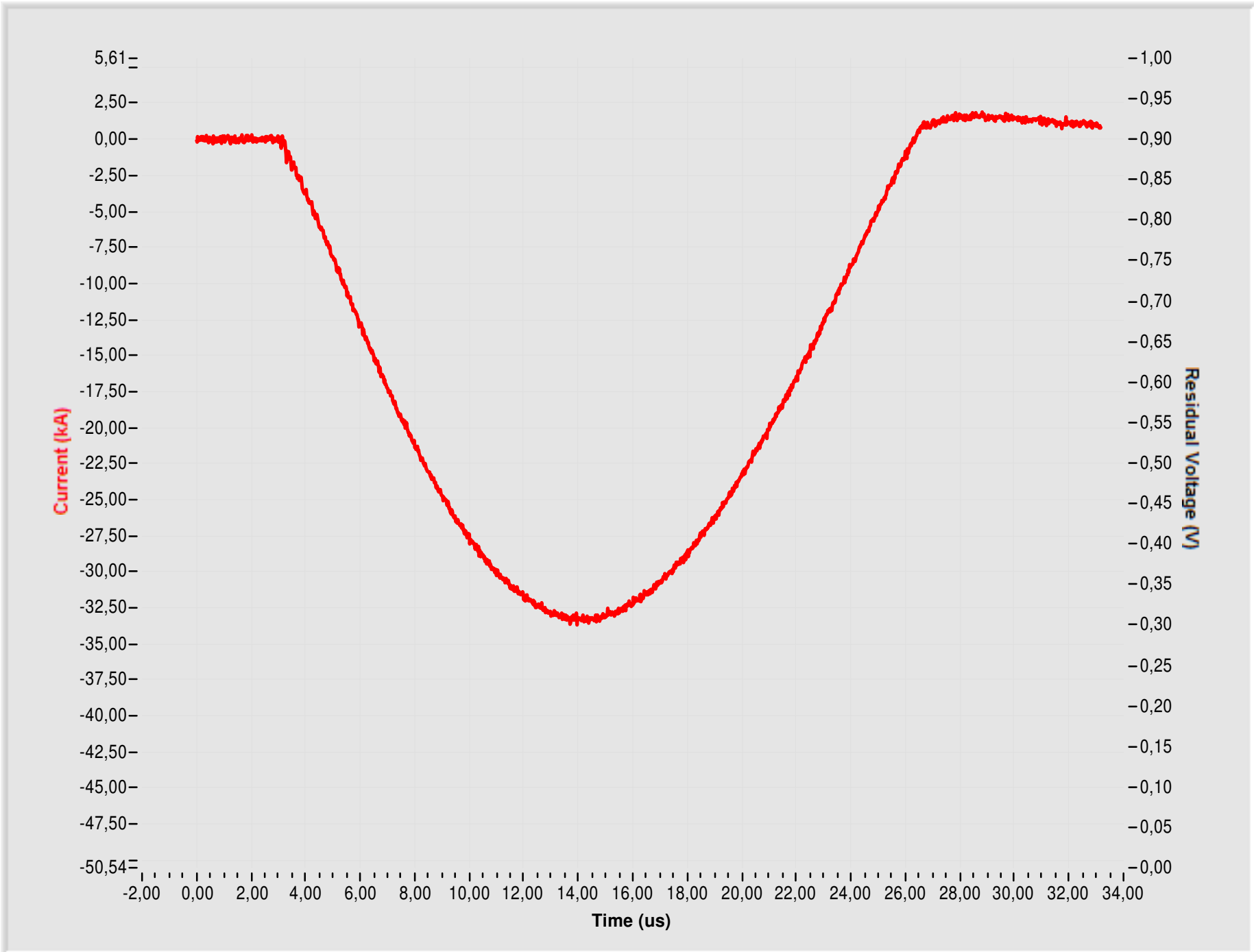


CESI C1011283 Oscillogram n. 48



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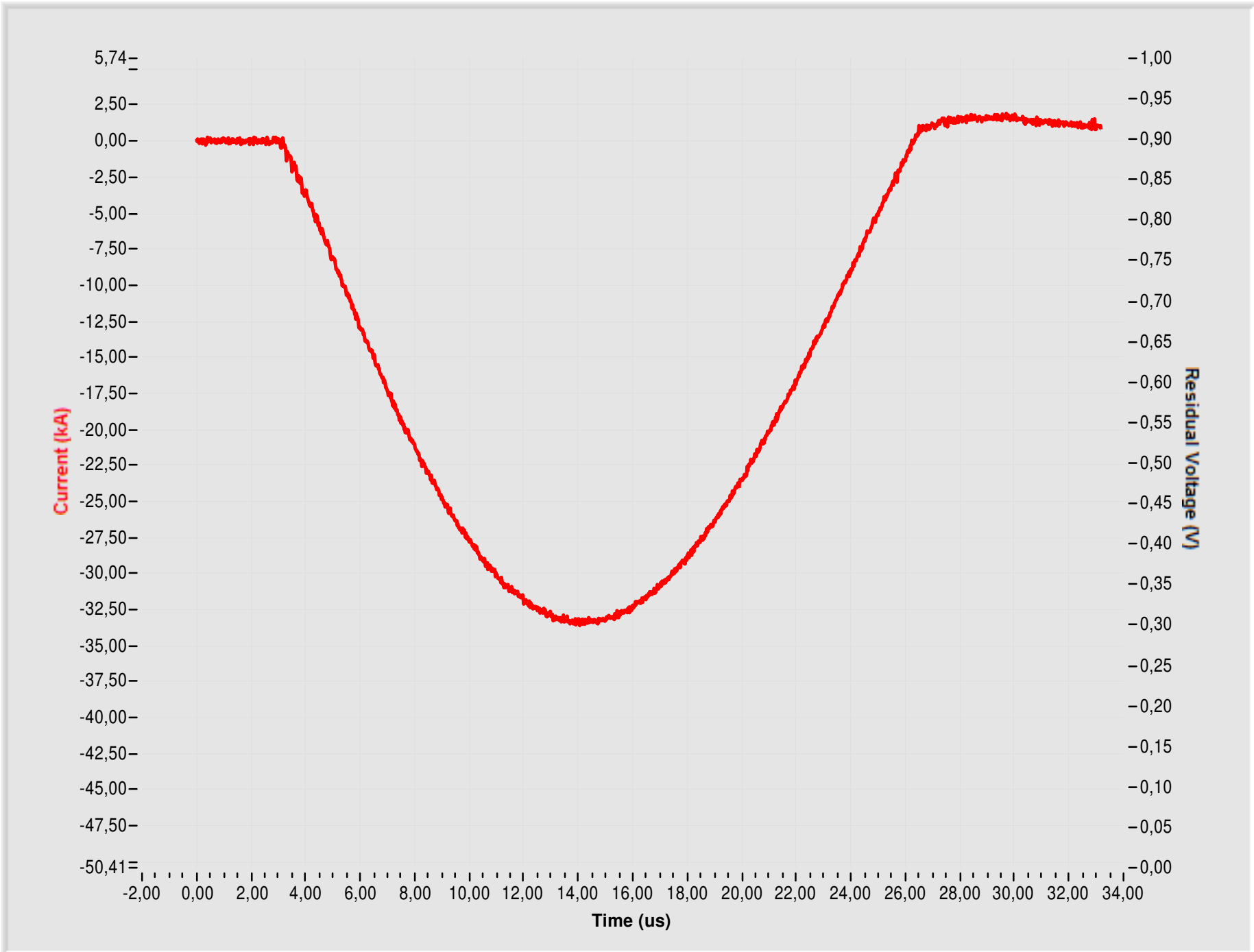
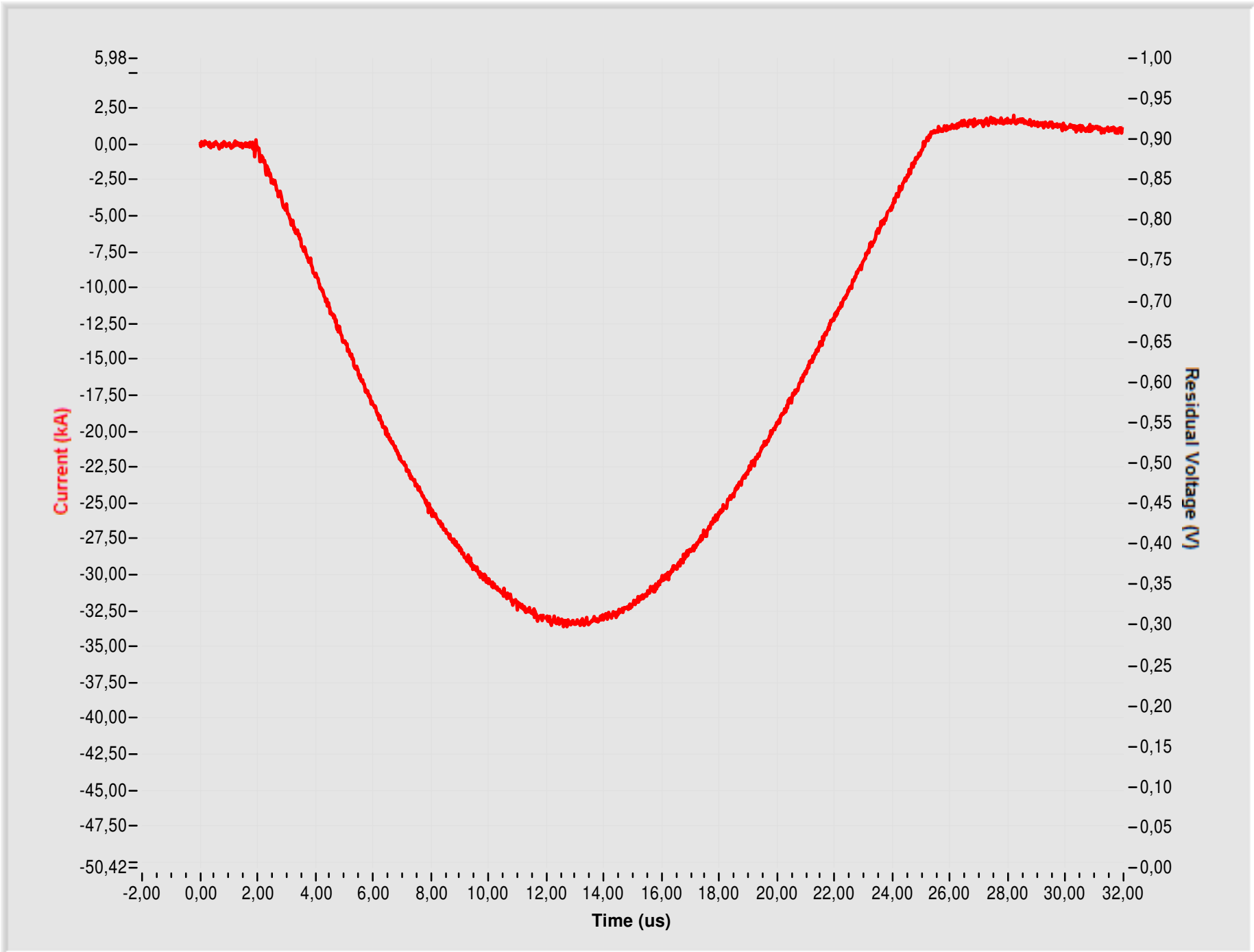
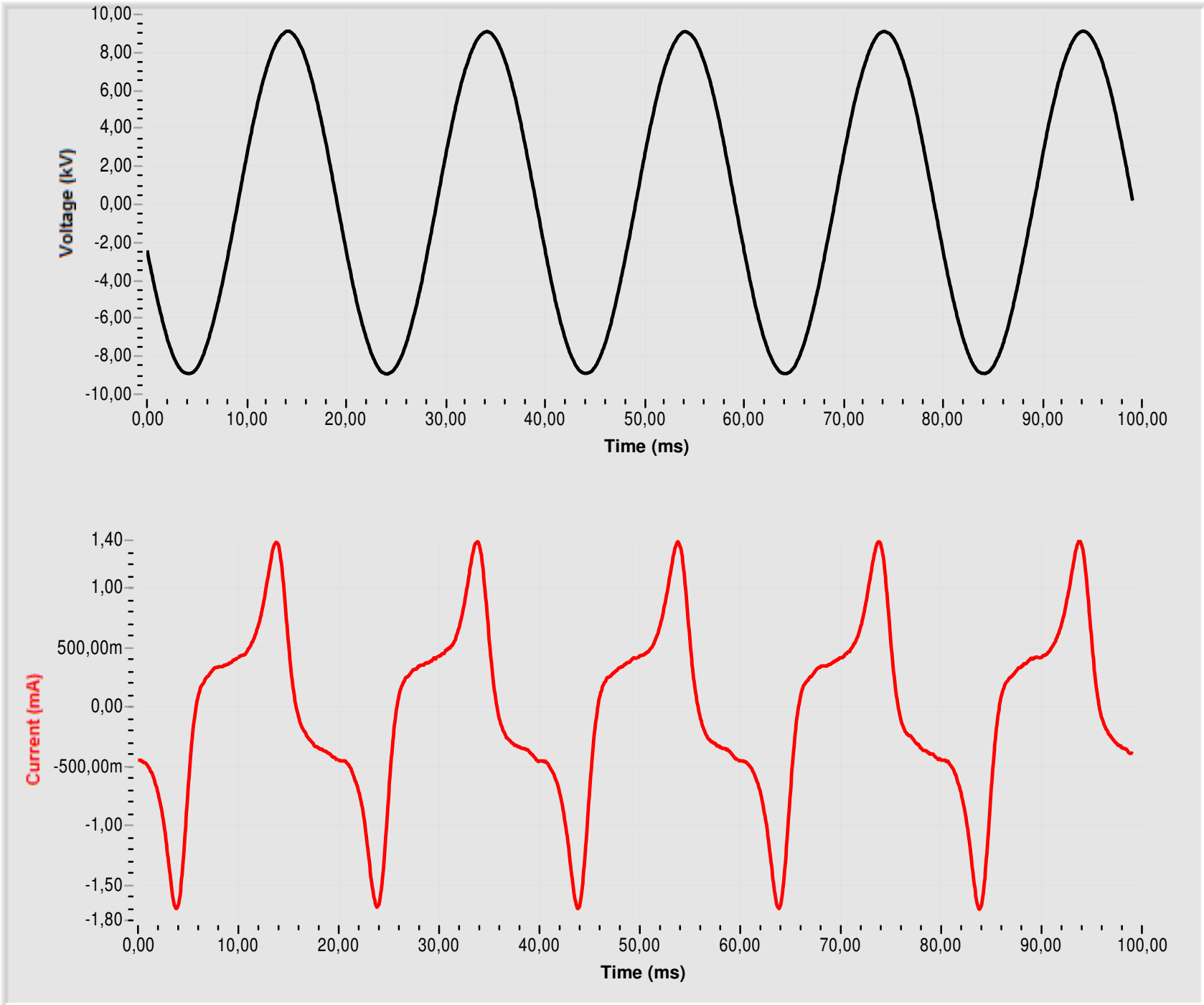


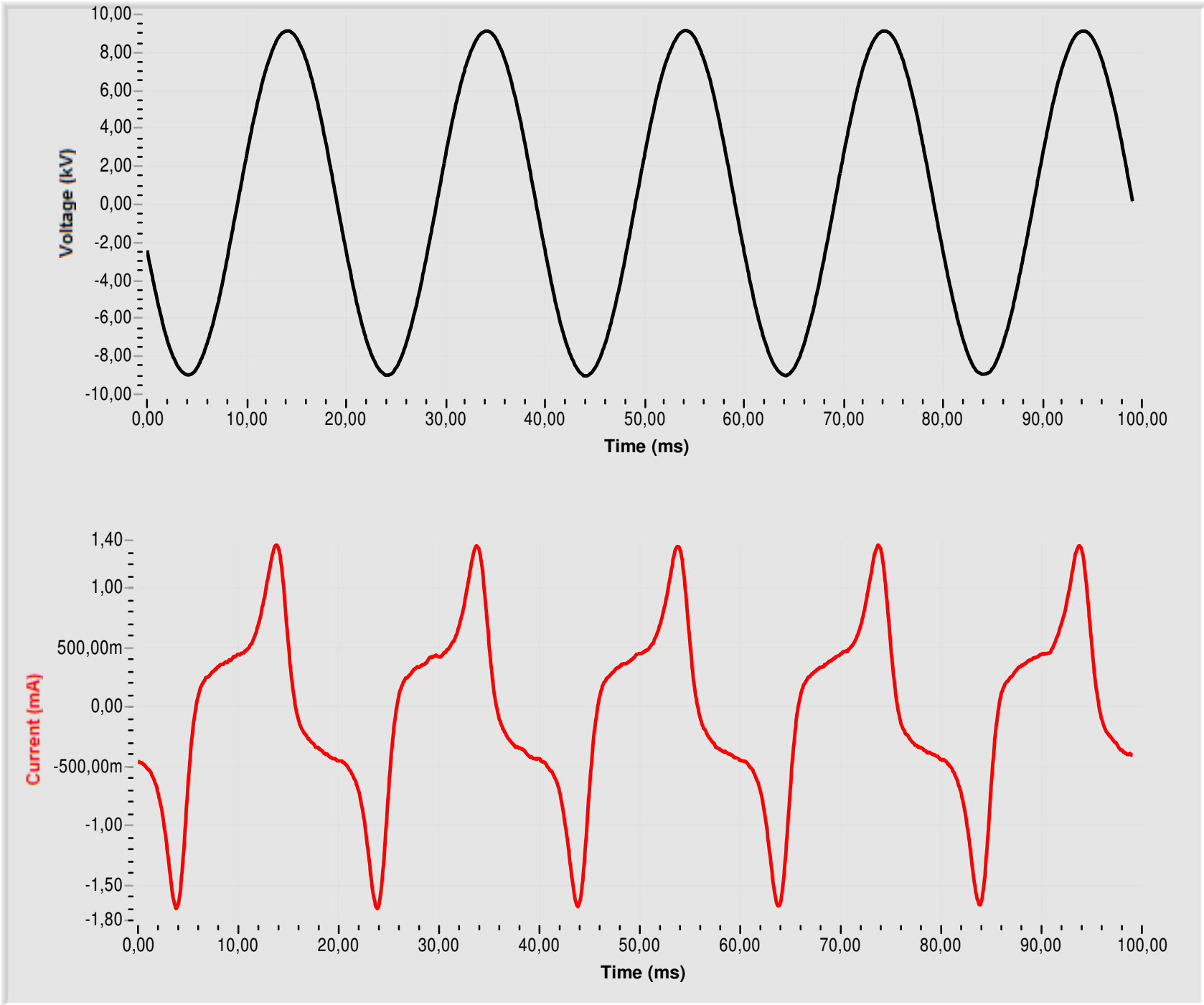
CESI C1011283 Oscillogram n. 50



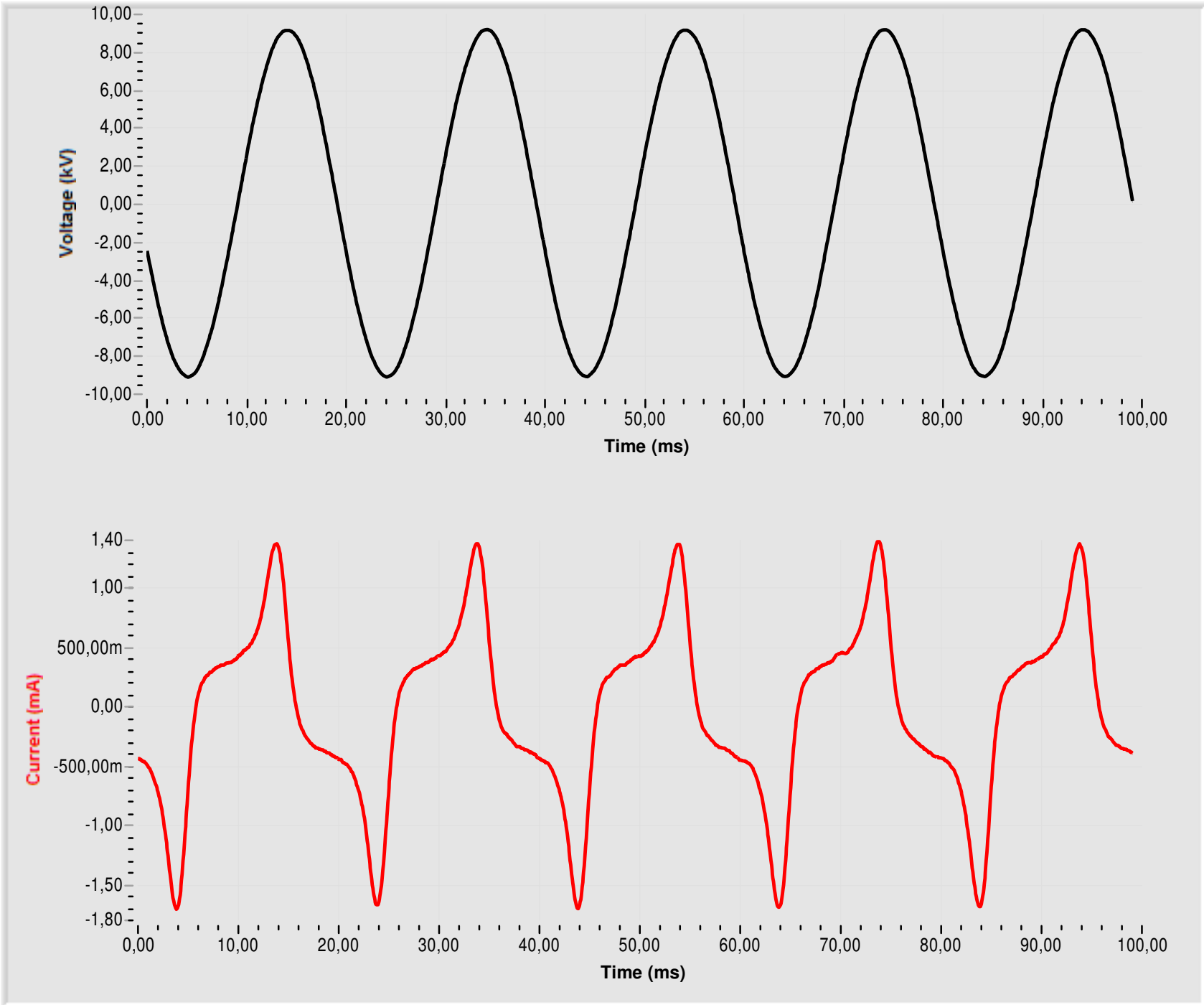
CESI C1011283 Oscillogram n. 51



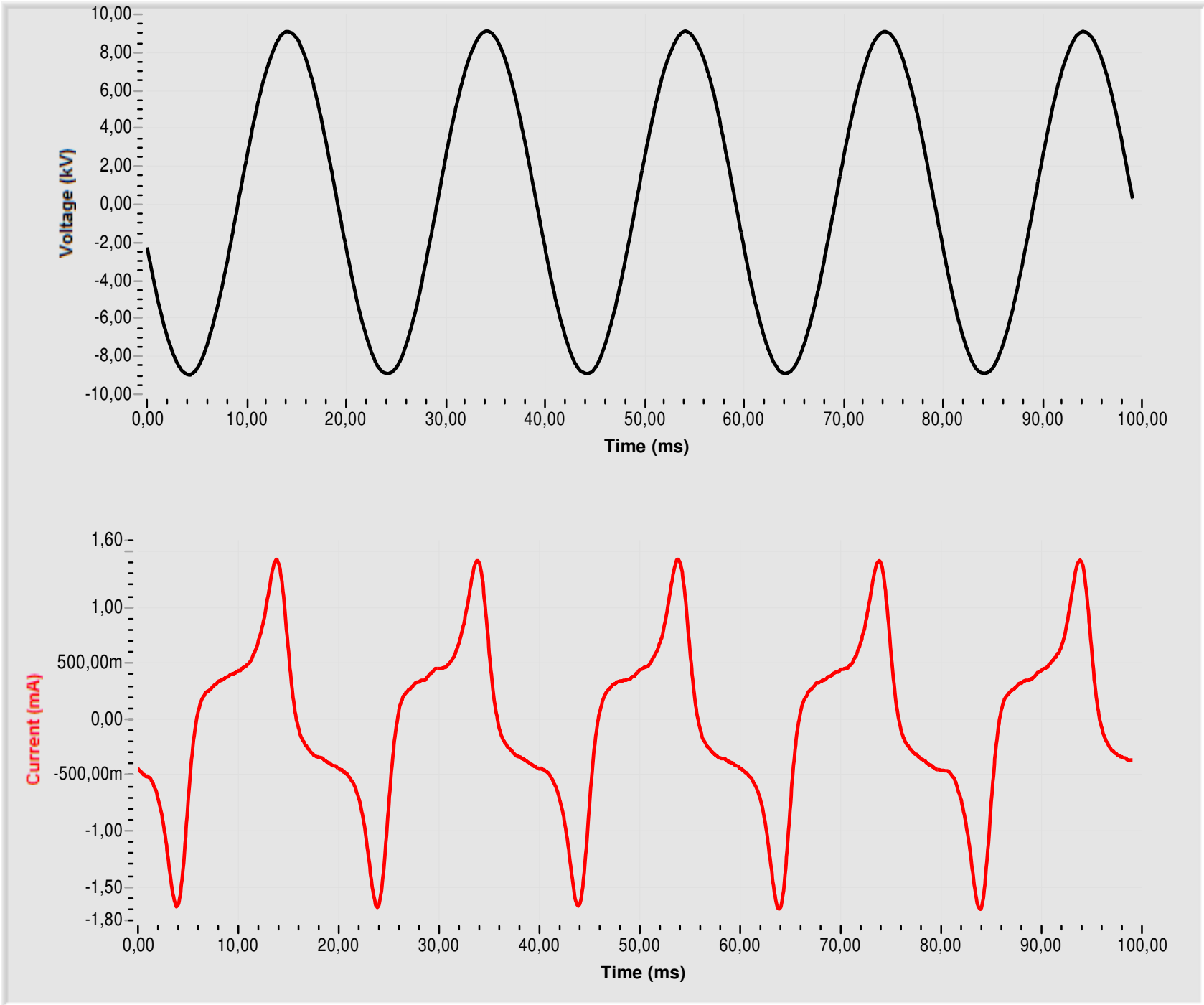
CESI C1011283 Oscillogram n. 52



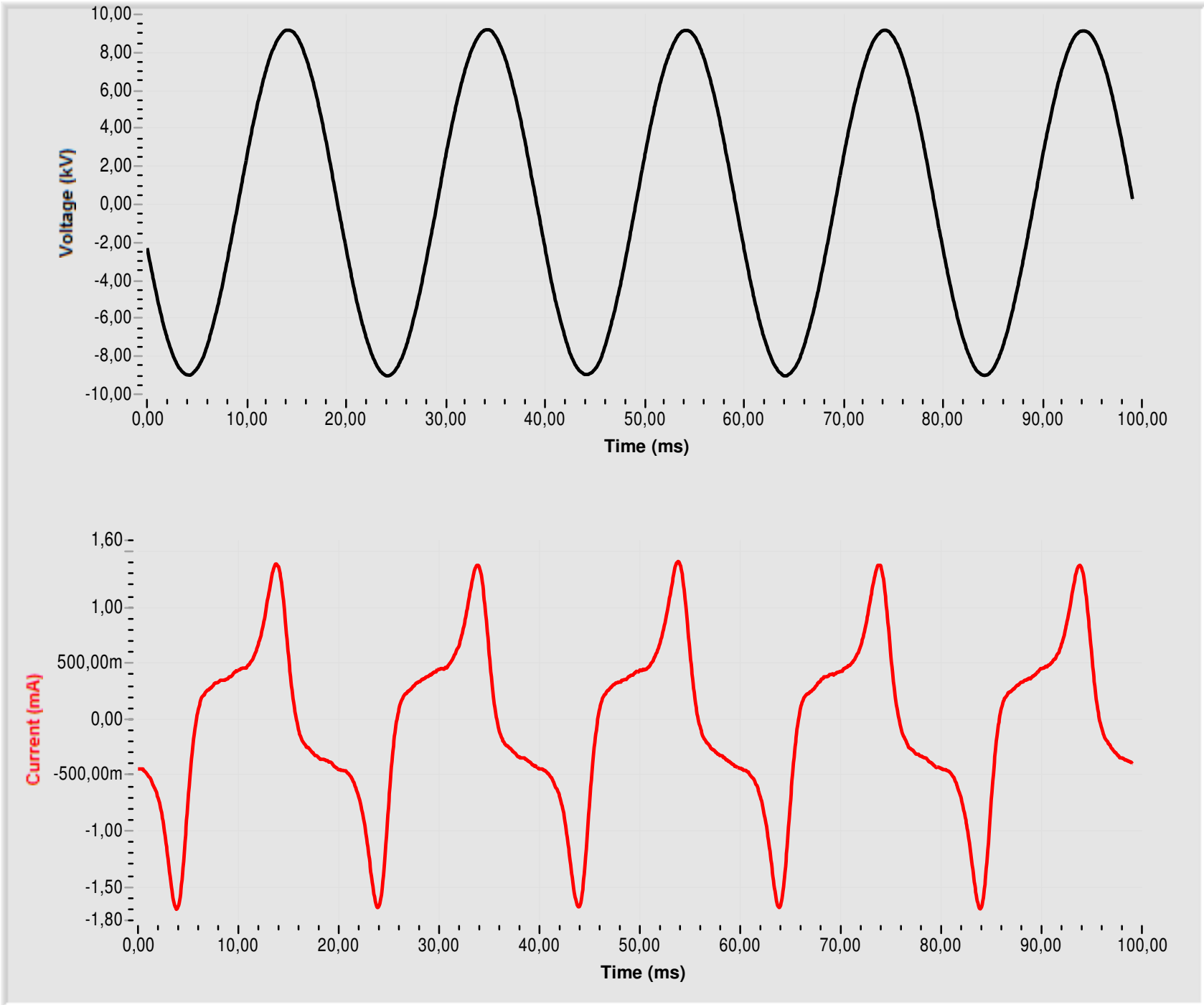
CESI C1011283 Oscillogram n. 53



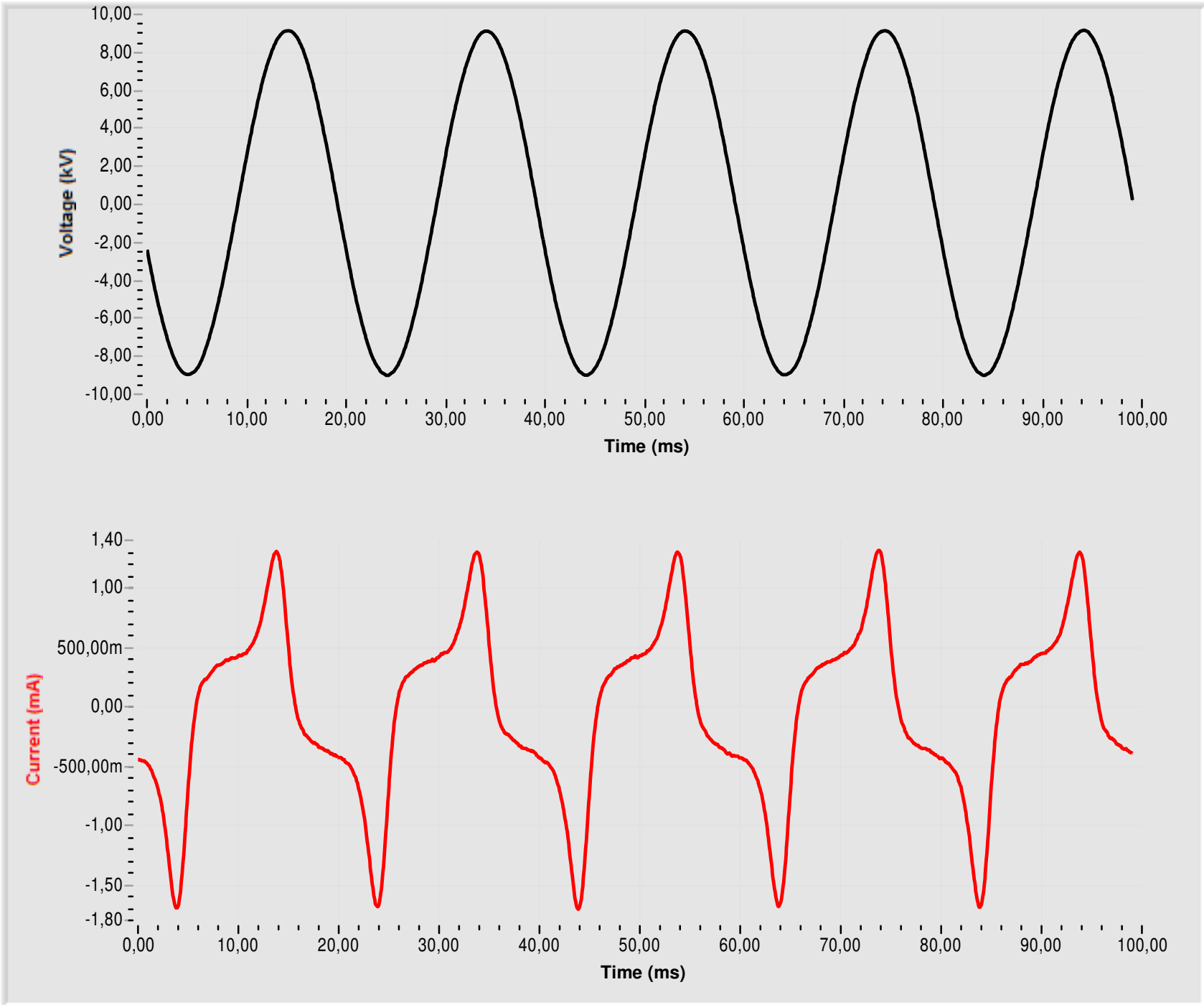
CESI C1011283 Oscillogram n. 54



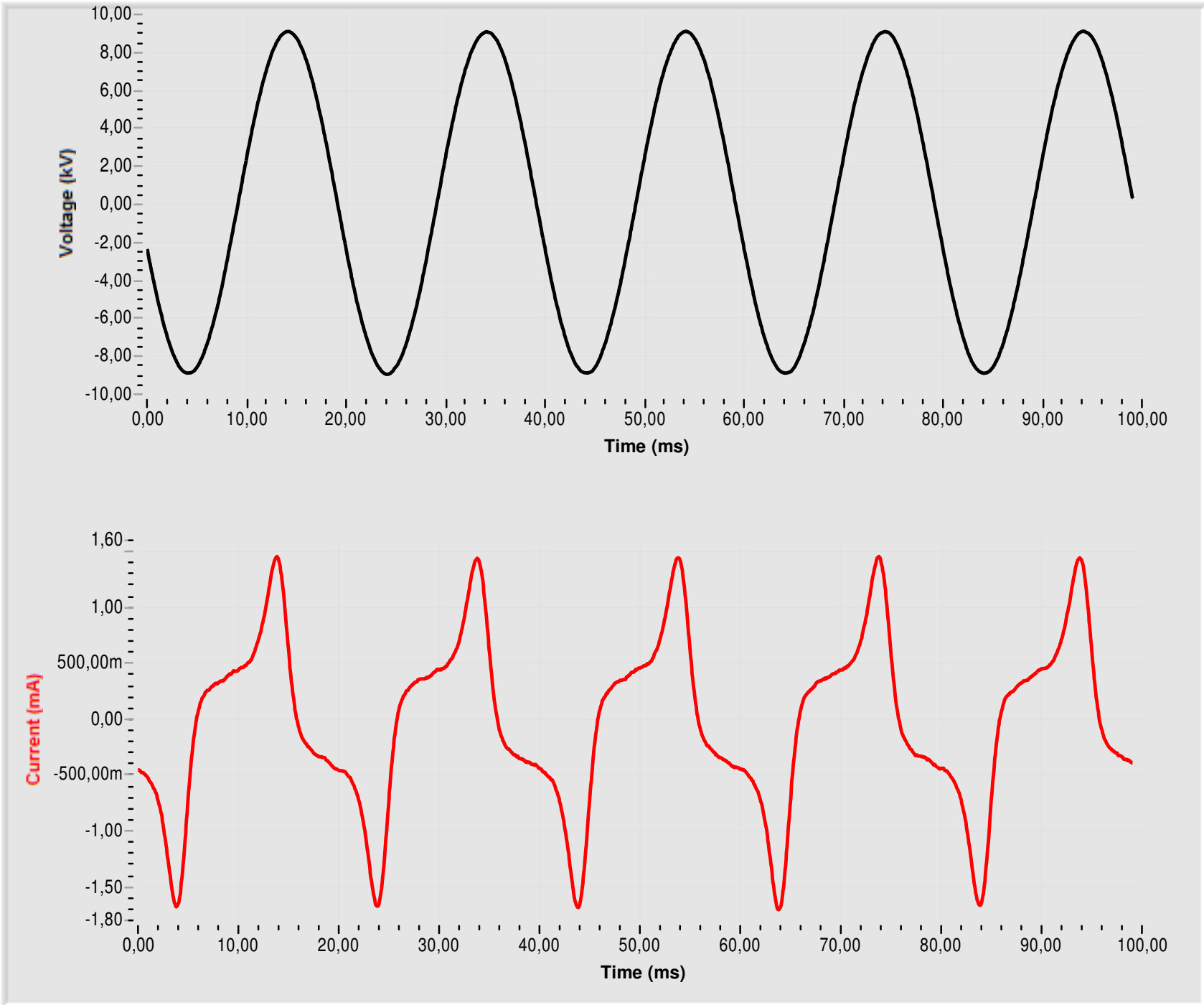
CESI C1011283 Oscillogram n. 55



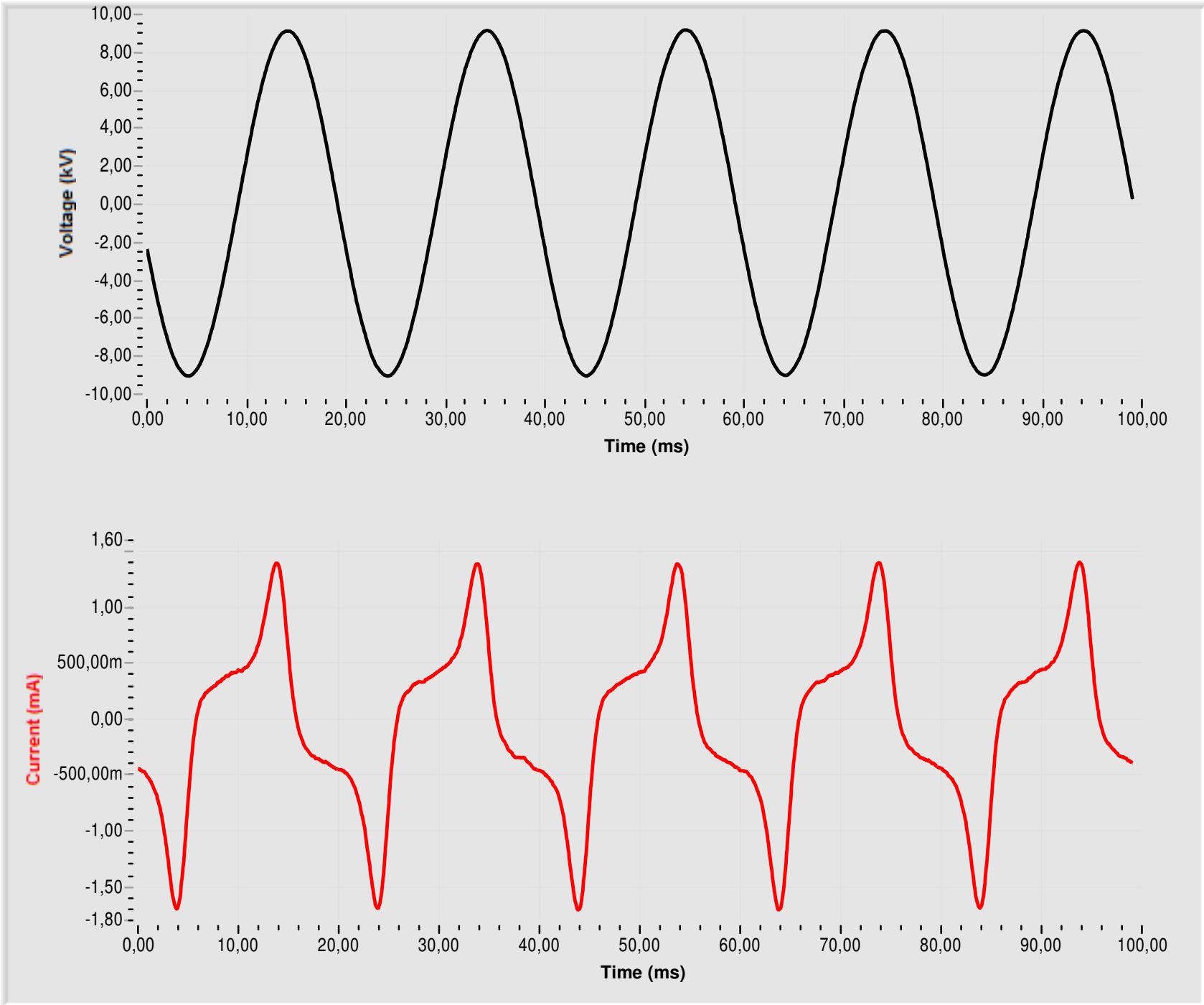
CESI C1011283 Oscillogram n. 56



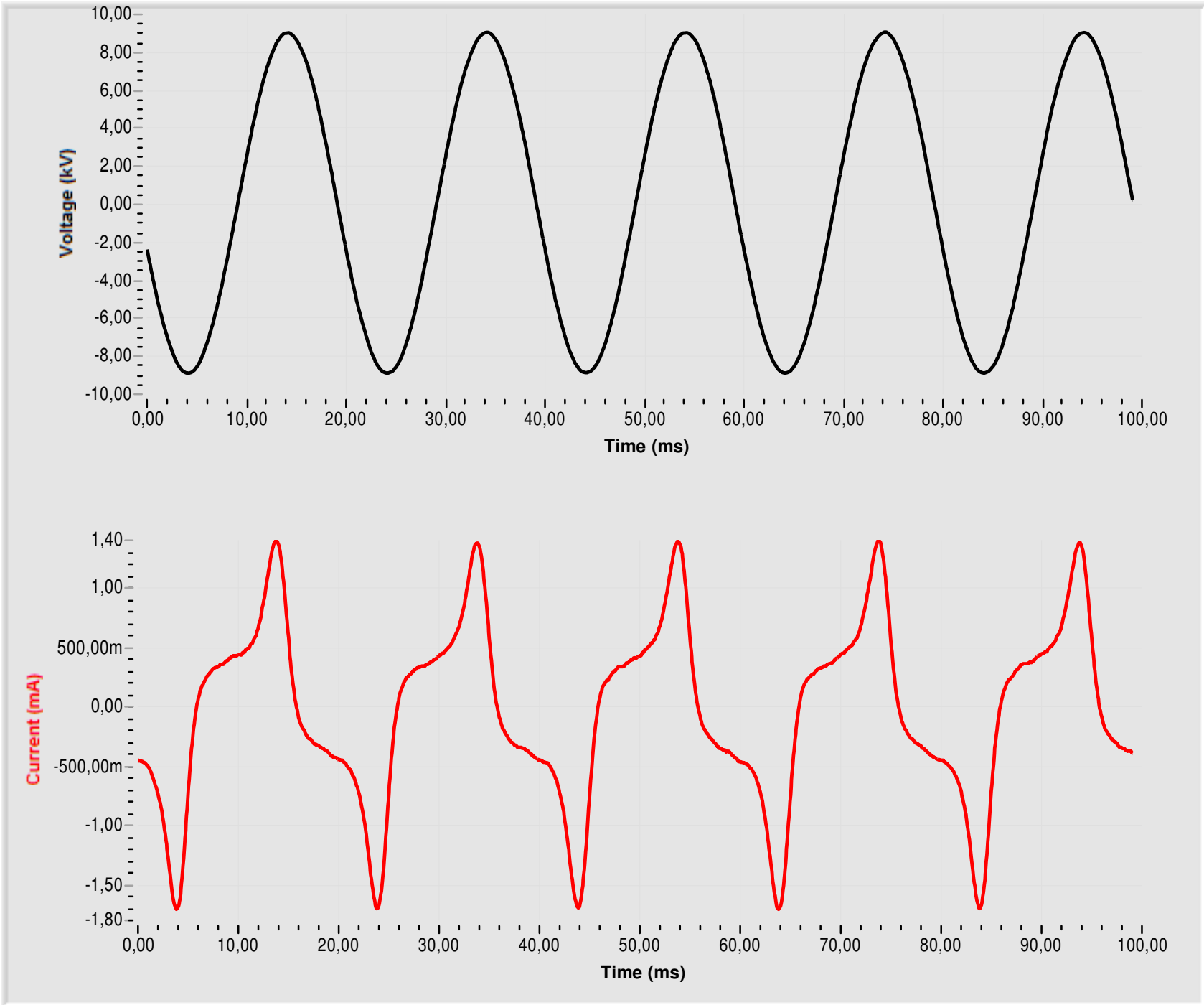
CESI C1011283 Oscillogram n. 57



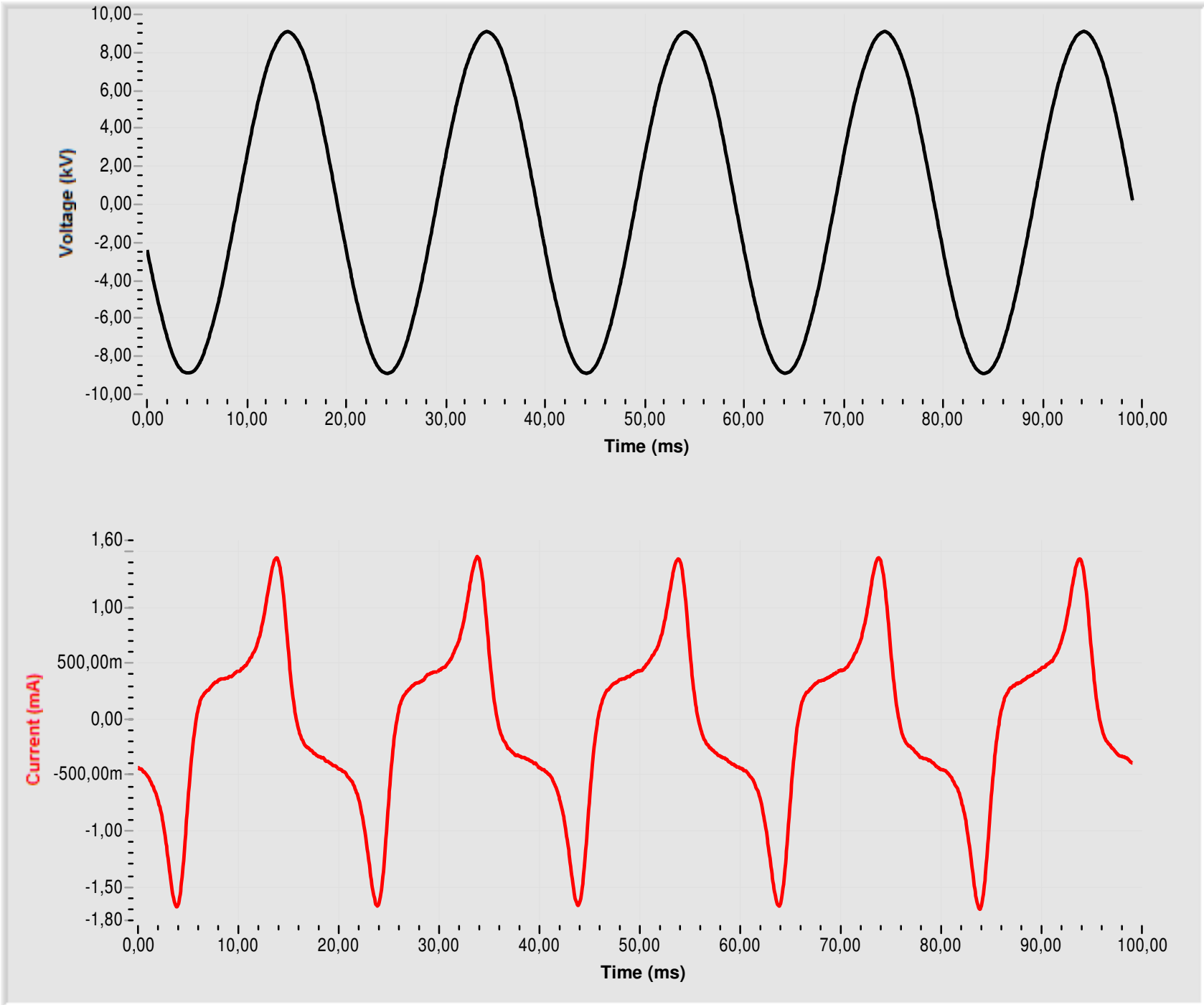
CESI C1011283 Oscillogram n. 58



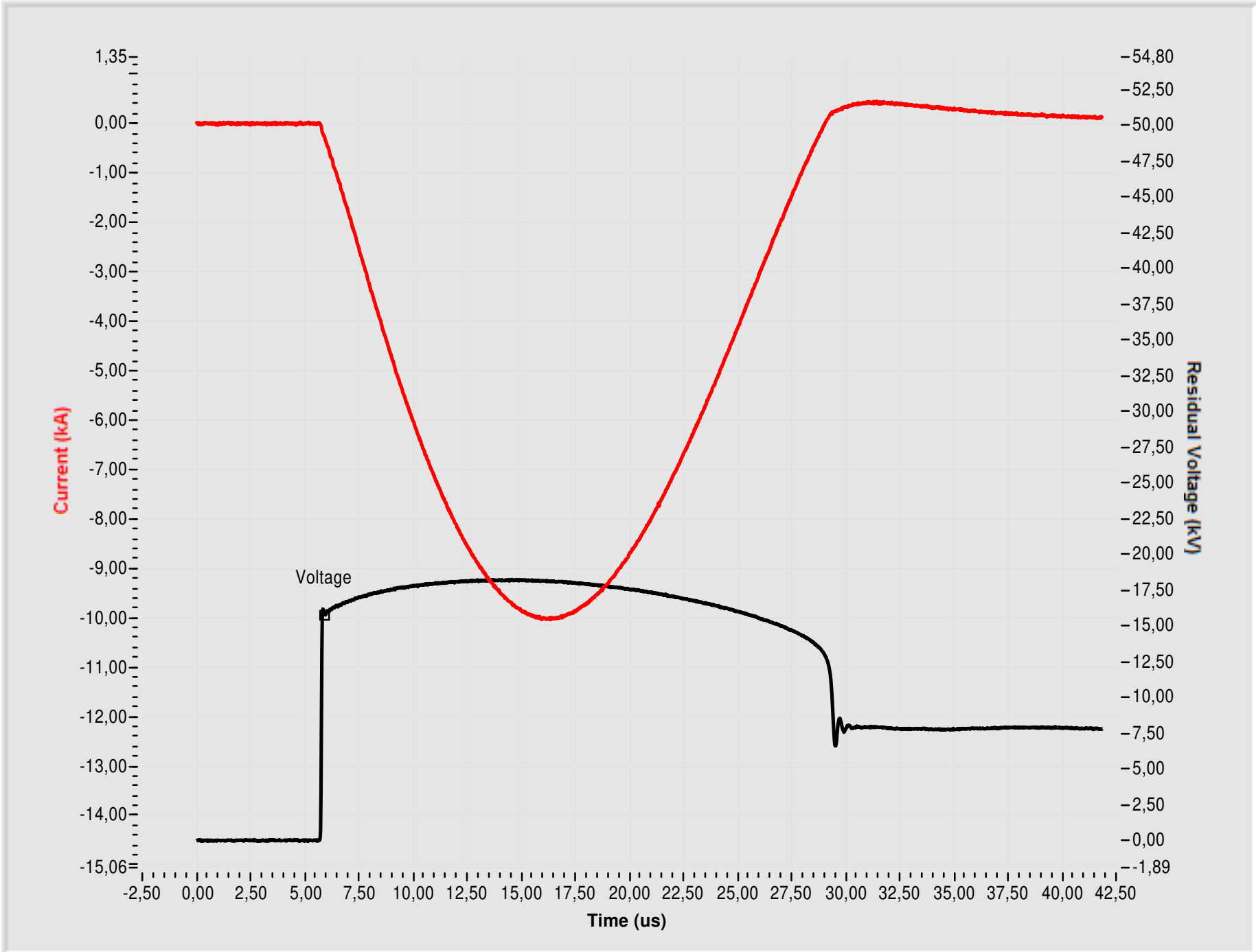
CESI C1011283 Oscillogram n. 59



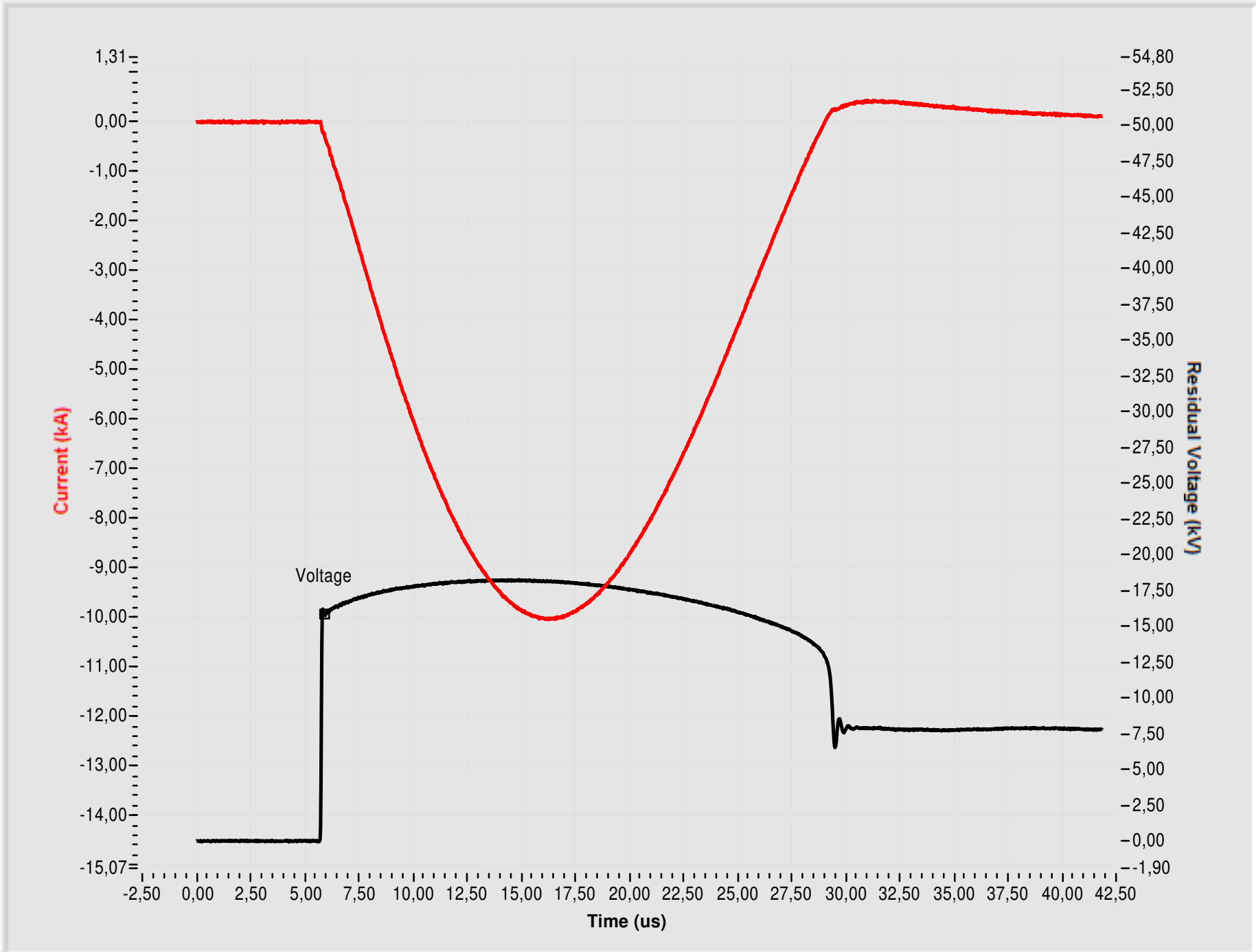
CESI C1011283 Oscillogram n. 60



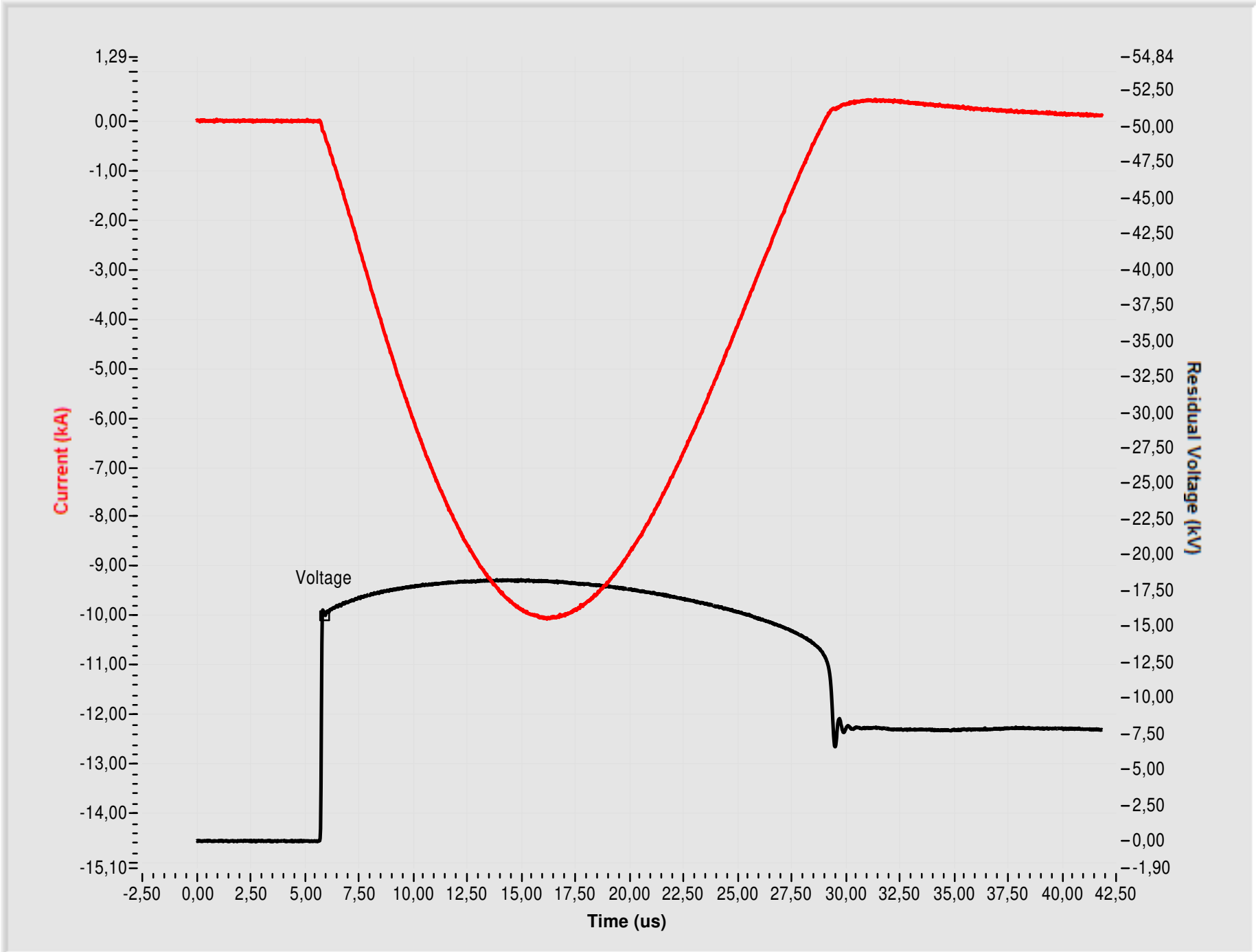
CESI C1011283 Oscillogram n. 61



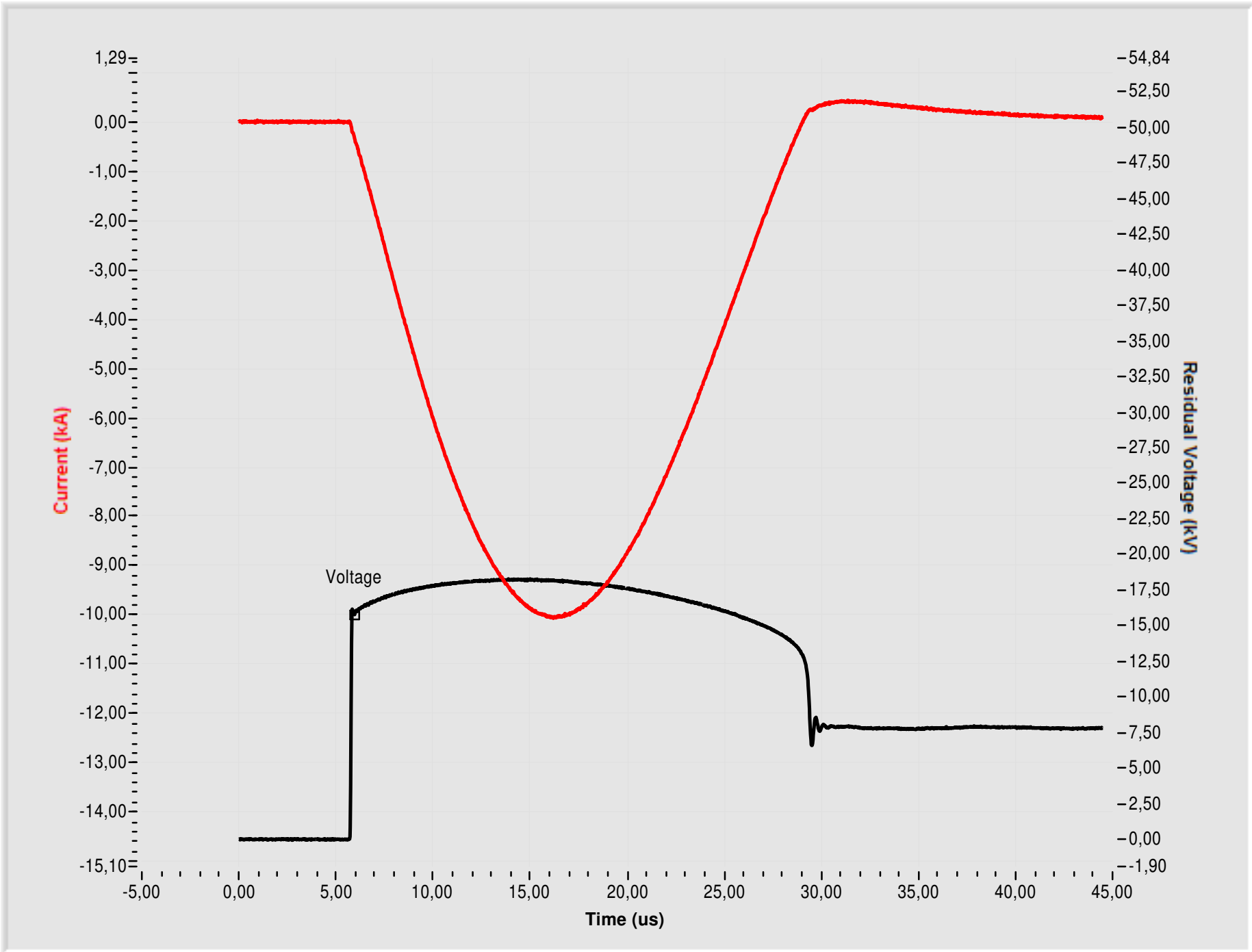
CESI C1011283 Oscillogram n. 62



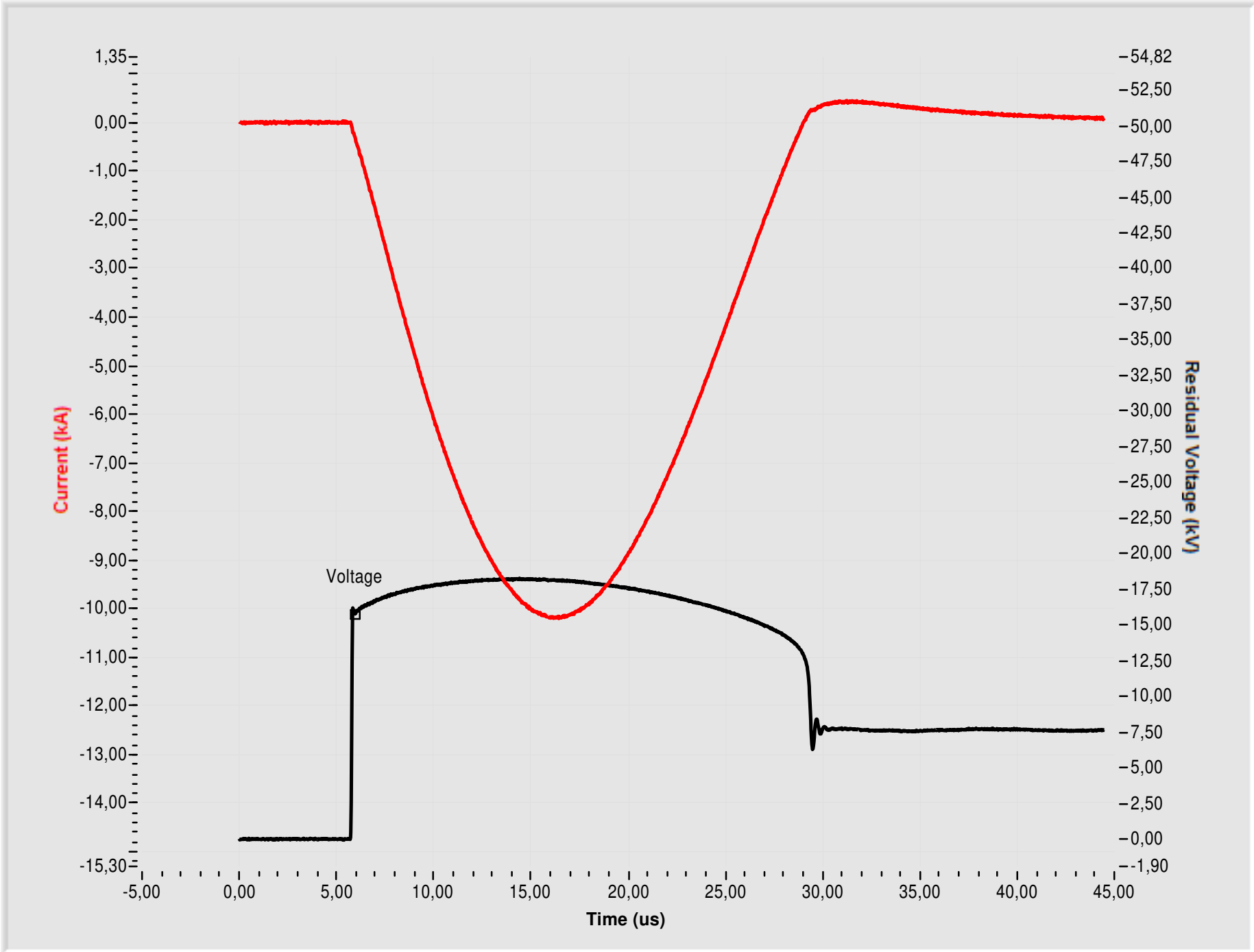
CESI C1011283 Oscillogram n. 63



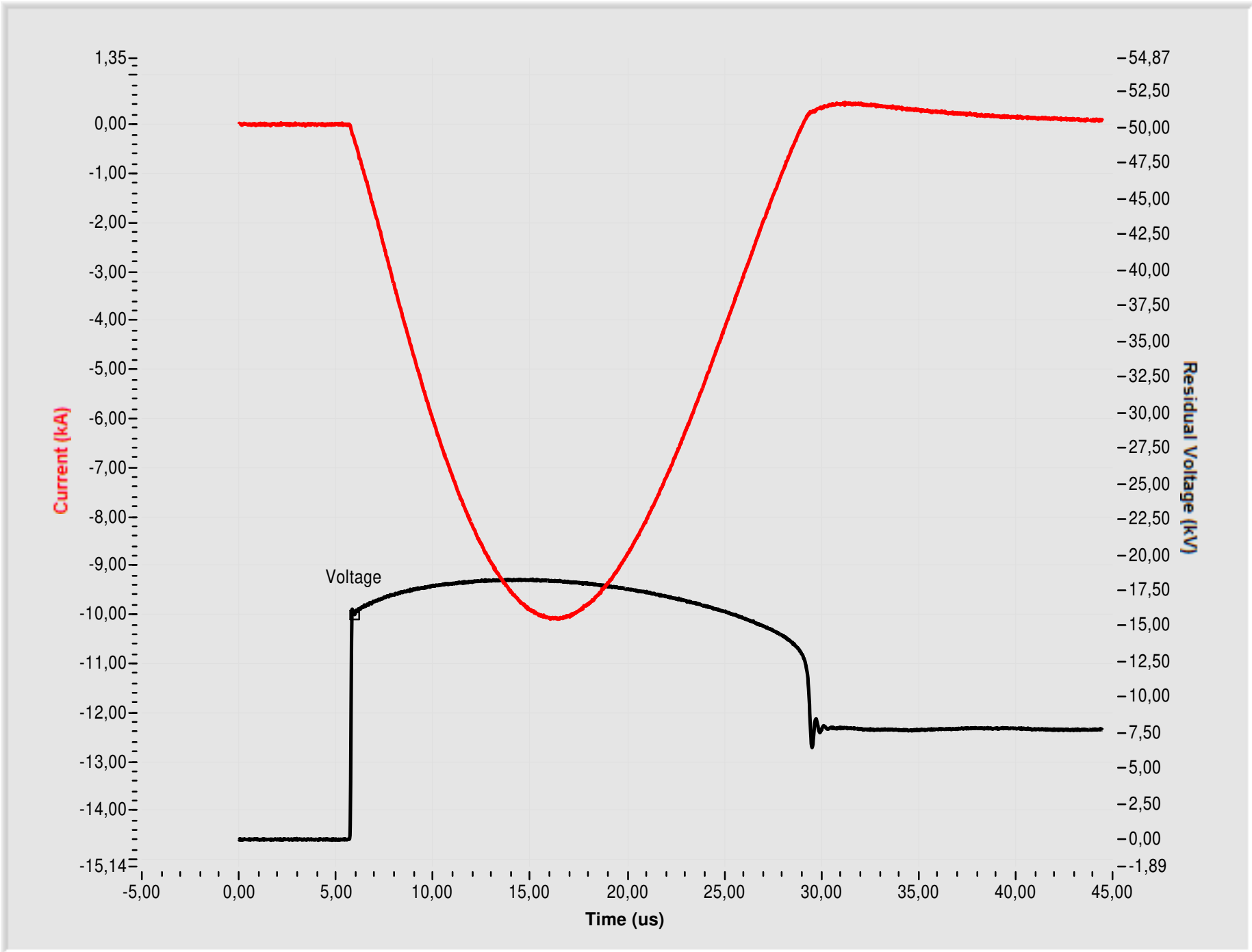
CESI C1011283 Oscillogram n. 64



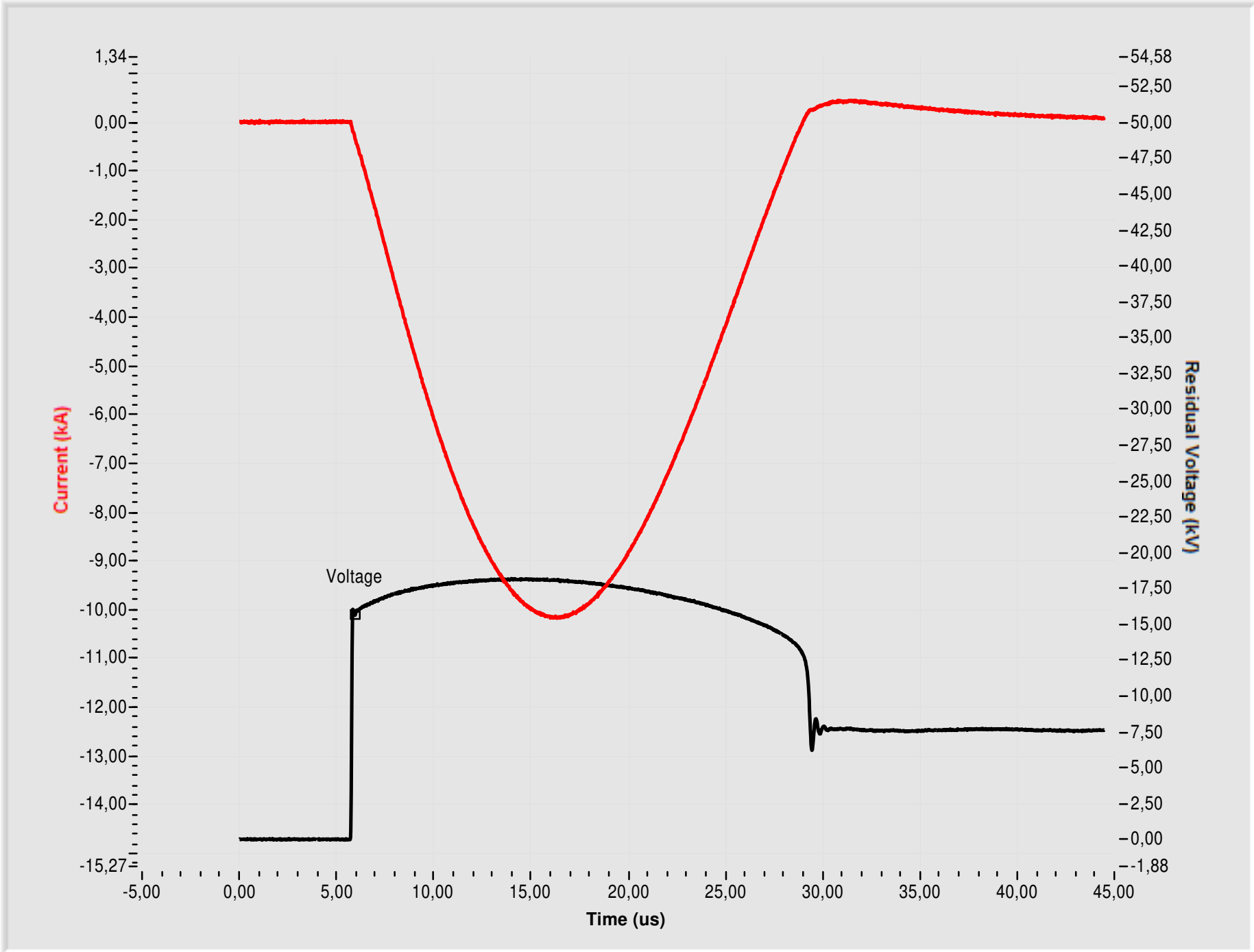
CESI C1011283 Oscillogram n. 65



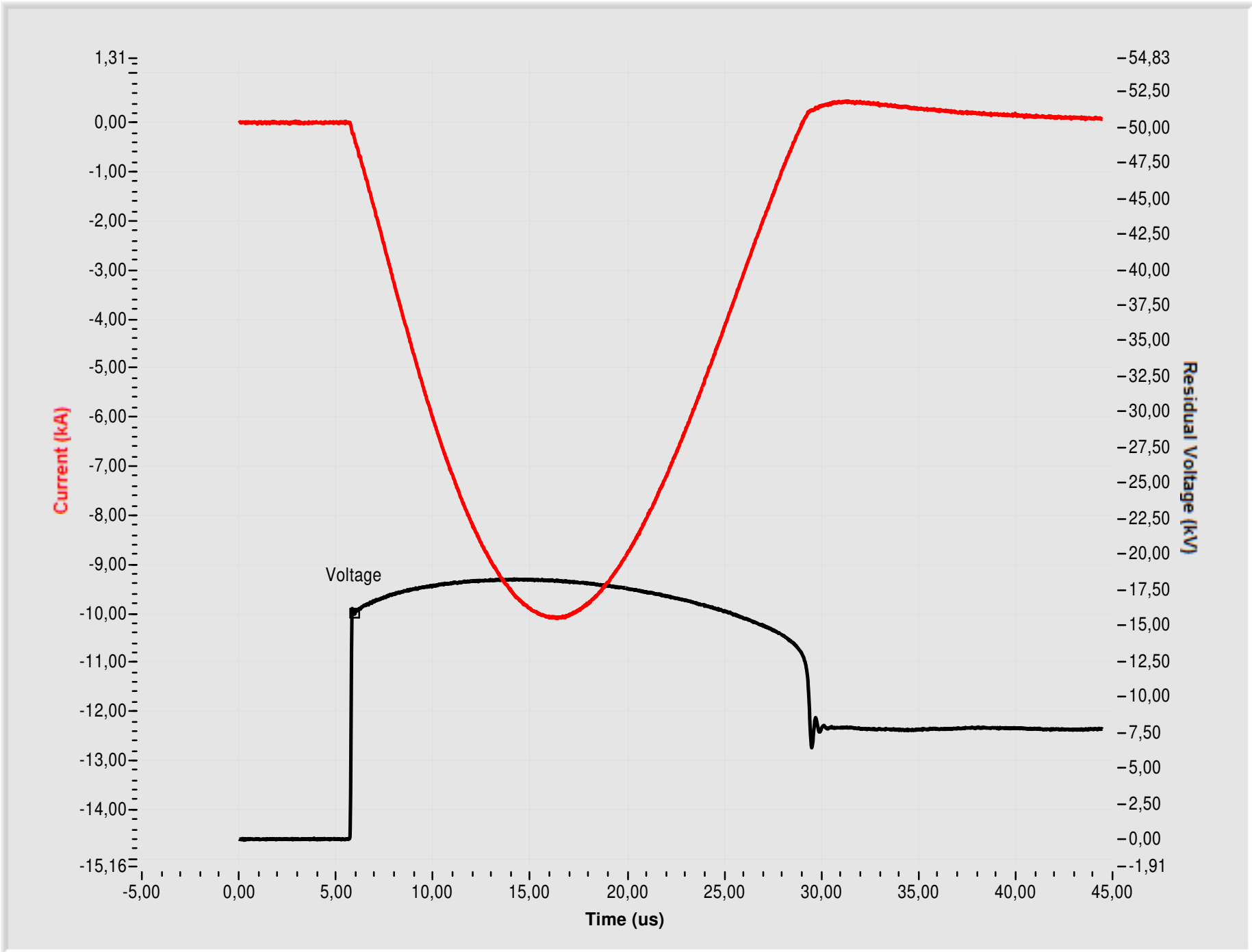
CESI C1011283 Oscillogram n. 66



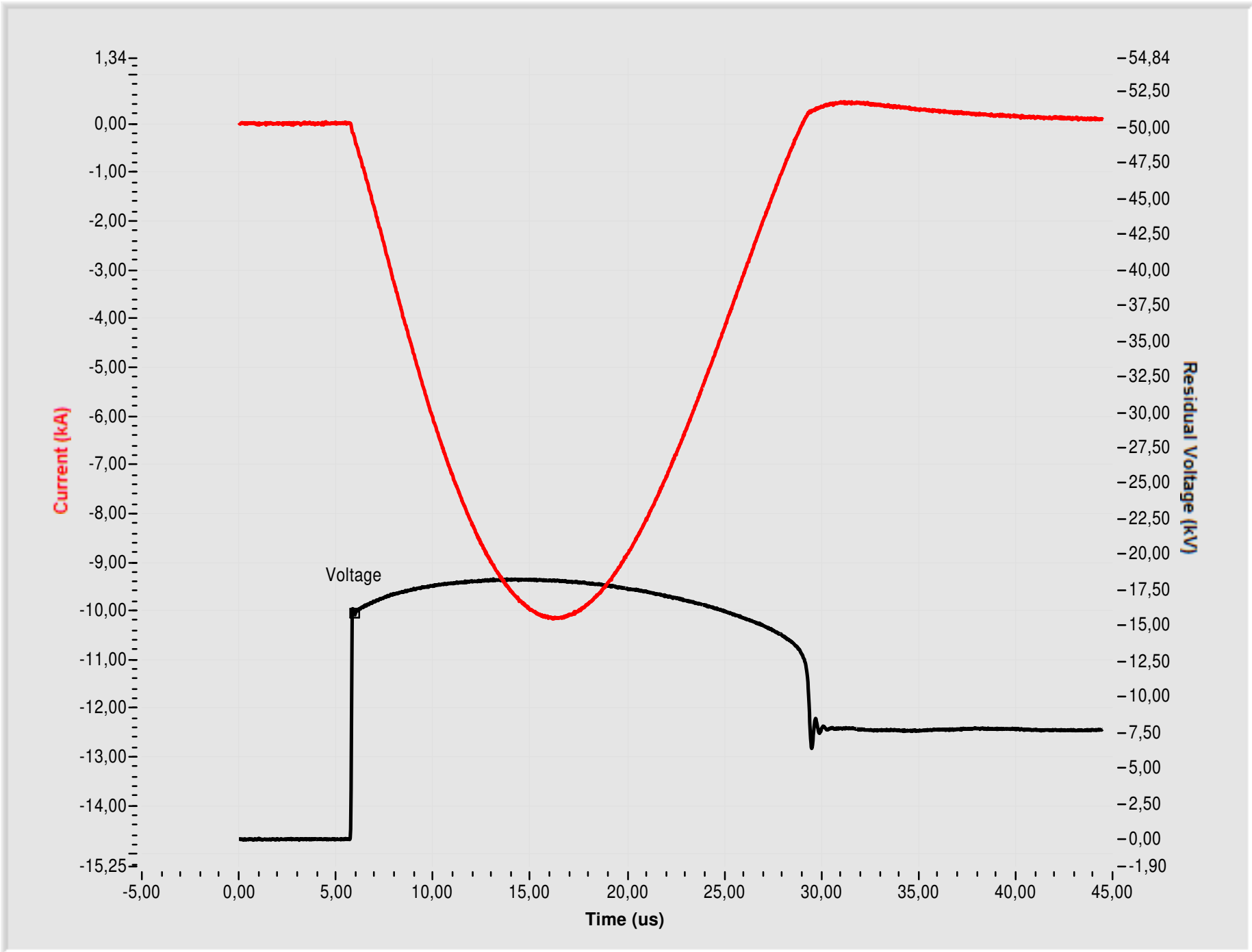
CESI C1011283 Oscillogram n. 67



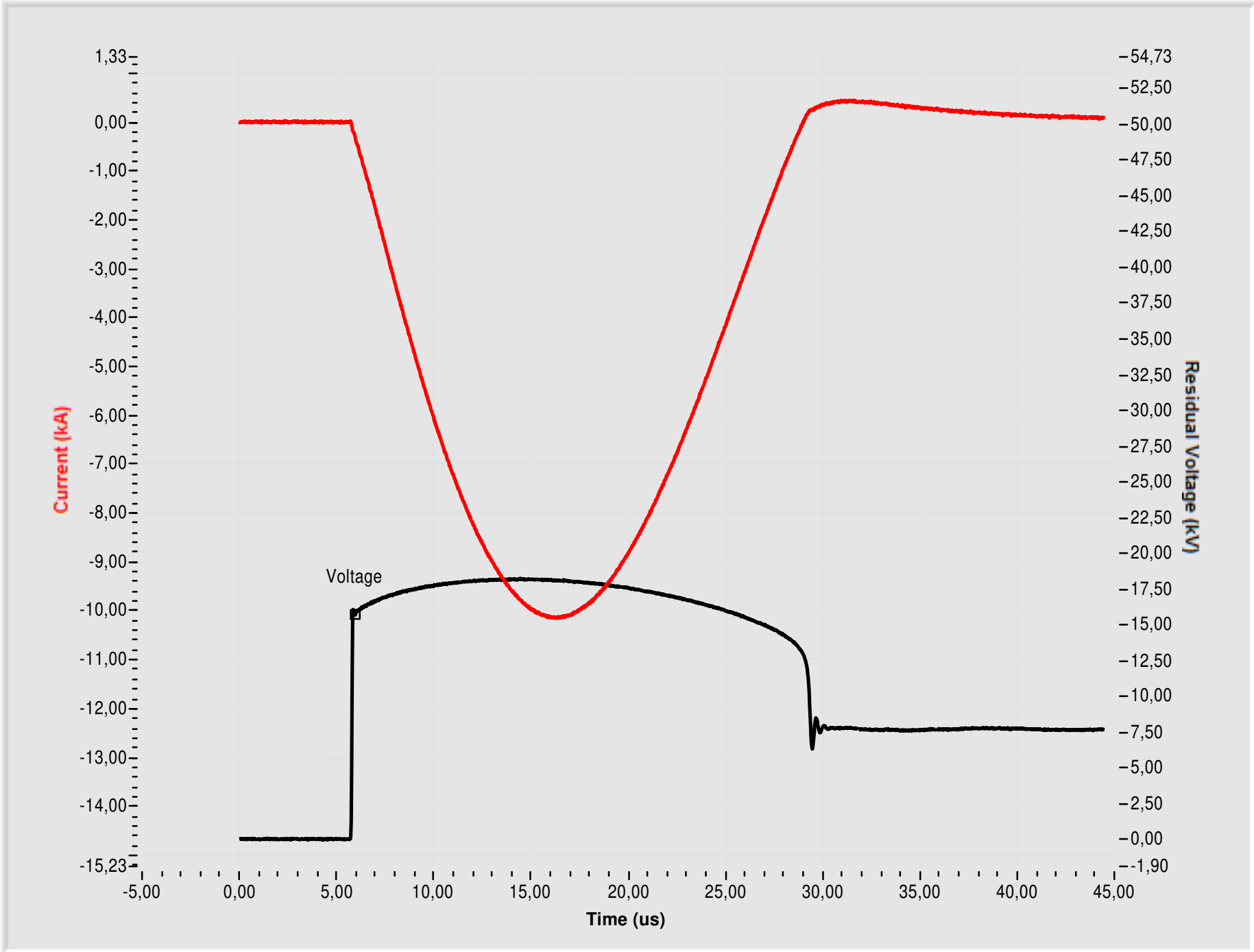
CESI C1011283 Oscillogram n. 68



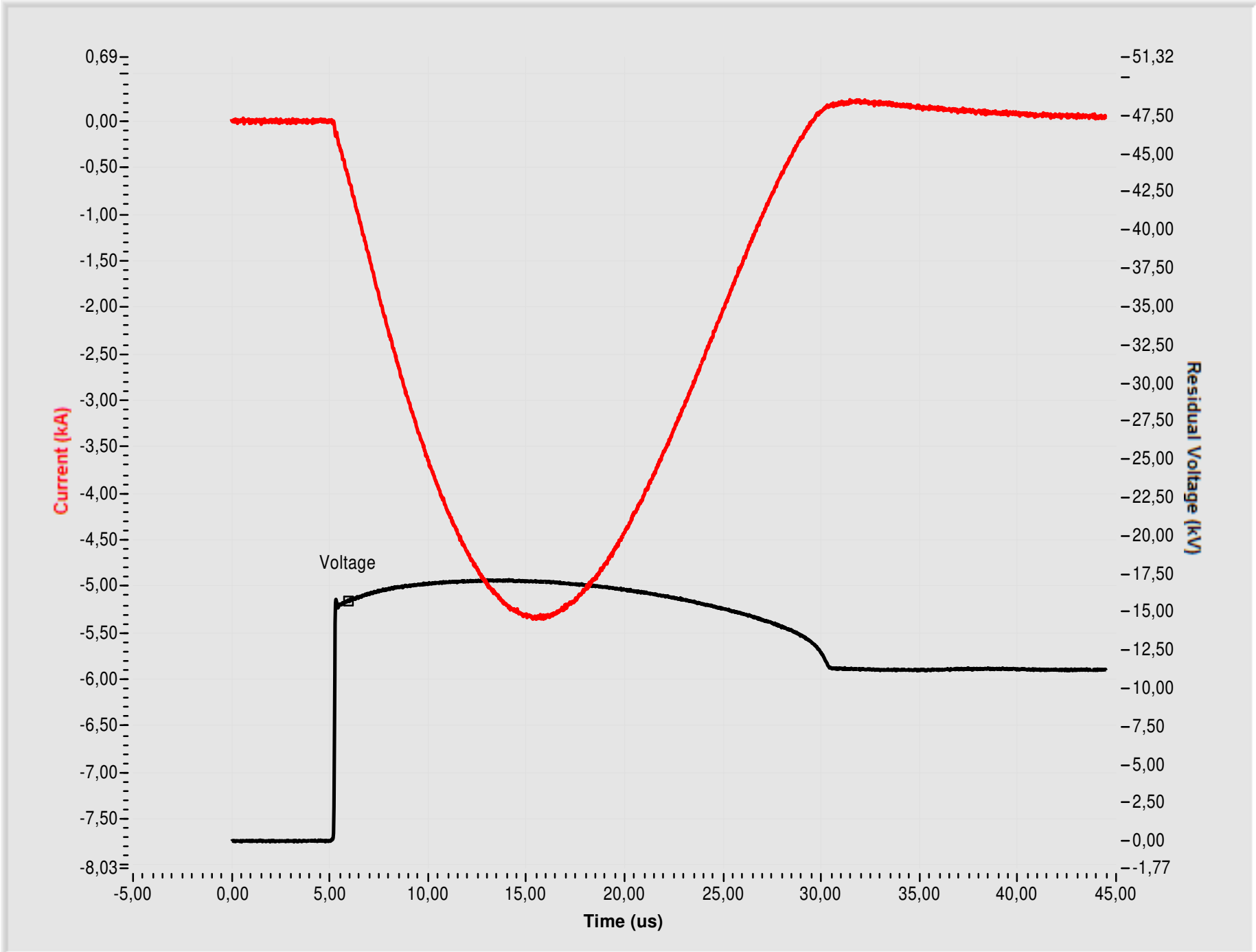
CESI C1011283 Oscillogram n. 69



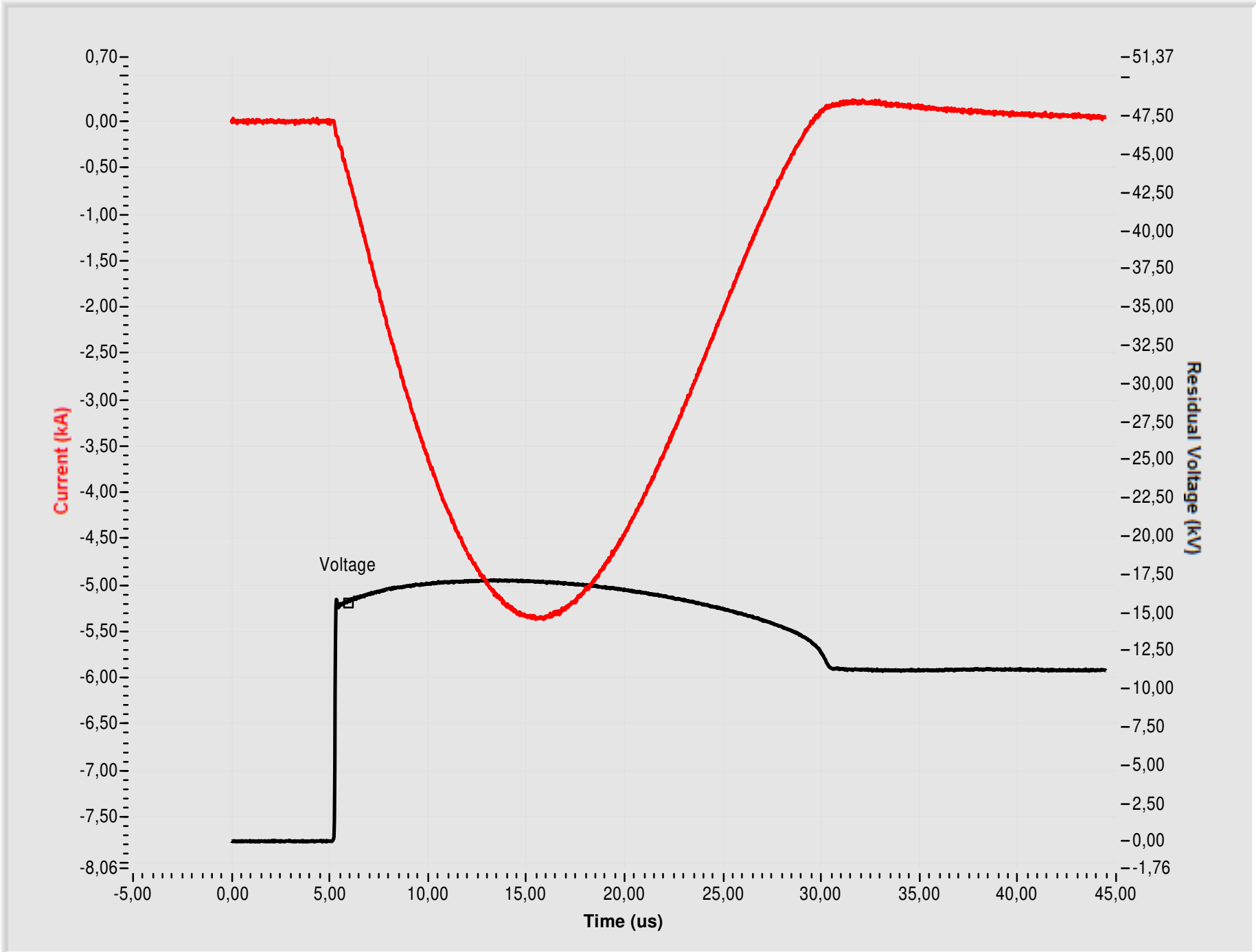
CESI C1011283 Oscillogram n. 70



CESI C1011283 Oscillogram n. 71



CESI C1011283 Oscillogram n. 72



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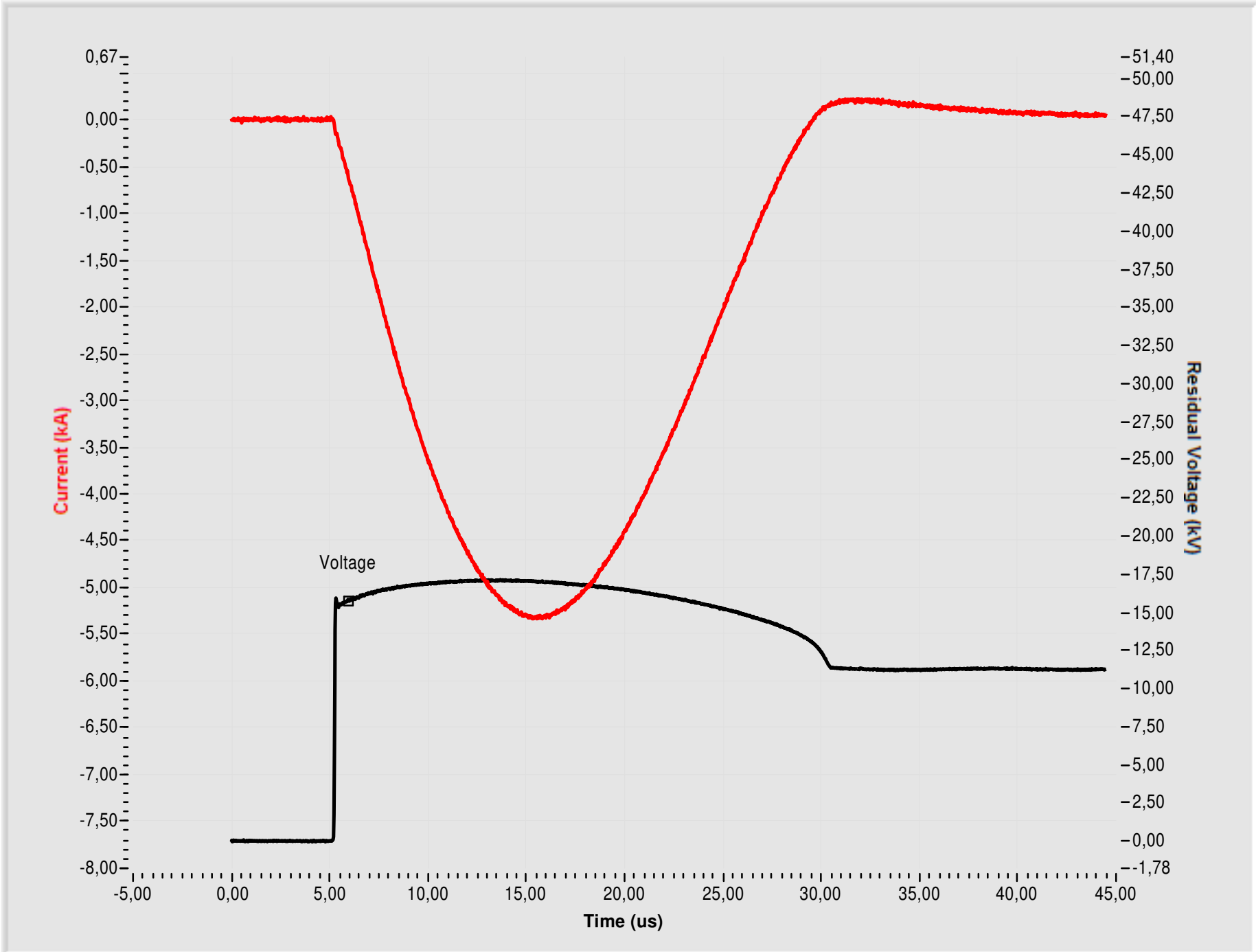

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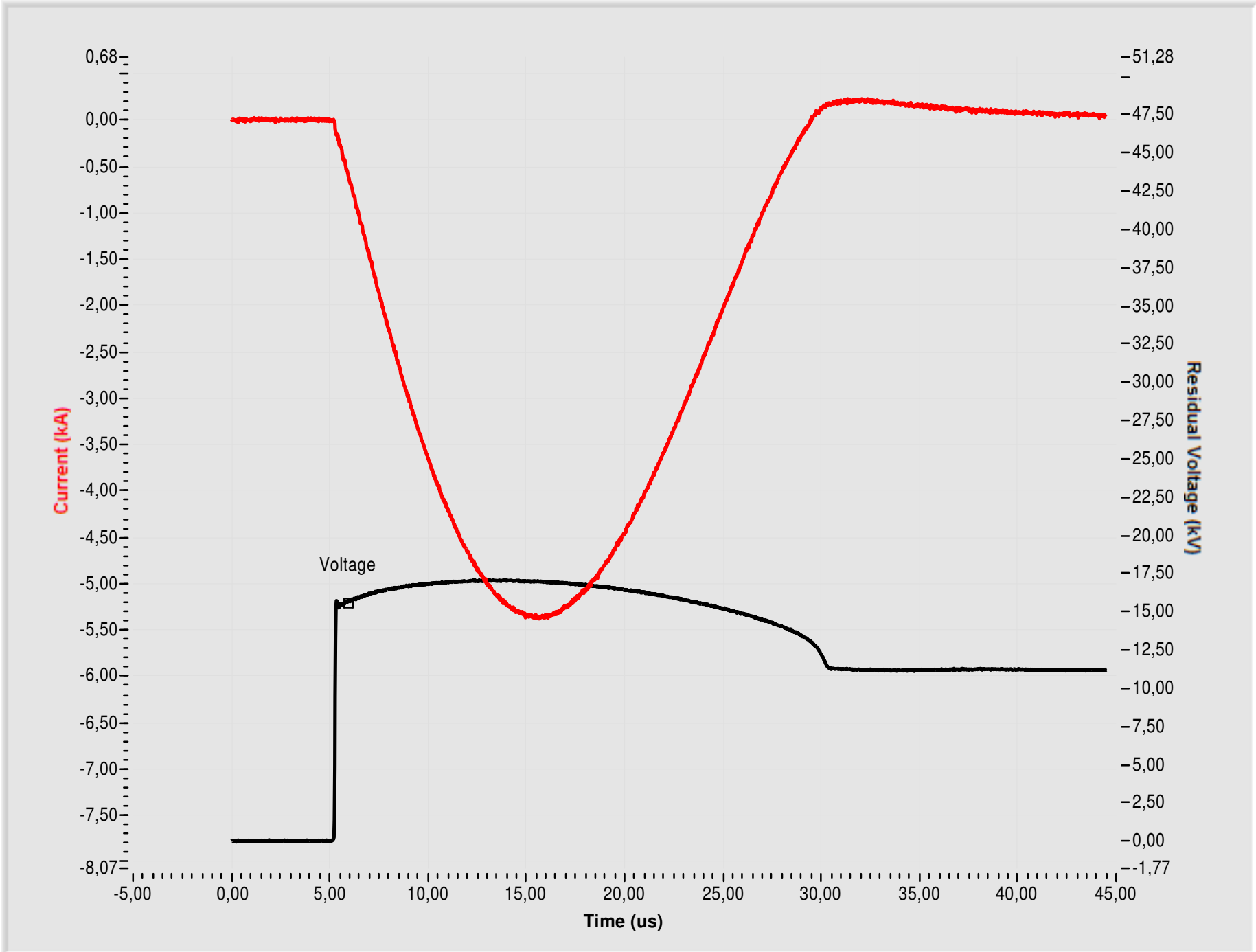
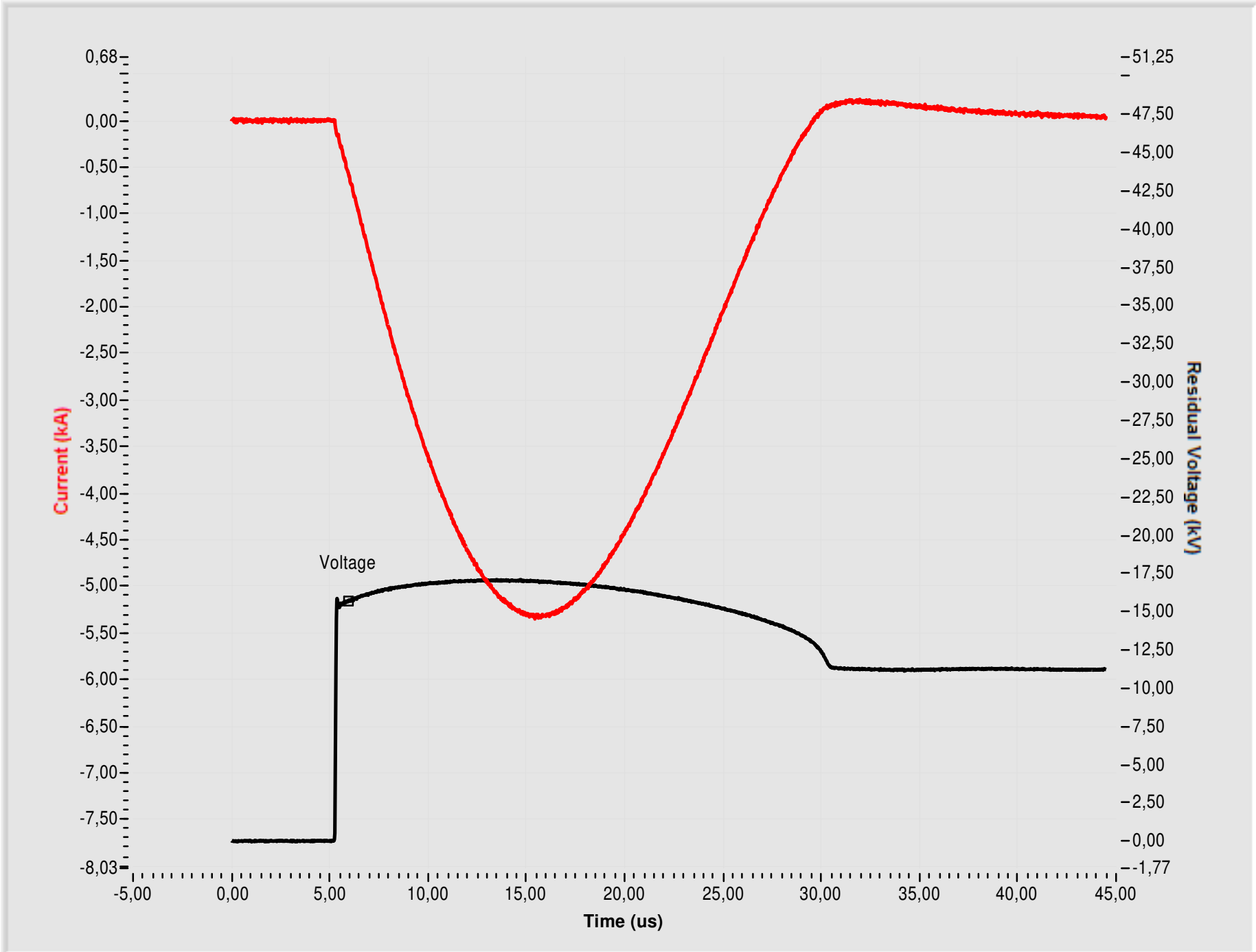
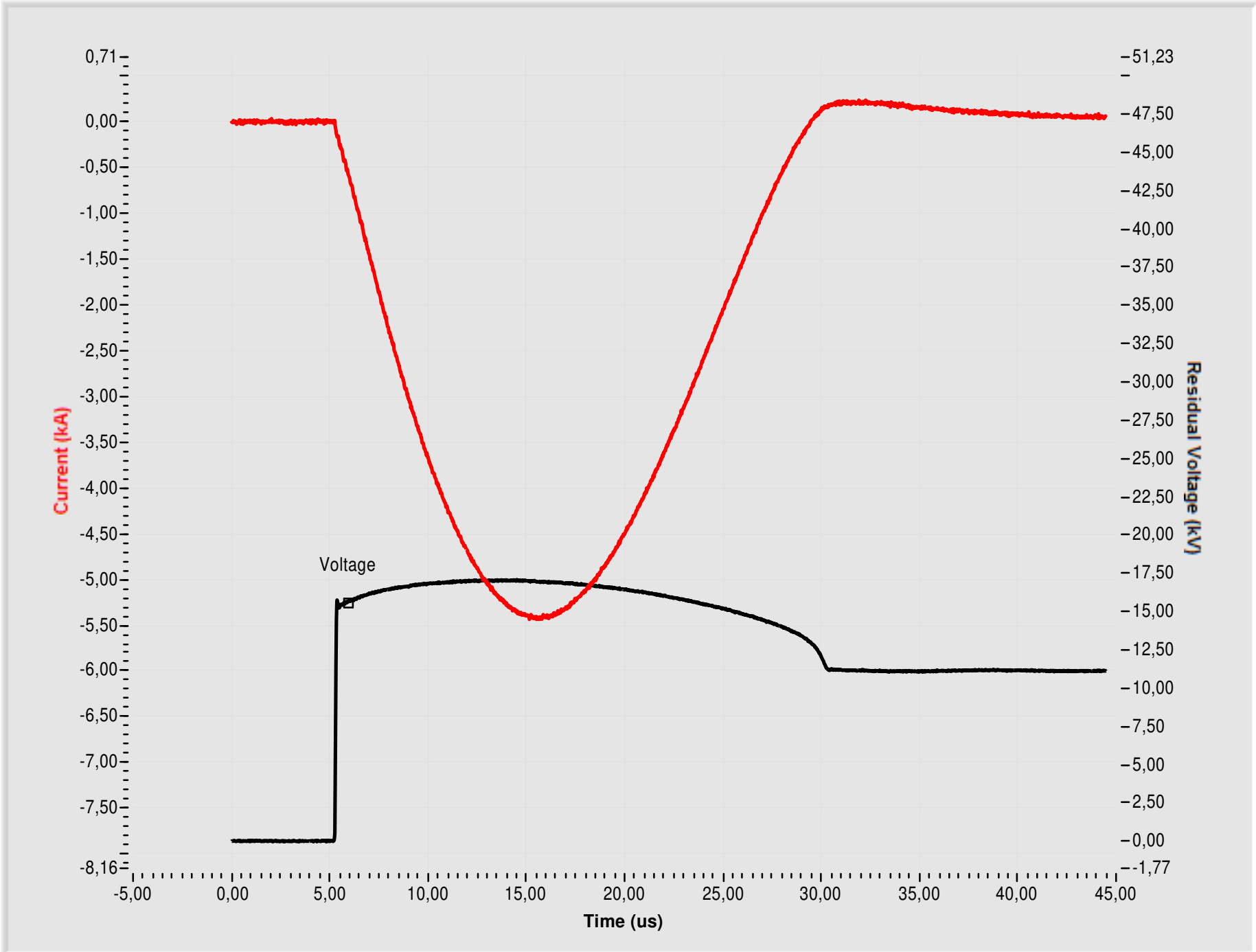


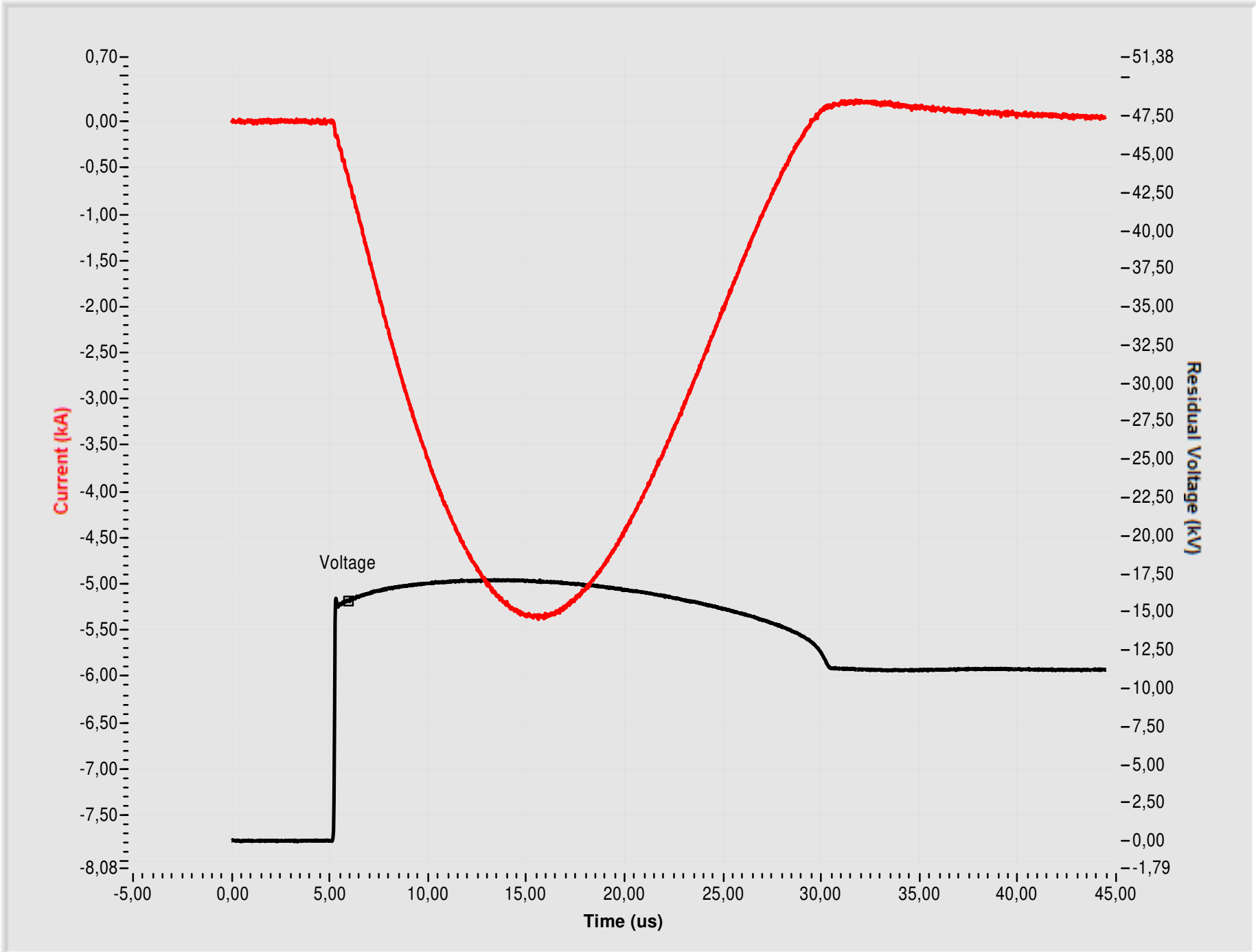
CESI C1011283 Oscillogram n. 75



CESI C1011283 Oscillogram n. 76



CESI C1011283 Oscillogram n. 77



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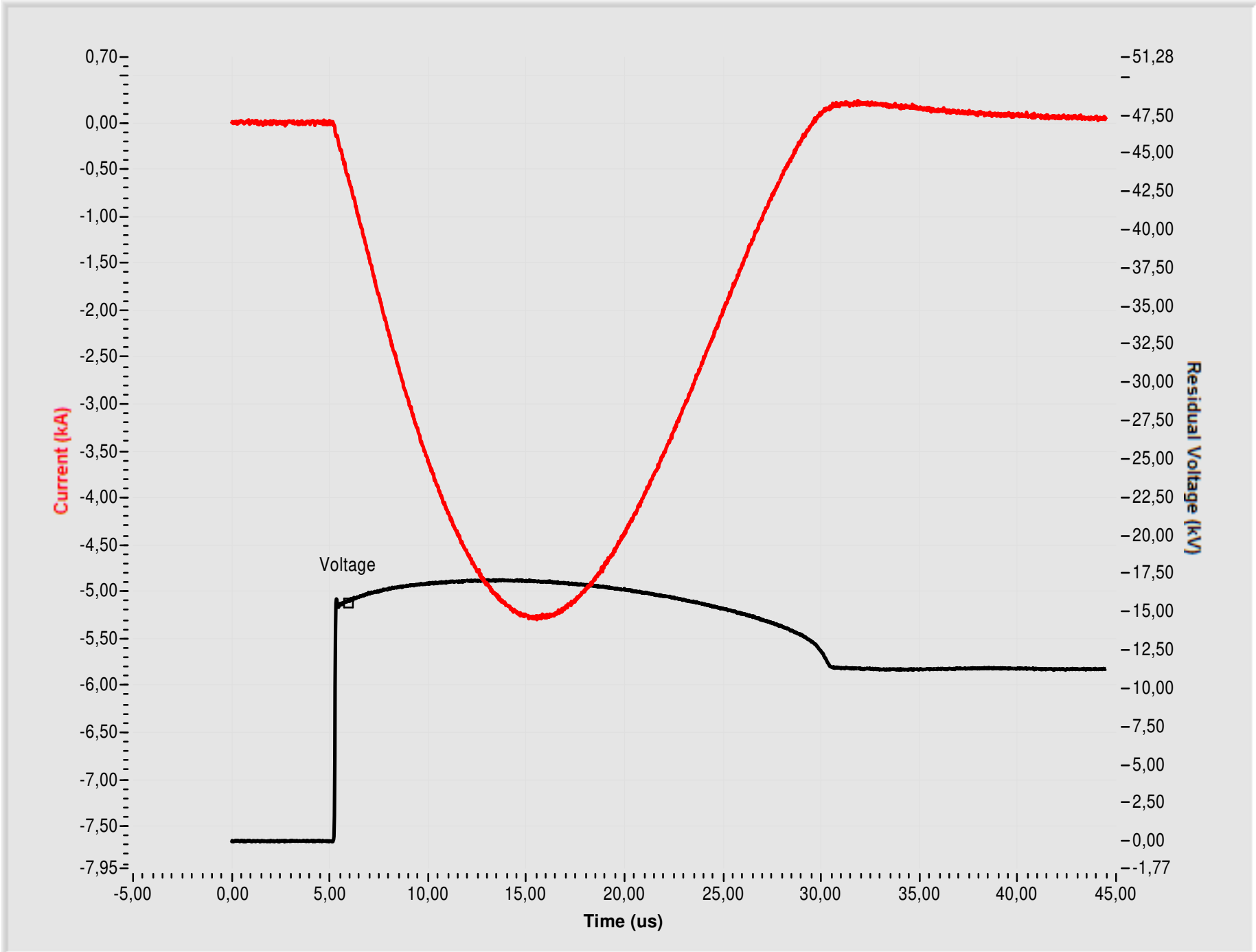

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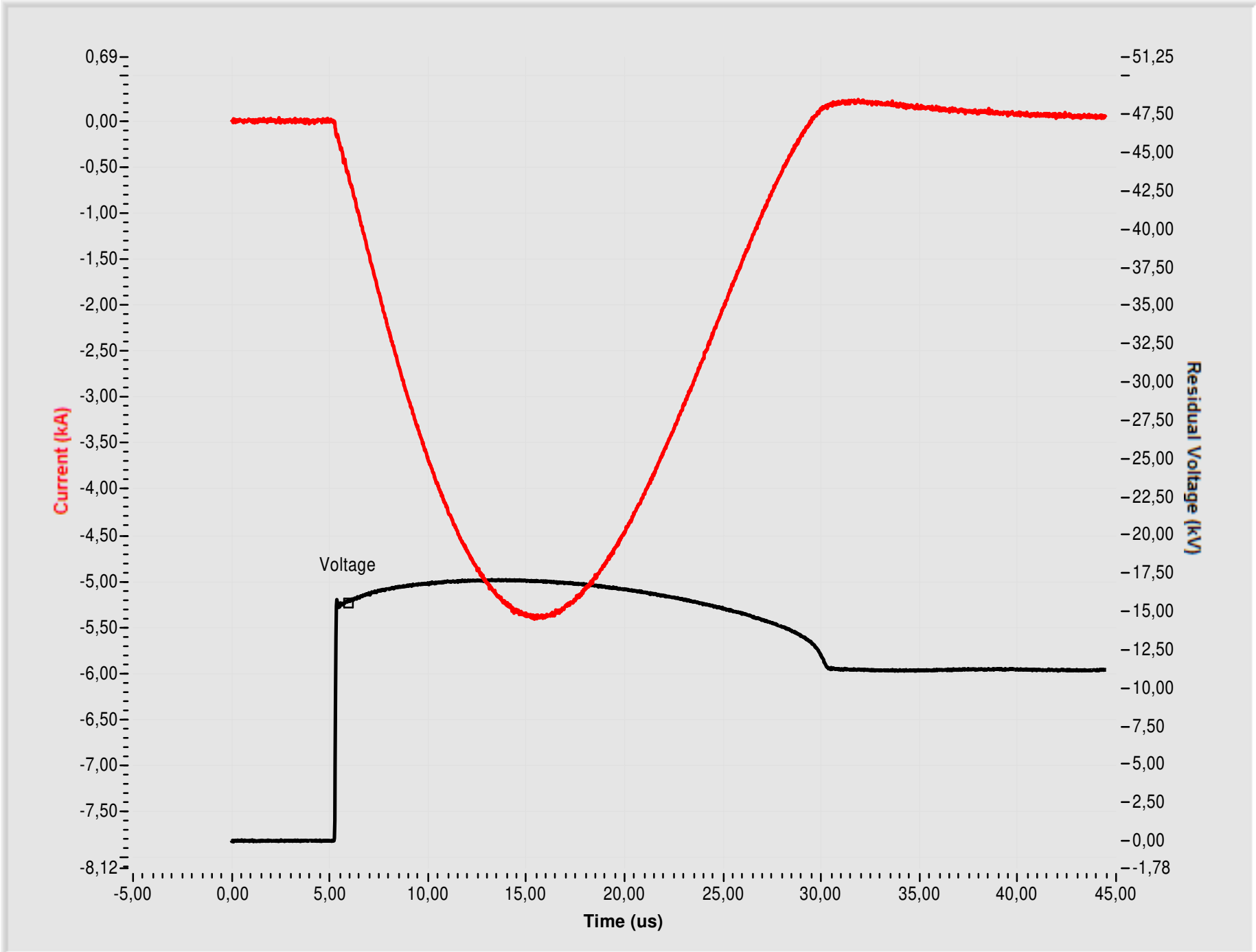
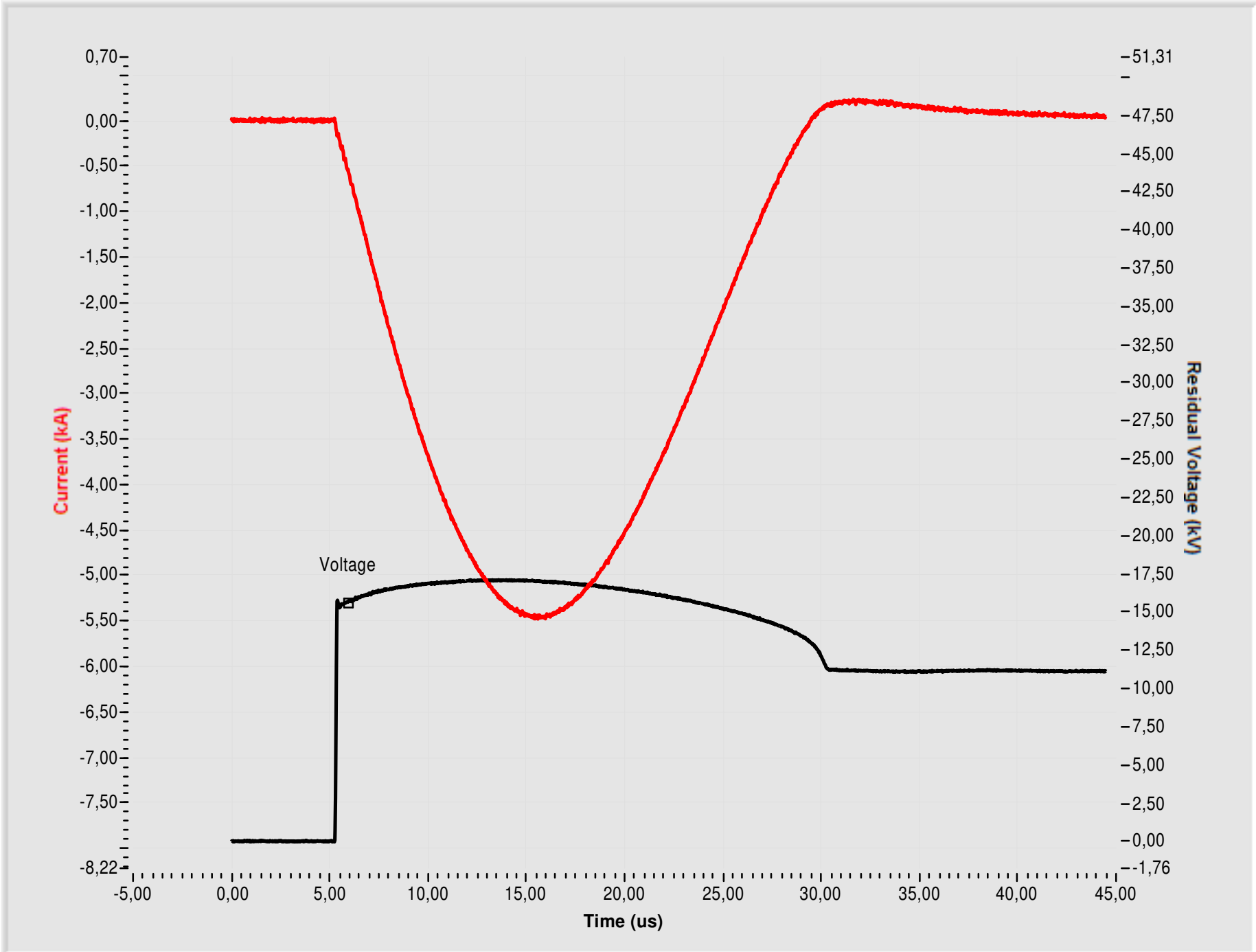
CESI C1011283 Oscillogram n. 80