Test Report

CESI Sinal n° 0030 Approved

Client	IZOELEKTRO d.o.o. Pesnica - SLOVENIA
Tested equipment	Polymer housed metal-oxide surge arrester
Tests carried out	Short-circuit tests
Standards/Specifications	IEC 60099-4 (2004)
Test date	**from** November 9, 2004 **to** November 9, 2004

No. of pages	15	**No. of pages annexed**	10
Issue date	March 17, 2005		
Prepared	PeC -. P. BECCARINI		
Verified	PeC - A. SIRONI		
Approved	PeC - M. de NIGRIS		

Digitally signed by Nguyen Huu thuy
Date: 2023.04.03 15:29:30 EEST
Reason: MoldSign Signature
Location: Moldova

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Tests witnessed by —

Identification of the object effected.
The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing identified by CESI and numbered A5/010293 No.1 is annexed to this document.

Only for laboratory requirement, in order to reproduce the test conditions, all the laboratory data are contained in the document marked: A4/518379

The measurement uncertainties of the test results reported in the document are the following:
voltage: ± 5 % ; current: ± 5 % ; time: ± 5 % temperature: ± 2 °C
The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to a confidence level of about 95 %) and have to be considered as maximum values.

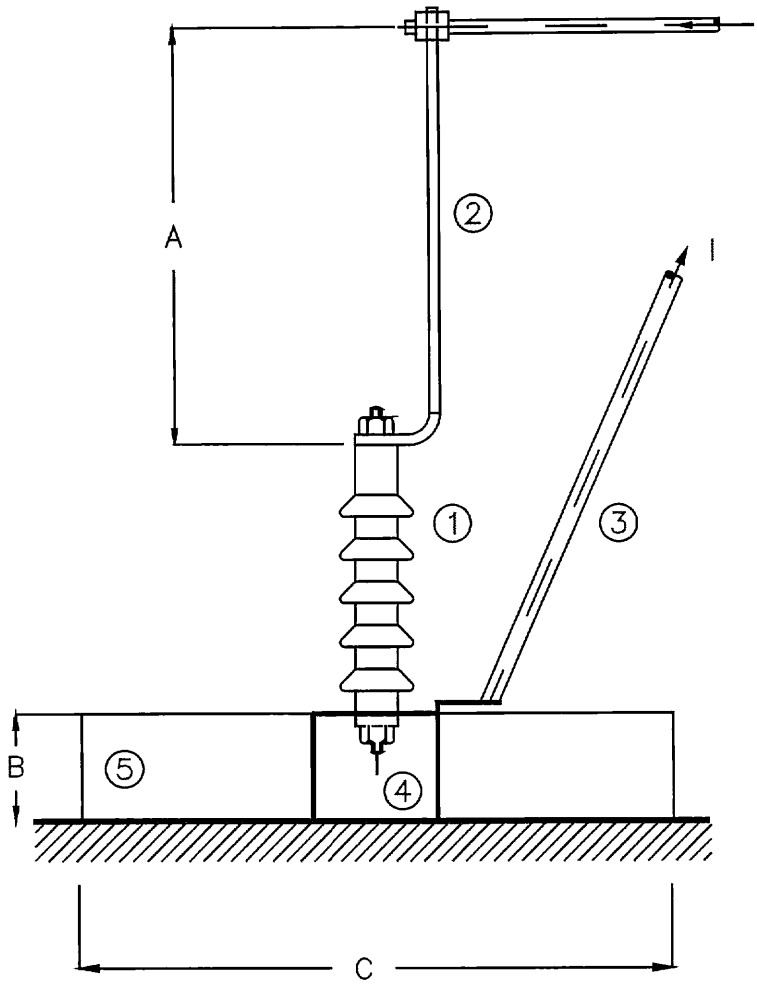
Receipt date of the sample October 8, 2004

Activity code 44836Q

Rated characteristics of the tested object assigned by the Client

Metal-oxide surge arrester		
Manufacturer		IZOELEKTRO
Type		2SS15N
Drawing		21-48-00
Rated voltage (Ur)		45,0 kV
Maximum continuous operating voltage (Uc)		36.0 kV
Rated frequency		50/60 Hz
Nominal discharge current (8/20 µs impulse shape)		10 kA
Line discharge class		1
Pressure relief class		
High current	for 0,20 s ;	20,0 kA

D8000 - Test arrangement



1 : Surge arrester
2 : Flexible conductor
3 : Rigid conductor
4 : Support
5 : Circular enclosure

A : 1,00 m
B : 0,40 m
C : 1,80 m

The arrester to be tested was fixed on a support at 0,40 m to ground in the middle of a circular enclosure of 1,80 m in diameter.
The live side of the supply was connected to the upper end of the arrester while the return circuit, earthed, was connected to the lower end.

High-current short-circuit test with 20,1 kA for 0,20 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Test arrangement : See D8000 and photo No.1.
To achieve the internal discharge, the surge arrester has been faulted by means of on overvoltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 6,00 A.
The voltage applied to the arrester was risen in order to get a current equal to 50 mA (0-peak)(i.e. 68 kVpk) and kept at this value till arrester failure.
The pre-failure process duration was 6 minutes and 30 seconds.
The short-circuit test was performed 5 minutes after the completion of the pre-failure process.

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
4	1	20,1	52,7

Condition of the apparatus before the tests: new, see photo No.2.

Date: November 9, 2004

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time of flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	S	kV	kA	kA	s	ms	No.
1	6	2	2	0,20	38,5	52,1	20,1	-	0,80	-

Condition of the apparatus after the tests: see photos No.3 to 5.

- The arrester remained connected to the supply and return circuit.
- The arrester structure was slightly damaged by the test.
- Some housing fragments were ejected inside the enclosure.
- Few housing fragments were ejected outside the enclosure.
- No flame was noted after the test.

High-current short-circuit test with 12,1 kA for 0,20 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Test arrangement : See D8000
To achieve the internal discharge, the surge arrester has been faulted by means of on overvoltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 6,00 A.
The voltage applied to the arrester was risen in order to get a current equal to 50 mA (0-peak)(i.e. 68 kVpk) and kept at this value till arrester failure.
The pre-failure process duration was 6 minutes and 00 seconds.
The short-circuit test was performed 5 minutes after the completion of the pre-failure process.

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
3	1	12,1	31,6

Condition of the apparatus before the tests: new, see photo No.6.

Date: November 9, 2004

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time of flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	S	KV	kA	kA	s	ms	No.
2	7	2	3	0,20	38,5	31,5	12,1	-	1,10	-

Condition of the apparatus after the tests: see photos No.7 to 9.

- The arrester remained connected to the supply and return circuit.
- The arrester structure was slightly damaged by the test.
- Some housing fragments were ejected inside the enclosure.
- Few housing fragments were ejected outside the enclosure.
- Time to flame extinction: 1 minute and 25 seconds.

High-current short-circuit test with 6,06 kA for 0,20 s

Test circuit : See D0046 Power factor : <0,15 Frequency : 50 Hz

Test arrangement : See D8000

To achieve the internal discharge, the surge arrester has been faulted by means of on overvoltage application using an auxiliary low power source.
The short-circuit current of the auxiliary low power source has been set at about 6,00 A.
The voltage applied to the arrester was risen in order to get a current equal to 50 mA (0-peak)(i.e. 68 kVpk) and kept at this value till arrester failure.
The pre-failure process duration was 6 minutes and 20 seconds.
The short-circuit test was performed 7 minutes after the completion of the pre-failure process.

Prospective test current			
Oscillogram		rms value	Peak value
No.	Sheets	kA	kA
2	1	6,06	15,7

Condition of the apparatus before the tests: new, see photo No.10.

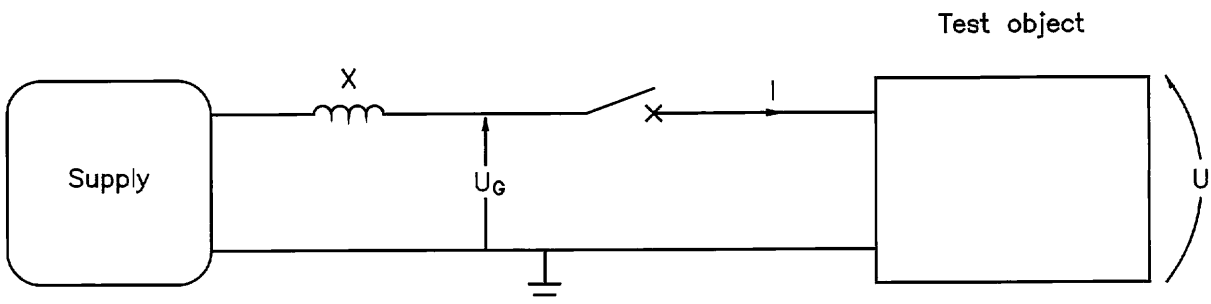
Date: November 9, 2004

Test	Oscillogram		Arrester under test	Duration	Test voltage	Test current		Time of flame extinction after the test	Venting time	Notes
						Peak value	rms value			
No.	No.	Sheets	No.	S	KV	kA	kA	s	ms	No.
3	8	2	4	0,20	38,5	15,7	6,06	-	1,80	-

Condition of the apparatus after the tests: see photo No.11.

- The arrester remained connected to the supply and return circuit.
- Light damages to the housing of the arrester.
- Some small pieces of porcelain were found only inside the enclosure.
- No flame was noted after the test.

Test circuit D0046



Symbols used in this diagram are the same as those on the oscillograms.

Photo no. 1

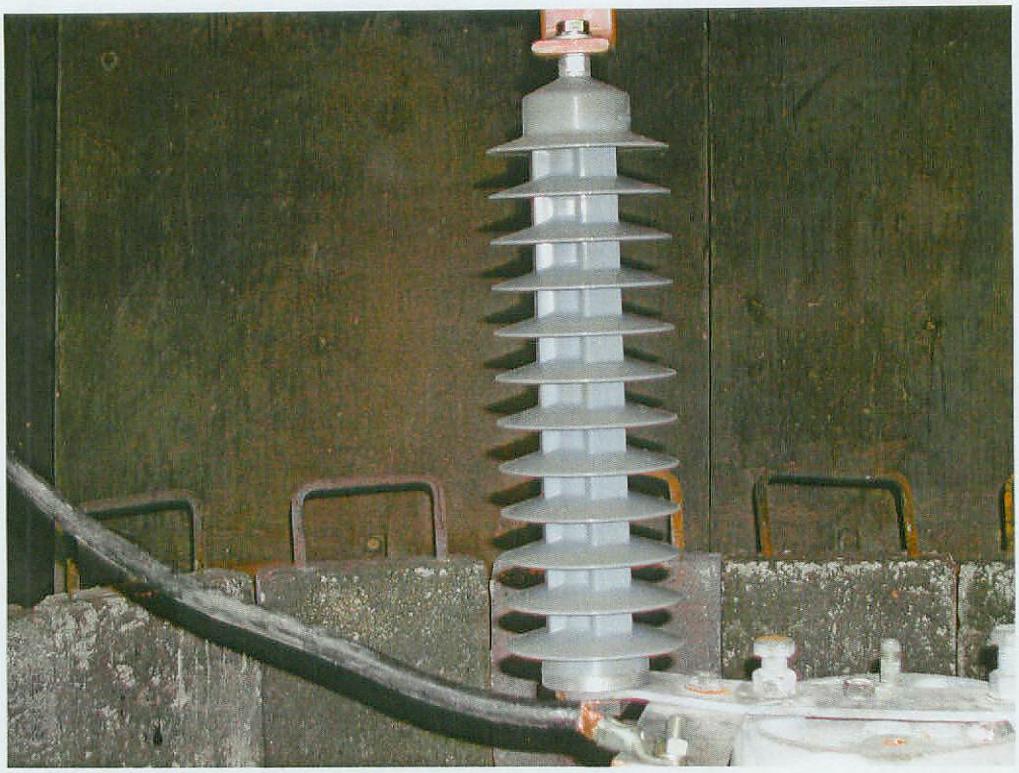


Photo no. 2

Photo no. 3

Photo no. 4

Photo no. 5

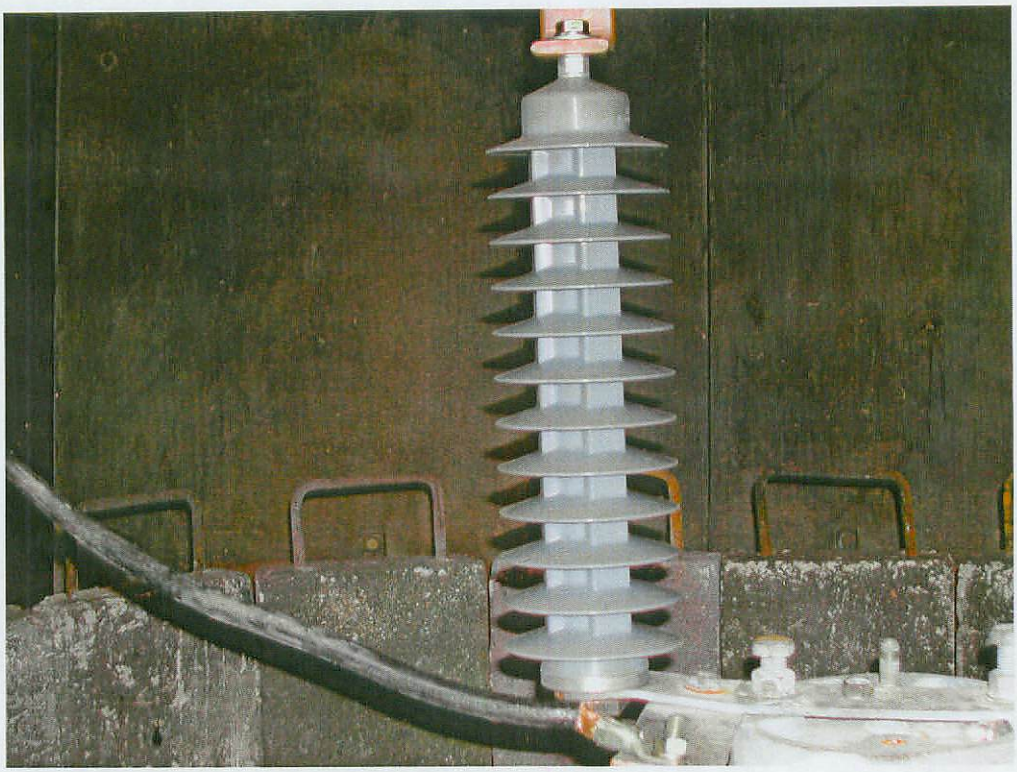


Photo no. 6

Photo no. 7

Photo no. 8

Photo no. 9

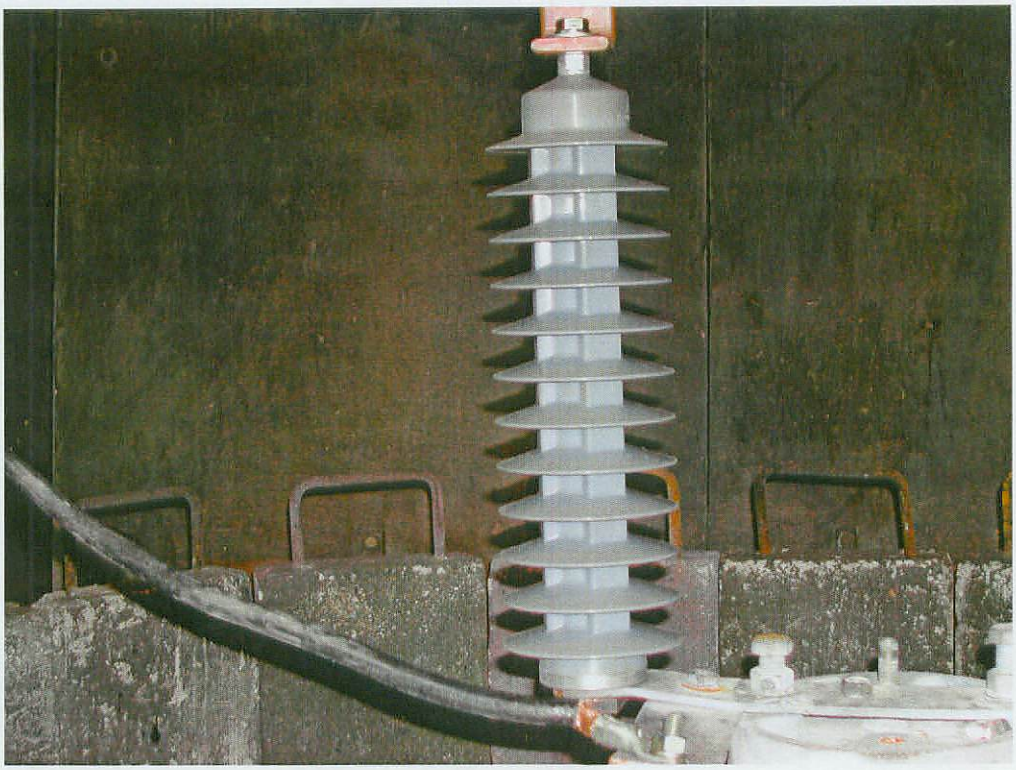


Photo no. 10

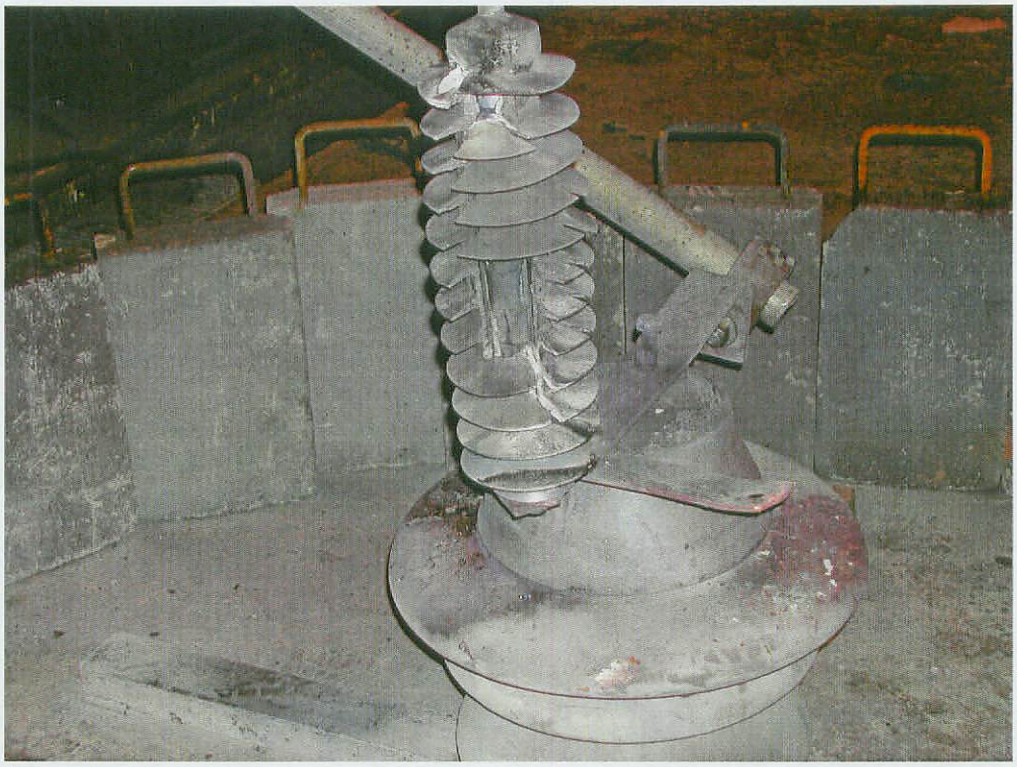
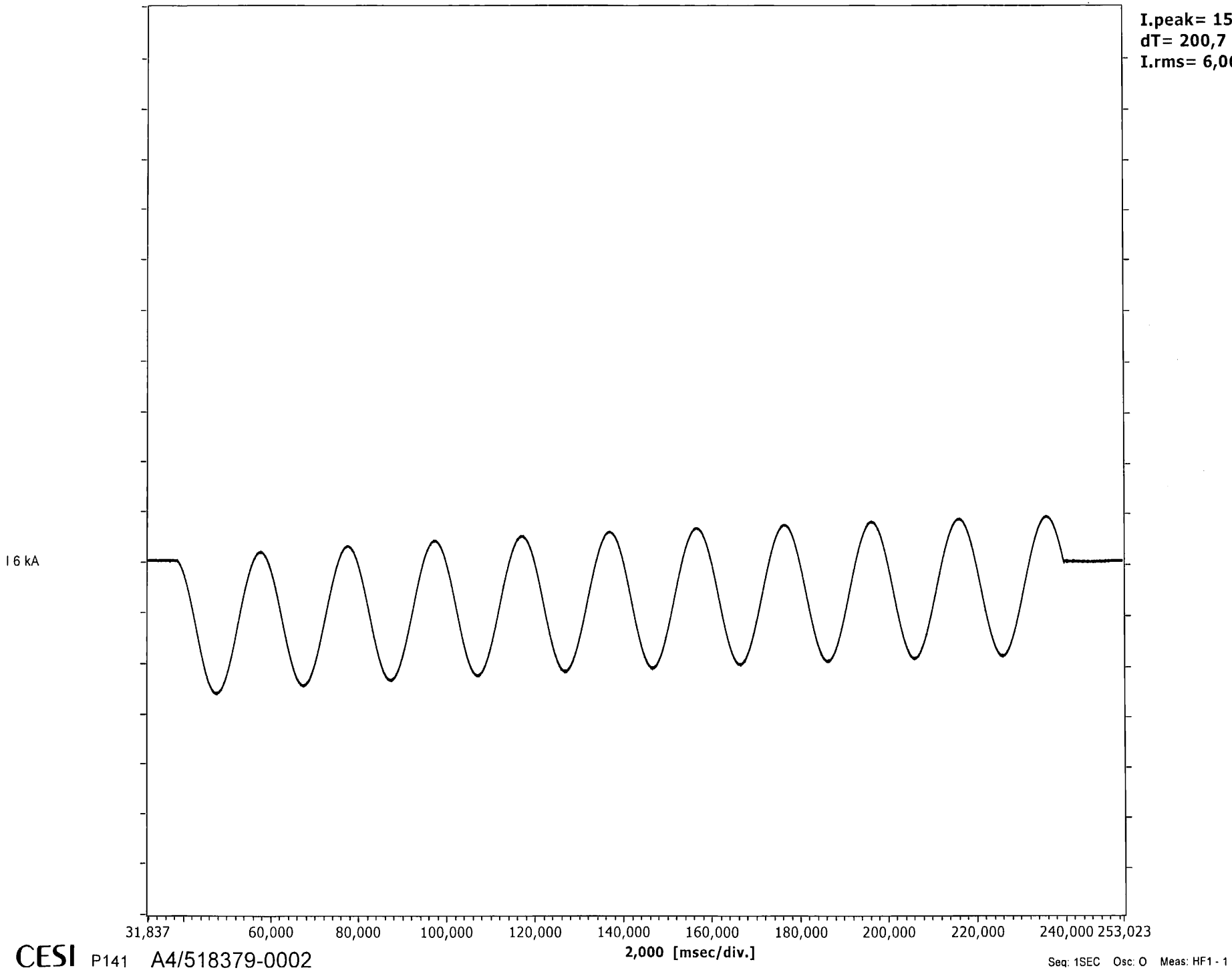
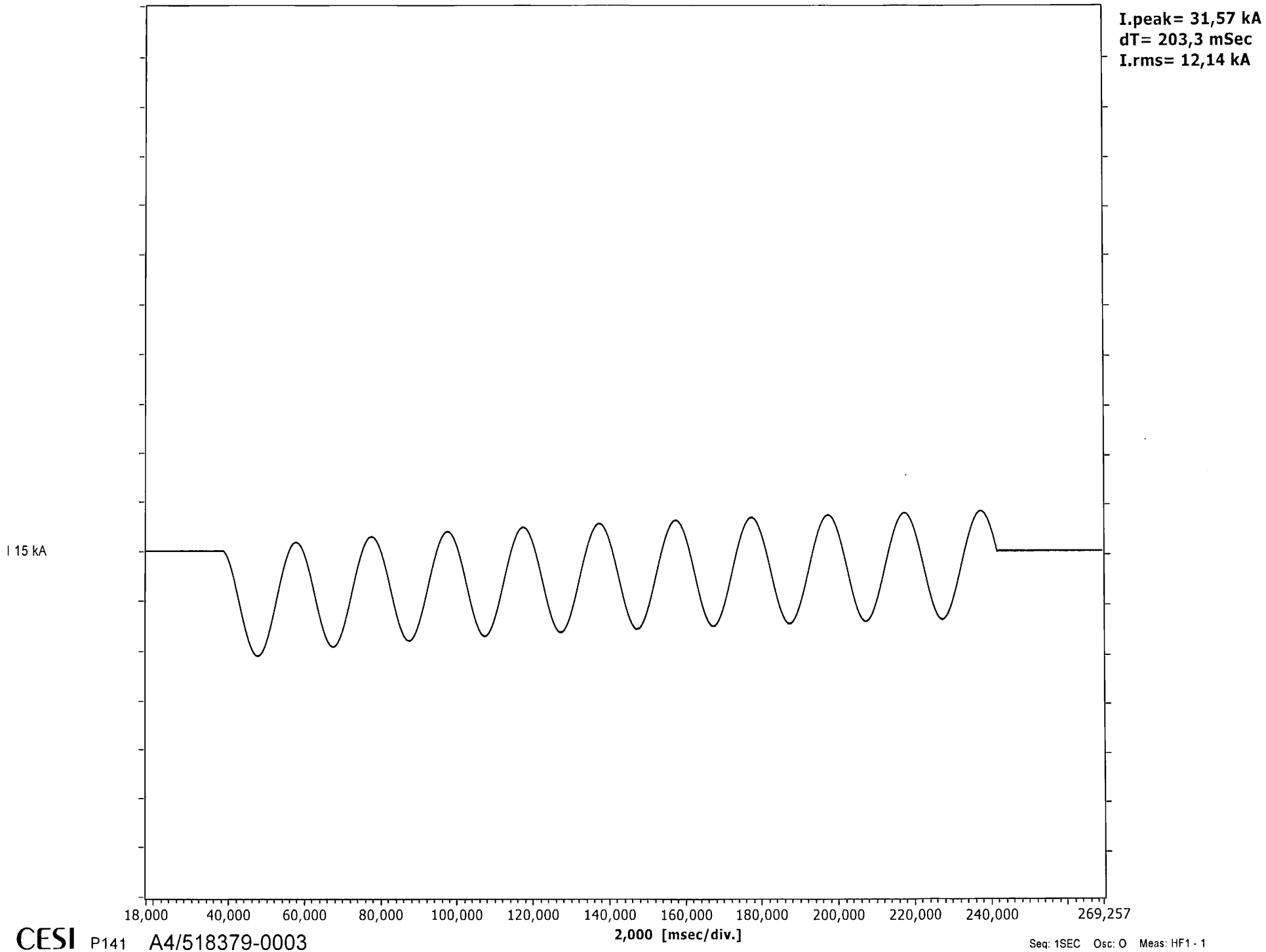


Photo no. 11



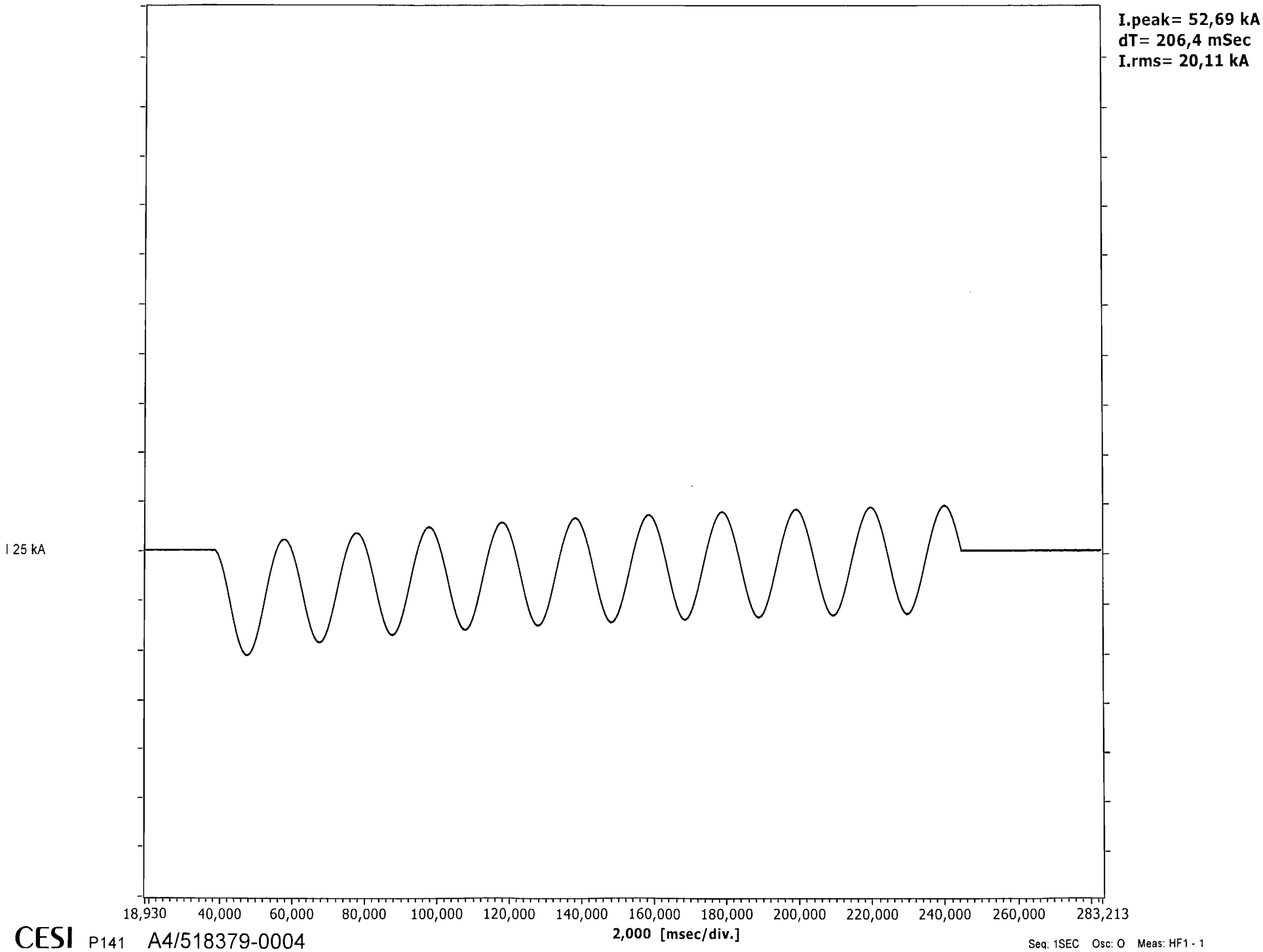
CESI P141 A4/518379-0002

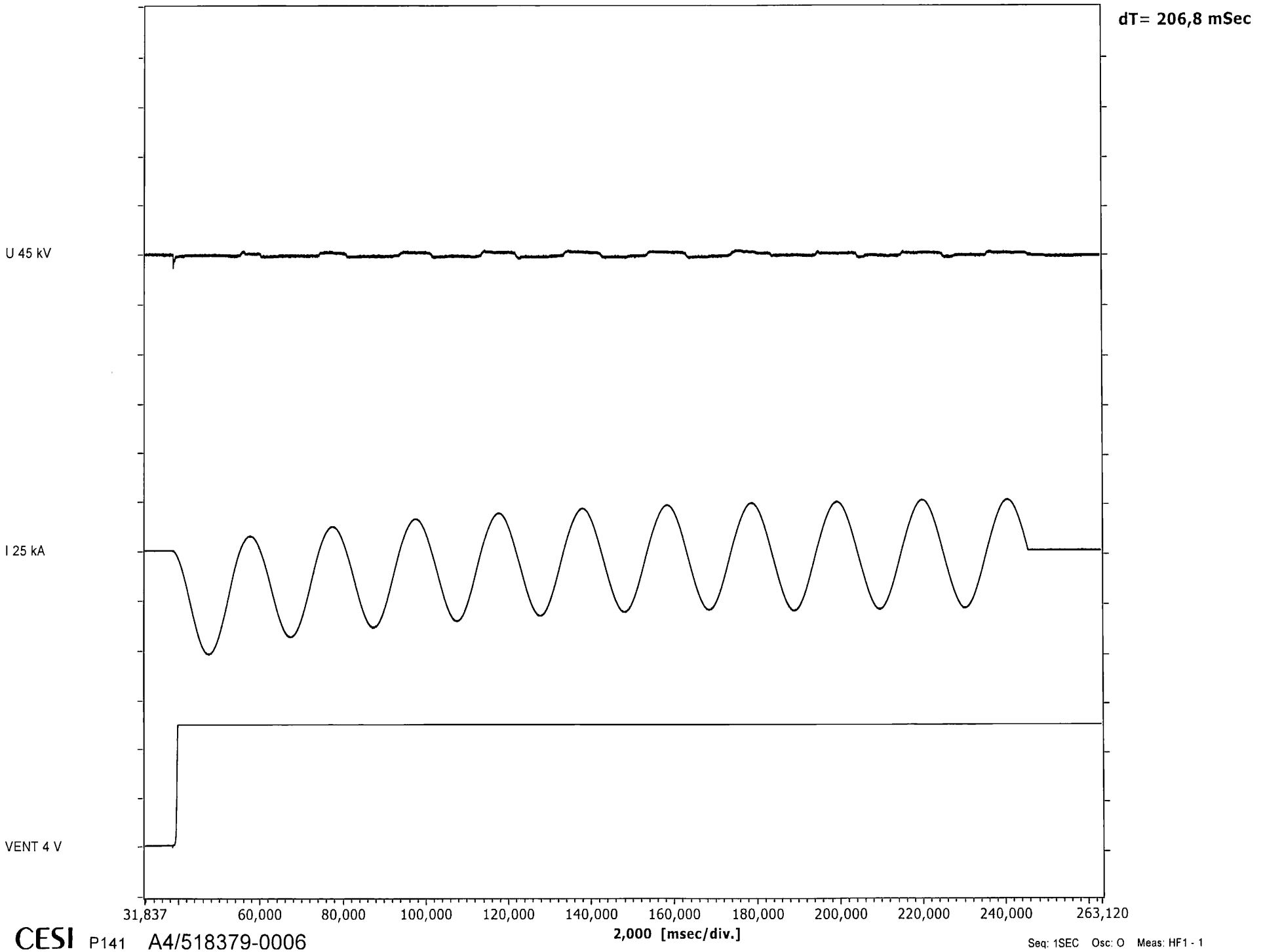
Seq: 1SEC Osc: O Meas: HF1 - 1



CESI P141 A4/518379-0003

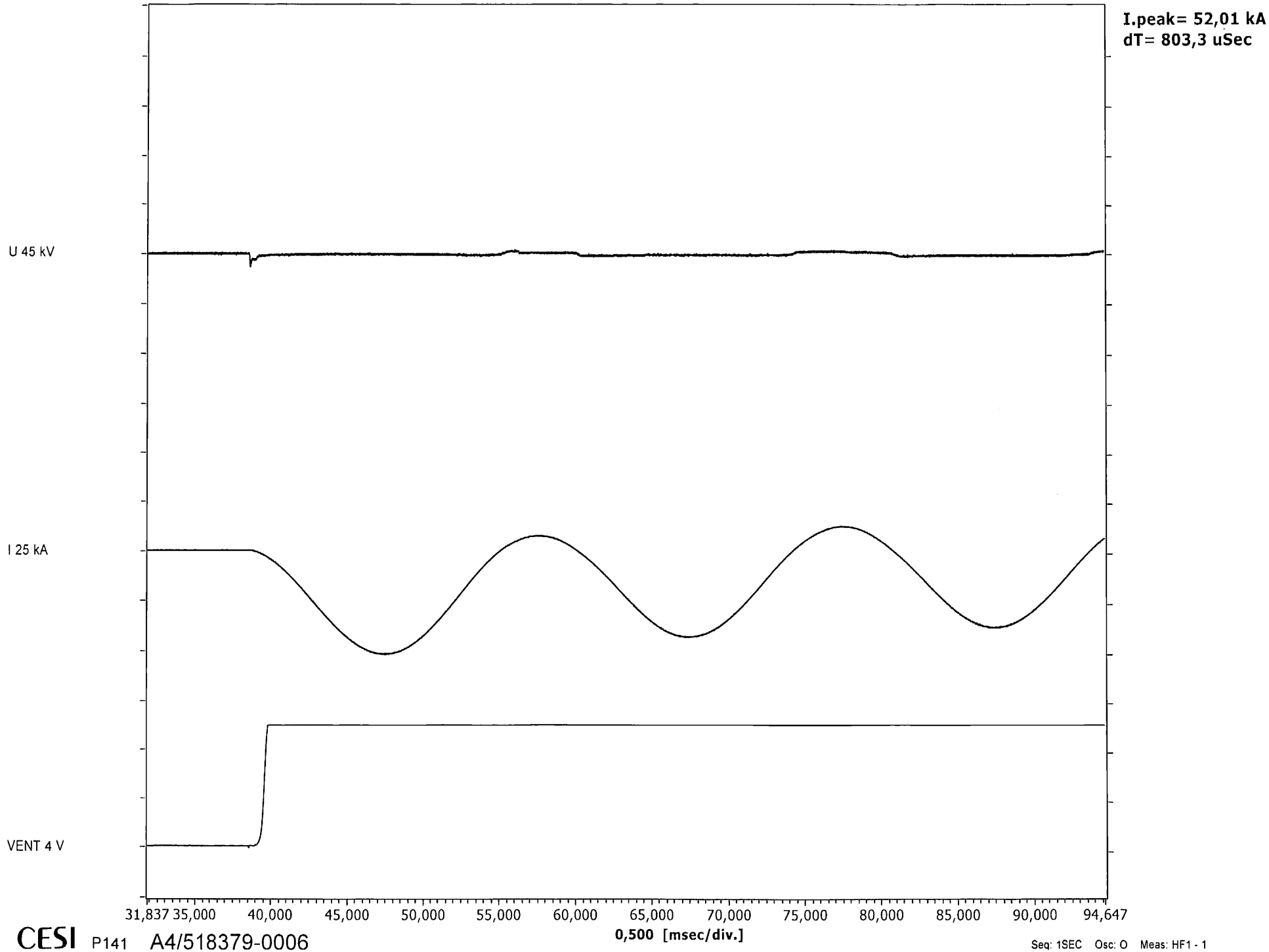
Seq: 1SEC Osc: O Meas: HF1 - 1


I.peak= 52,69 kA
dT= 206,4 mSec
I.rms= 20,11 kA
I 25 kA
18,930
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
220,000
240,000
260,000
283,213
2,000 [msec/div.]
CESI P141 A4/518379-0004
Seq: 1SEC Osc: O Meas: HF1 - 1



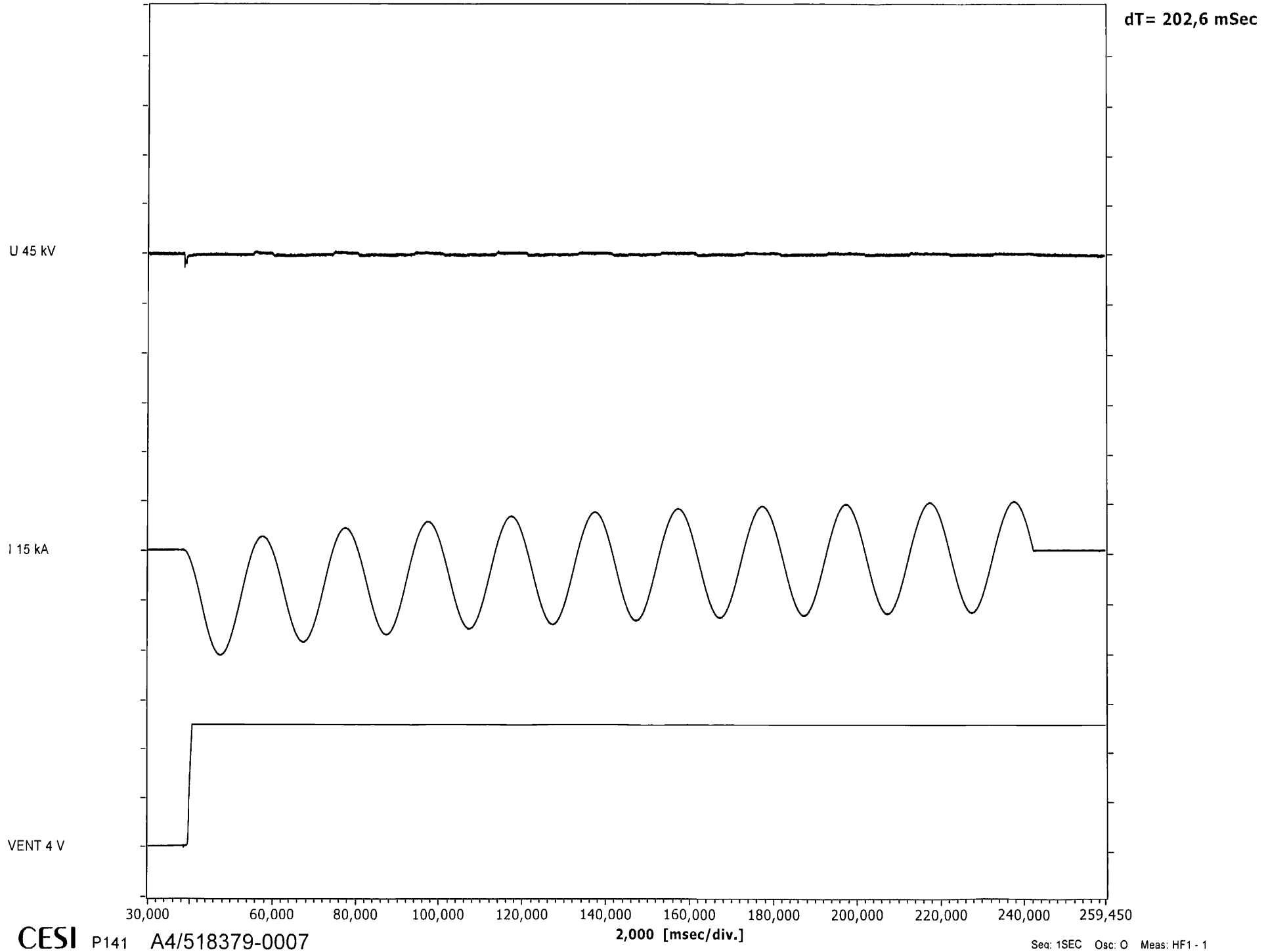
CESI P141 A4/518379-0006

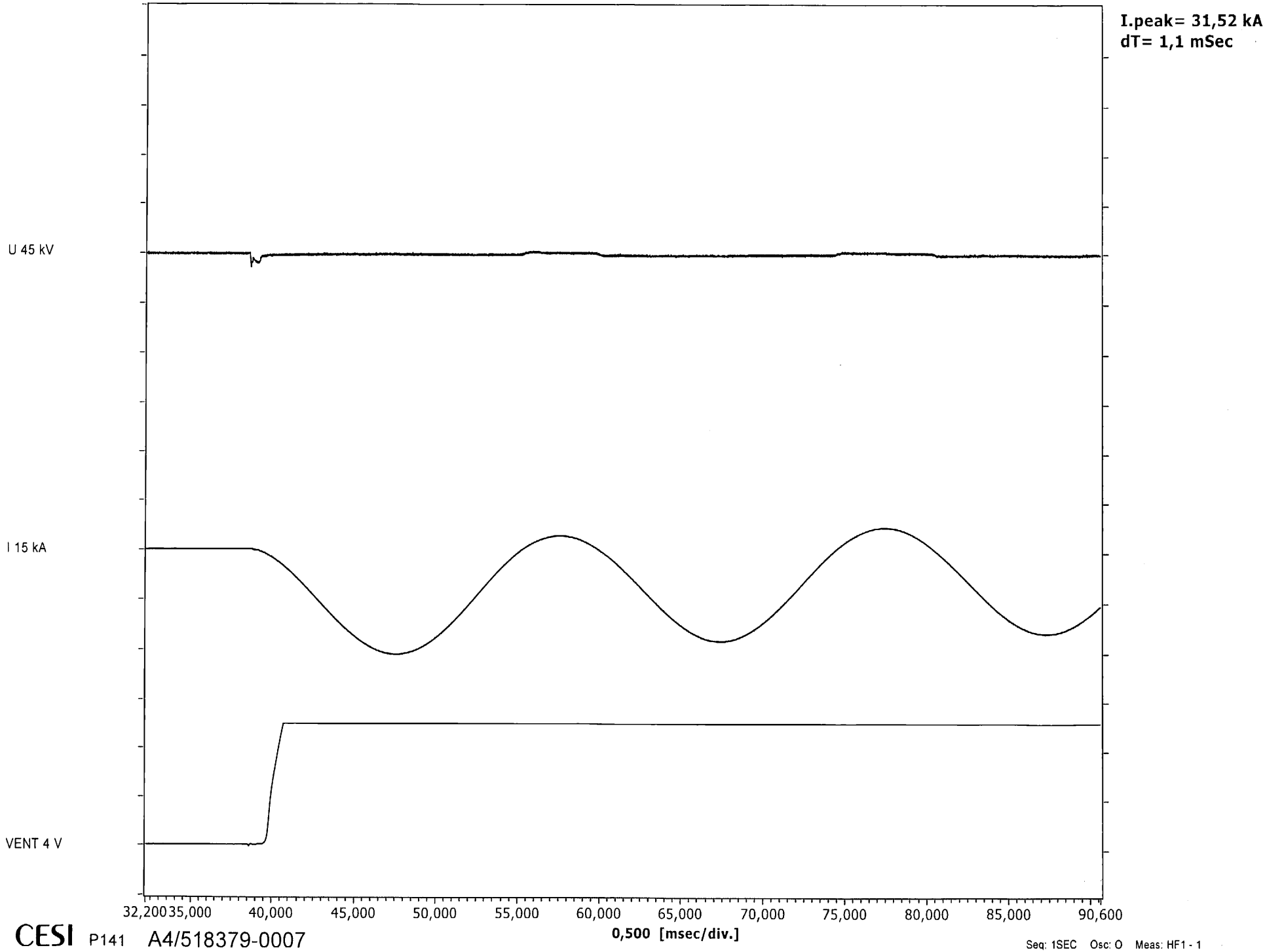
Seq: 1SEC Osc: O Meas: HF1 - 1



CESI P141 A4/518379-0006

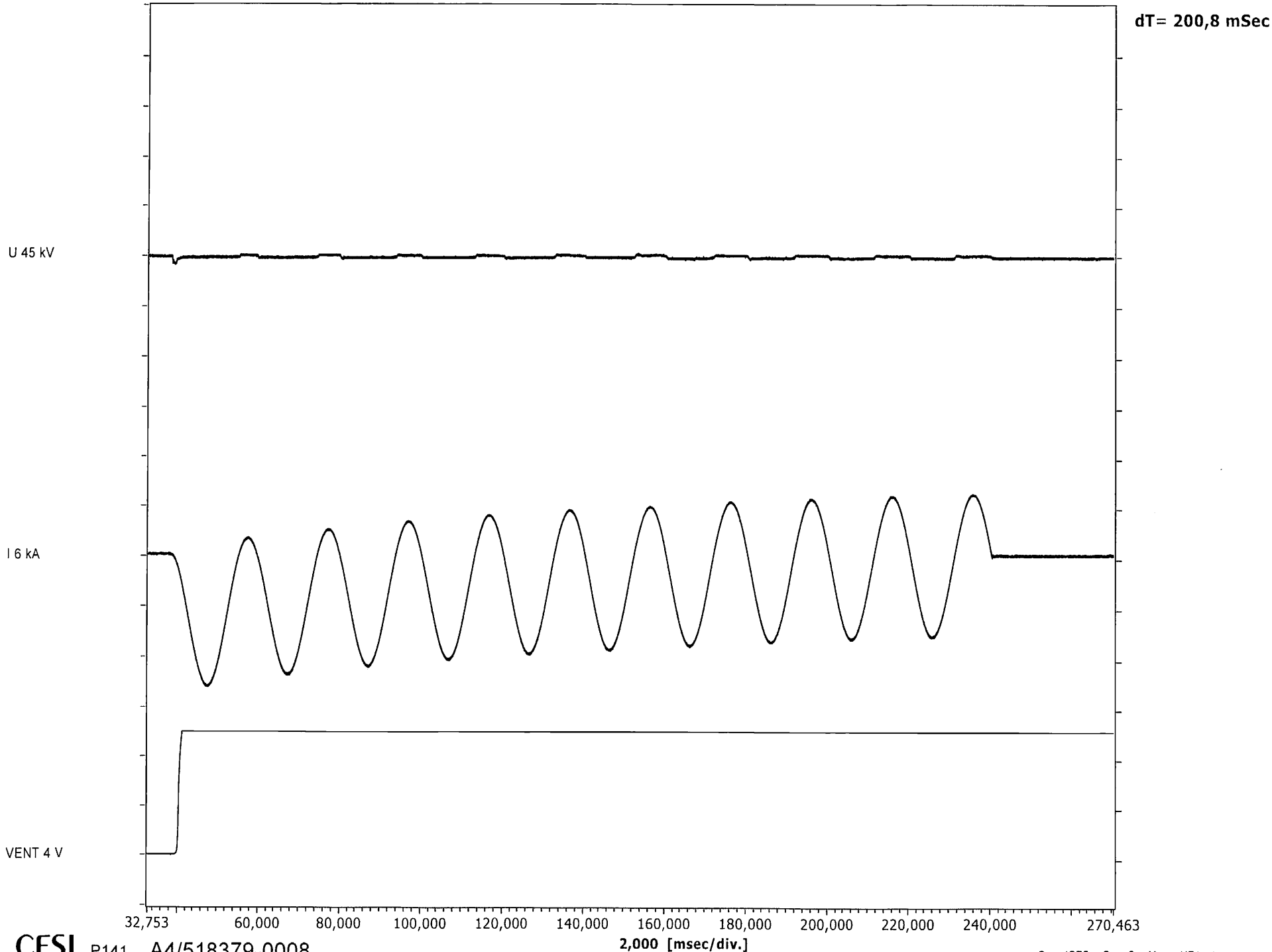
Seq: 1SEC Osc: O Meas: HF1 - 1


dT= 202,6 mSec
U 45 kV
I 15 kA
VENT 4 V
30,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
220,000
240,000
259,450
2,000 [msec/div.]
CESI P141 A4/518379-0007
Seq: 1SEC Osc: O Meas: HF1 - 1



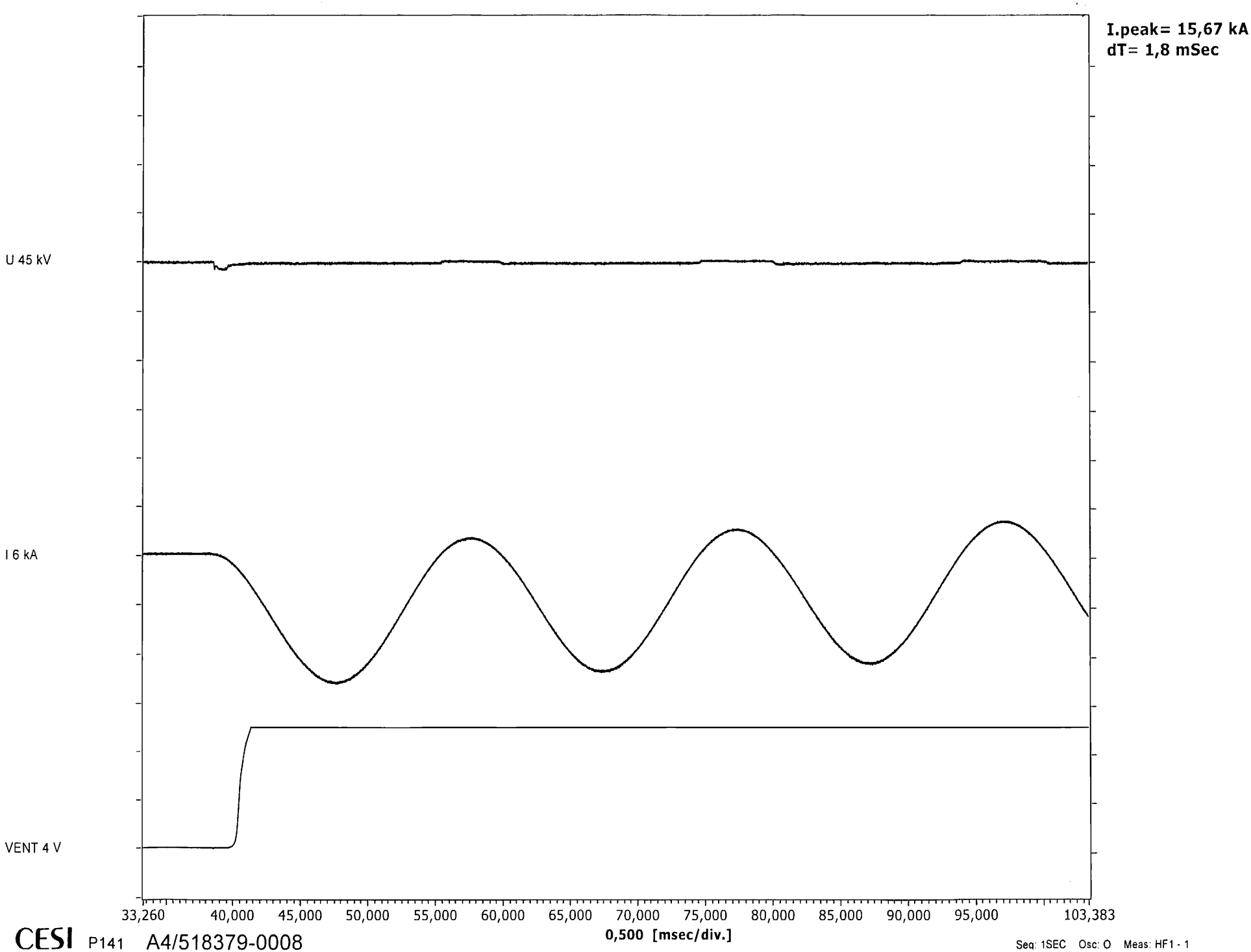
CESI P141 A4/518379-0007

Seq: 1SEC Osc: O Meas: HF1 - 1



CESI P141 A4/518379-0008

Seq: 1SEC Osc: O Meas: HF1 - 1



CESI P141 A4/518379-0008

Seq: 1SEC Osc: O Meas: HF1 - 1

CESI

PROTOCOLLO DATA

A 5/ 0 1 0 2 9 3 n.0 1 1 8 MAR. 2005

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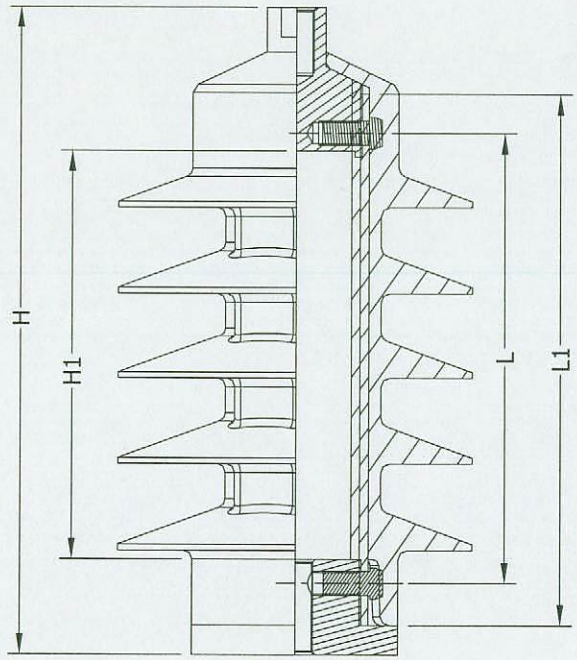

Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks H1 (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
21-48-01	3,75	147	3	67	107	81
21-48-02	5	147	3	67	107	81
21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
21-48-06	15	193	5	113	153	127
21-48-07	17,5	243	6	163	203	177
21-48-08	20	243	6	163	203	177
21-48-09	22,5	243	6	163	203	177
21-48-10	25	270	7	190	230	204
21-48-11	26,25	270	7	190	230	204
21-48-12	27,5	270	7	190	230	204
21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

ZO EKTRO ...

ISO2768 -

	Date:	Name:	Signature:
Izdelal:	27.8.03	R. Kurnik	
Pregledal:	1.9.03	P. Pungercar	
Odobril:	1.9.03	P. Pungercar	

Opombe:

Measure: 7:10 Weight:

Materiali:

Type:

SURGE ARRESTER 2SS15N

Code:

21-48-00

Sheet: 1/1

Izdelek: Prip.:

Pro/ENGINEER

Test Report

CESI Sinal n° 0030 Approved

Client	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Tested equipment	Polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	Long duration current impulse withstand tests
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	**from** December 10, 2004 December 16, 2004

No. of pages	20	**No. of pages annexed**	25
Issue date	February 23, 2005		
Prepared	BU PeC - M. Gregori		
Verified	BU PeC - A. Sironi		
Approved	BU PeC - M. de Nigris		

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Il Responsabile del Laboratorio

Tests witnessed by: ---

Identification of the object:

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5006707 No. 1, is annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 29, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L. Podavitte – Mr I. Guacci
Test laboratory	P177
Activity code	19774B

Test object characteristics

type: Polymer housed metal-oxide surge arrester section

electrical characteristics (assigned by the client)

Manufacturer's name	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Nominal discharge current - I_N [kA]	10,0
Rated voltage - U_n [kV]	0,9912 x Uref.
Continuous operating voltage - U_c [kV]	0,7930 x Uref.
Reference current - $I_{ref.}$ [mA]	1,4
Line discharge class	1
Rated frequency - [Hz]	50 – 60
year of manufacture	2004

geometrical characteristics (measured on the test sample)

Height [mm]	195
Number of sheds	5
Shed diameter [mm]	117

other characteristics

Housing material	Silicone
Housing color	grey

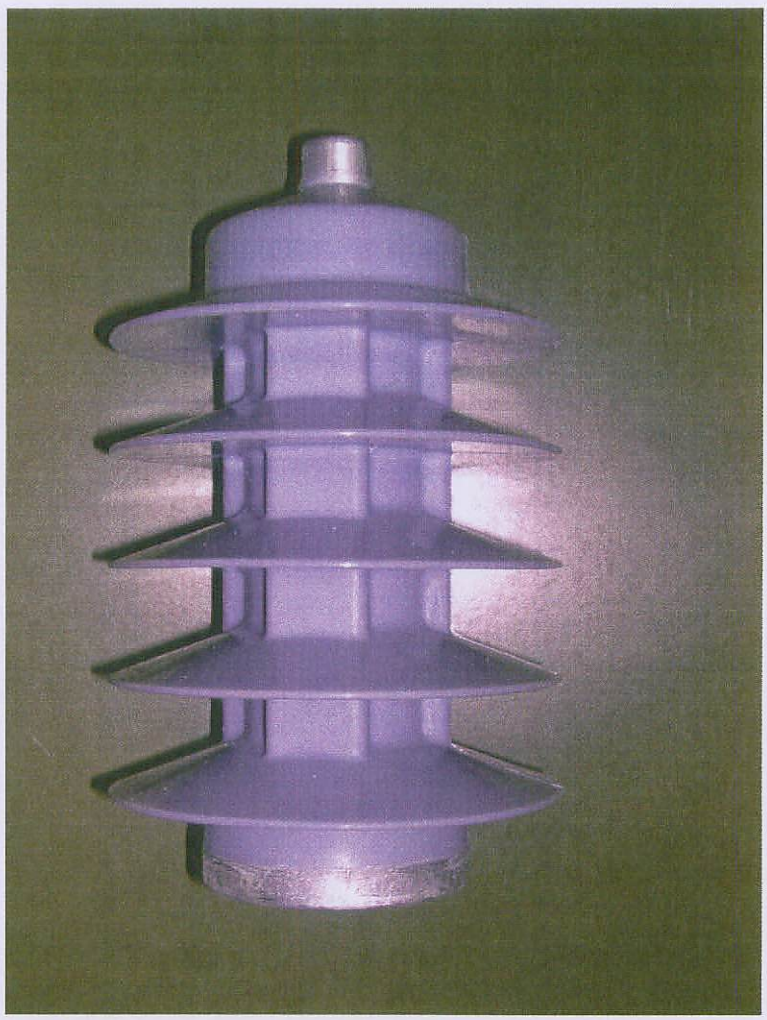


Photo no. 1
Panoramic view of the test object

Reference Standard

IEC 60099-4 (2004-05) Clause 10.8.4
"Metal-oxide surge arrester without gaps for a.c. system"

Test carried out	Number of sample tested
Long duration current impulse withstand test	3

Test object identification

Test object name	Identification of test sample (given by Cesi)
polymer housed metal-oxide surge arresters section	LD1-LD2-LD3

Test procedure

- The power frequency voltage at reference current (I_{ref} = 1,4 mA) has been measured
- The lightning impulse residual voltage at I_N = 10 kA has been measured
- Eighteen long duration current impulses with the specified calculated energy (see pag.12) and virtual duration of 2000 μs have been applied in six groups of three operations.
  Intervals between operations of the same groups have been about 60 seconds; between different groups the samples have been let to cool down to near ambient temperature
- After the eighteenth impulses the test sample have been cool down to ambient temperature and a nineteenth impulse has been applied
- The measurement of the lightning impulse residual voltage at I_N has been repeated

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	%
LD1	10,20	37,37	10,20	37,17	- 0,54
LD2	10,00	39,19	10,00	38,98	- 0,54
LD3	10,15	37,77	10,00	37,98	- 0,56

Visual inspection and summary test results

The visual inspection of the metal-oxide surge arrester 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%).
The oscillographic record of the 19th impulse doesn't reveal any sign of internal discharge.
All acceptance criteria according to the reference standard are satisfied and therefore the result is to be considered positive.

Power frequency voltage-current characteristics. IEC 60099-4 Standard

Test circuit: A0019

Date: December 10, 2004

Sample No. LD1						
Oscillogram	Voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	μA
1	14,79	0,98	1,40	0,611	5,07	---

Sample No. LD2						
oscillogram	Voltage	current	current	current	Power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	μA
2	15,05	1,0	1,41	0,594	5,18	---

Sample No. LD3						
oscillogram	Voltage	current	current	current	Power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	μA
3	14,88	1,04	1,41	0,607	5,25	---

Long duration current impulse withstand test. IEC 60099-4 Standard

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: December 13, 2004

Sample	Requested current	Charging Voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		KV	No.	µs	kA	kV
LD1	I_N	51,0	4	8,0/19,4	10,20	37,37
LD2		52,0	5	8,0/19,4	10,00	39,19
LD3		52,0	6	8,0/19,4	10,15	37,77

	Oscilloscope settings		
	Sampling division	input	attenuation
	µs	V_{div}	
Current	5	0,5	50:5
Voltage	5	1,0	50:5

Notes:

Switching impulse residual voltage test. IEC 60099-4 Standard

Test circuit: A0122

Date: Decemberb 13, 2004

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage	Switching impulse protection level
No.	A	kV	No.	µs	A	kV	kV
LD1	125	28,9	7	31/86	127	27,67	28,28
LD2	125	29,1	8	31/86	122	28,28	
LD3	125	29,0	9	31/86	123	27,88	

	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	20	0,5	5:5
Voltage	20	1,0	50:5

Notes:

Long duration current impulse withstand test. IEC 60099-4 Standard

Voltage correction factor and energy calculations

Date: December 15, 2004

Sample	U_{ref} [1]	kU_r [2]	kU_c [3]	U_r' [4]	U_c' [5]
No.	kV	kV	kV	kV	kV
LD1	14,77	0,9912	0,7930	14,64	11,71
LD2	15,05			14,92	11,93
LD3	14,88			14,75	11,80

[1] U_{ref} : measured reference voltage
[2] kU_r : maximum guarantees factor for calculation of Ur
[3] kU_c : maximum guarantees factor for calculation of Uc
[4] U_r' : corrected rated voltage [4] = [1] × [2]
[5] U_c' : corrected continuous operating voltage [5] = [1] × [53

Sample	Ur'	U_L	V_{res}	T	Z	W	W'
No.	kV	kV	kV	µs	kV	kV	kV
LD1	14,64	46,88	27,67	2000	71,79	14,809	1,012
LD2	14,92	47,74		2000	73,11	15,195	1,018
LD3	14,75	47,20		2000	72,73	14,954	1,014

V_{res} : switching impulse residual voltage
U_L , T , Z : see table 5 of IEC 60099-4 Standard
W : = $V_{res} \times (U_L - V_{res}) \times (T / Z)$

Long duration current impulse withstand test. IEC 60099-4 Standard

Test circuit: A017

Date: December 15, 2004

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	KV	No.	A	kV	kJ
LD1	1	28,50		260	25,70	16,10
	2	28,50		265	25,70	16,0816,00
	3	28,50	10	263	25,80	15,30
	4	28,50		258	25,80	15,28
	5	28,50		255	25,80	15,10
	6	28,50		255	25,80	15,30
	7	28,50		255	25,80	15,47
	8	28,50		260	25,80	15,40
	9	28,50	13	255	25,80	15,40
	10	28,50		257	25,80	15,30
	11	28,50		256	25,80	15,22
	12	28,50		255	25,80	15,25
	13	28,50		255	25,80	15,05
	14	28,50		251	25,80	15,25
	15	28,50		257	25,80	15,37
	16	28,50		250	25,80	15,05
	17	28,50		250	25,90	15,10
	18	28,50	16	252	25,80	15,15

Notes:

Measured waveshape	
virtual duration	virtual total duration
µs	µs
2060	2610

Oscilloscope settings			
	sampling division	input	Attenuation
	µs	V_{div}	
Current	100	1,0	10:5
Voltage	100	0,5	50:5

Continued

Continued

Date: December 15, 2004

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	KJ
LD2	1	29,0		262	26,0	16,10
	2	29,0		260	26,0	16,00
	3	29,0	11	266	26,20	16,10
	4	29,0		262	26,11	15,95
	5	29,0		263	26,71	16,00
	6	29,0		262	26,70	16,00
	7	29,0		265	26,70	16,44
	8	29,0		266	26,70	16,30
	9	29,0	14	265	26,50	16,06
	10	29,0		268	26,20	16,32
	11	29,0		260	26,20	15,80
	12	29,0		266	26,20	16,20
	13	29,0		264	26,20	16,06
	14	29,0		259	26,25	15,75
	15	29,0		254	26,30	15,45
	16	29,0		262	26,20	16,10
	17	29,0		260	26,30	15,95
	18	29,0	17	255	26,25	15,70

Notes:

Measured waveshape	
virtual duration	virtual total duration
µs	µs
2060	2610

Oscilloscope settings			
	sampling division	input	attenuation
	µs	V_{div}	
Current	100	1,0	10:5
Voltage	100	0,5	50:5

continued

Continued

Date: December 15, 2004

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	KV	kJ
LD3	1	28,50		255	25,80	15,50
	2	28,50		252	25,80	15,20
	3	28,50	12	252	25,90	15,25
	4	28,50		254	25,94	15,34
	5	28,50		253	25,90	15,10
	6	28,50		252	25,90	15,06
	7	28,50		250	25,90	15,10
	8	28,50		250	25,90	15,09
	9	28,50	15	255	25,80	15,30
	10	28,50		254	25,90	15,27
	11	28,50		251	25,80	15,04
	12	28,50		258	25,90	15,50
	13	28,50		249	25,90	15,06
	14	28,50		248	25,90	15,09
	15	28,50		248	25,90	15,05
	16	28,50		256	26,20	15,69
	17	28,50		249	25,90	15,05
	18	28,50	18	248	25,80	15,00

Notes:

Measured waveshape	
Virtual duration	virtual total duration
µs	µs
2060	2610

Oscilloscope settings			
	sampling division	input	attenuation
	µs	V_{div}	
Current	100	1,0	10:5
Voltage	100	0,5	50.5

continued

Long duration current impulse withstand test. IEC 60099-4 Standard

(check the integrity of the internal parts with an additional shot at ambient temperature)

Test circuit: A017

Date: December 16, 2004

Sample	Impulse	Charging voltage V_c	Oscillogram	Peak current I	Residual voltage V_r	Energy E
No.	No.	kV	No.	A	kV	kJ
LD1	19	28,5	19	258	25,80	16,20
LD2	19	28,5	20	268	26,20	16,40
LD3	19	28,5	21	256	25,90	15,60

Notes:

Measured waveshape	
virtual duration	virtual total duration
µs	µs
2060	2610

Oscilloscope settings			
	sampling division	input	attenuation
	µs	V_{div}	
Current	100	1,0	10:5
Voltage	100	0,5	50:5

continued

Long duration current impulse withstand test. IEC 60099-4 Standard

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

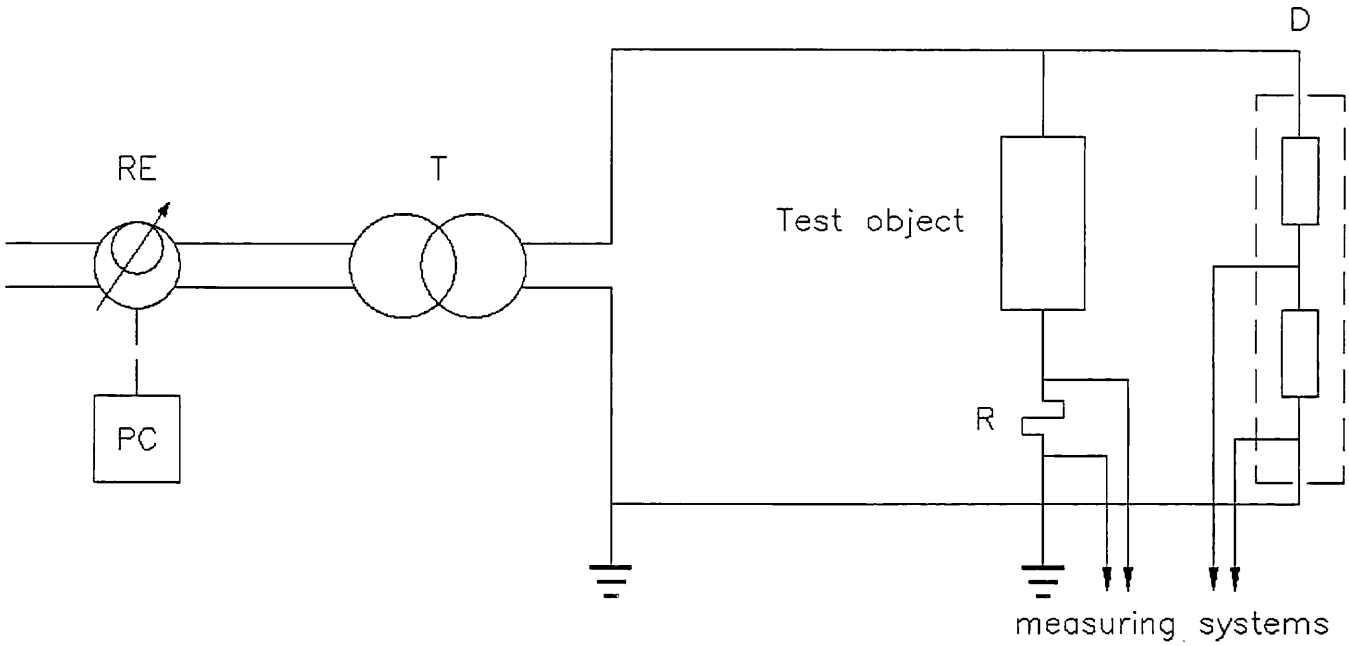
Date: December 16, 2004

Sample	Requested Current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
LD1	I_N	51,0	22	8,0/19,4	10,20	37,17
LD2		52,0	23	8,0/19,4	10,00	38,98
LD3		51,0	24	8,0/19,4	10,00	37,98

	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	5,0	0,5	50:5
Voltage	5,0	1,0	20:5

Notes:

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

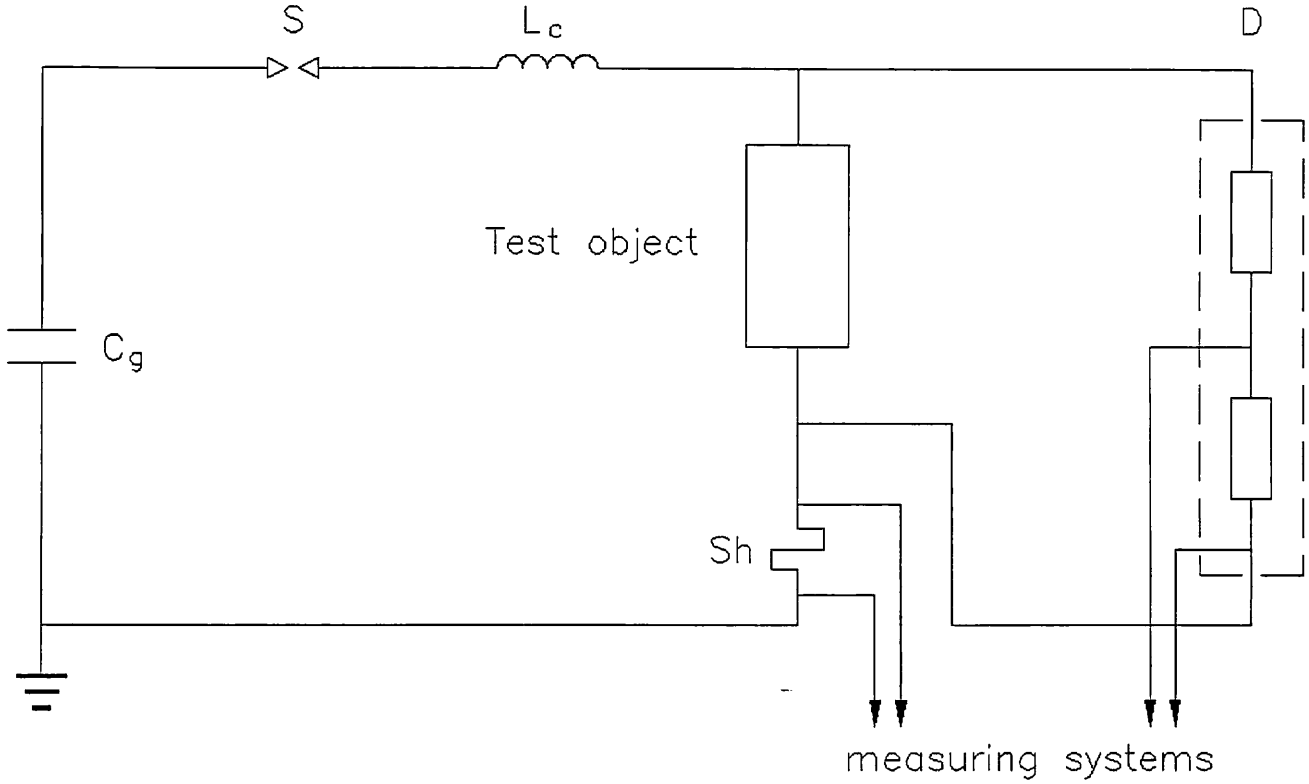
Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system CESI No.11517/518; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11521/522; attenuation 50:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Circuit A0120



Impulse generator

No. of stages	1
Cg	4,98 µF
Lc	10 µH
S	- Spark-gap

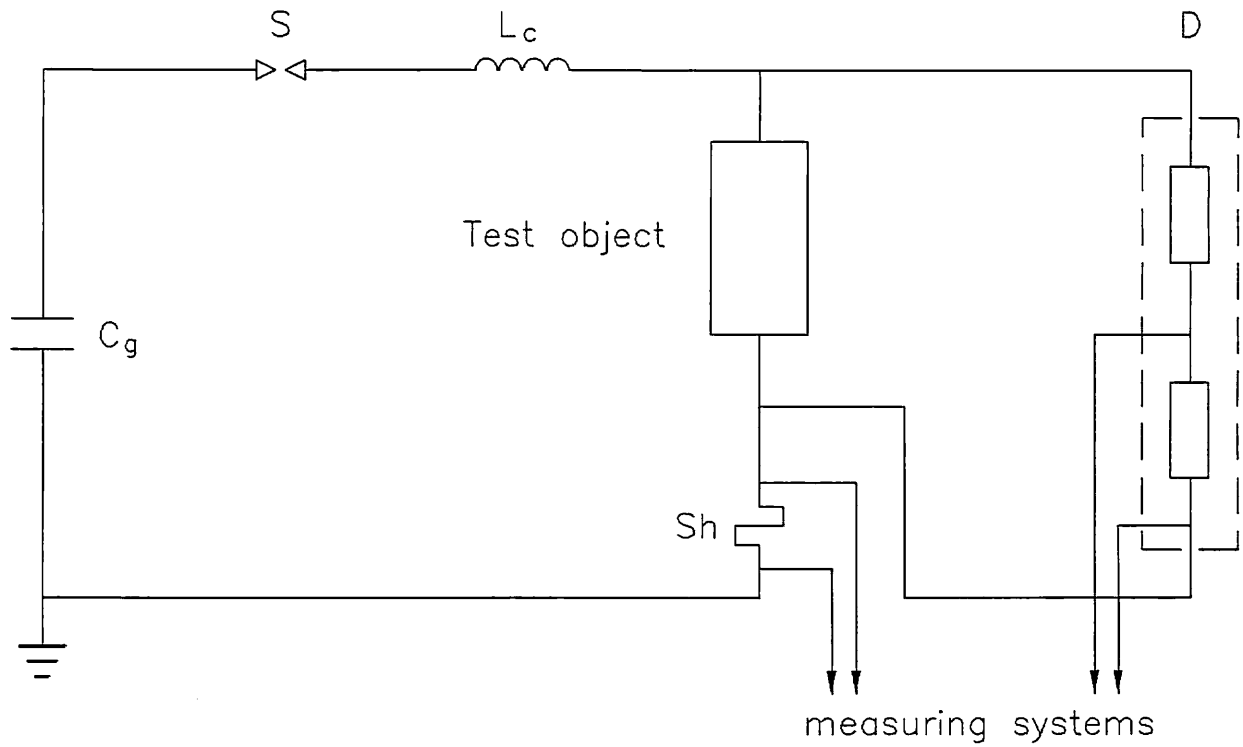
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.11120
	- Electro optical system CESI No.11521/522;
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ ; peak current= 250 kA
	- Electro optical system CESI No.11517/518;
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0122



Impulse generator

No. of stages
Cg μF
Lc μH

S - Spark-gap

Voltage measuring system.

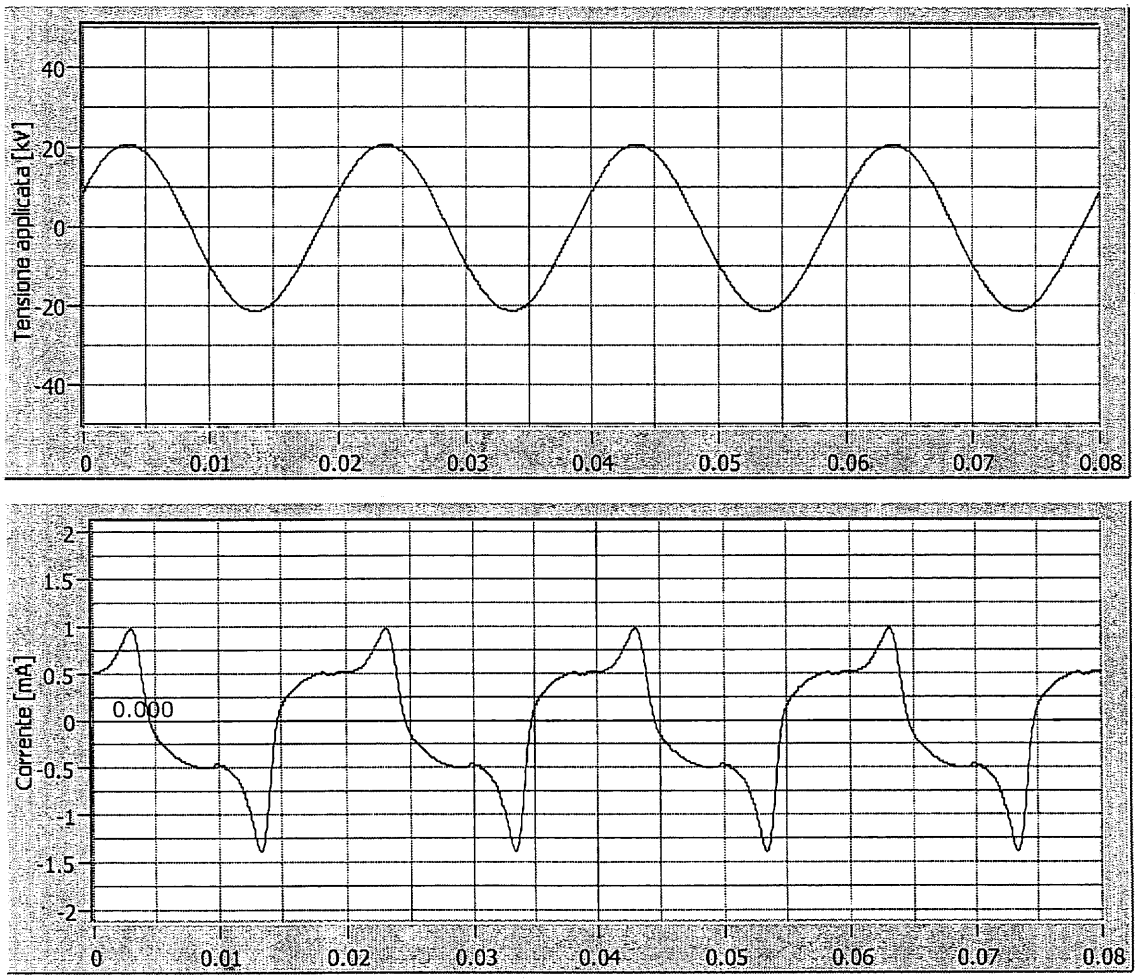
D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No 11521/522

OSC - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

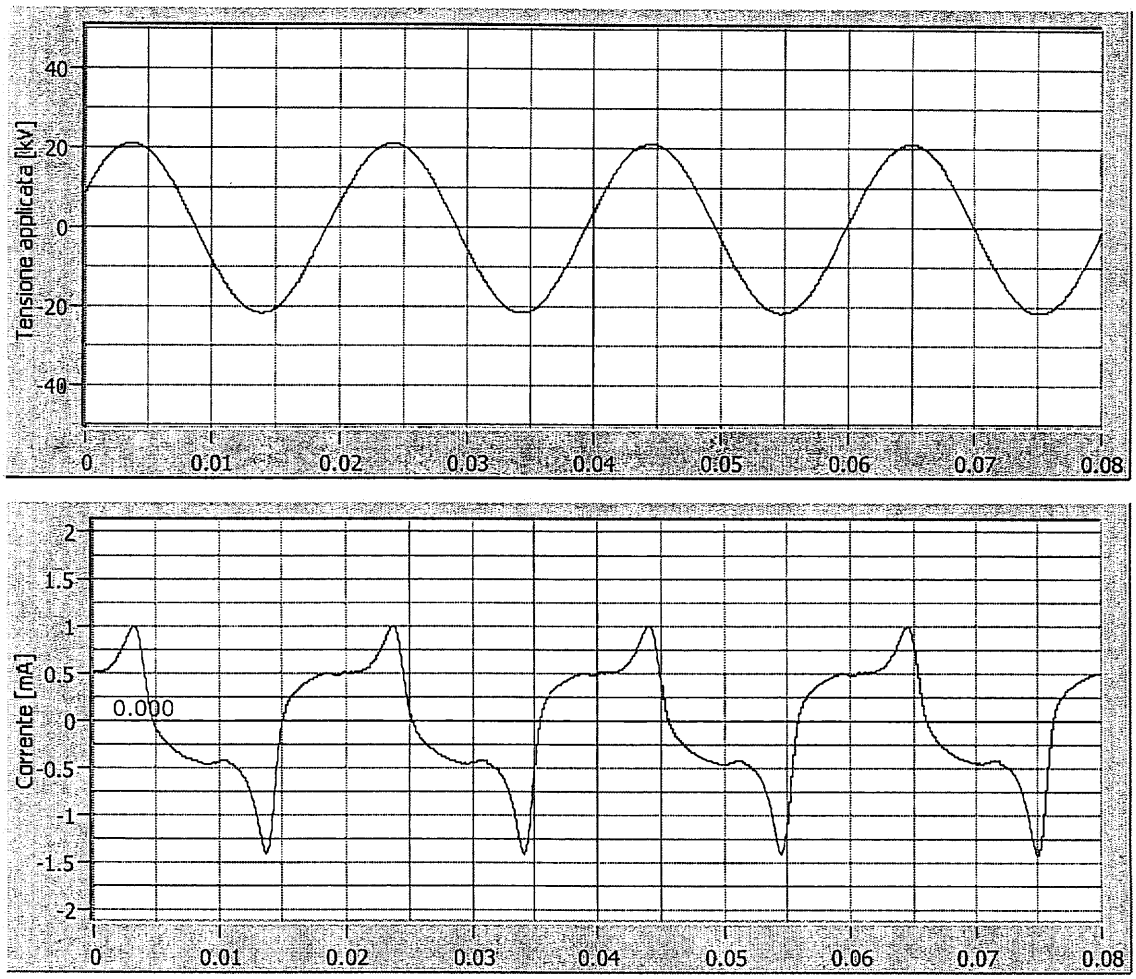
Current measuring system

Sh - Current shunt CESI No.6037; R= 20 mΩ ; peak current= 250 kA
- Electro optical system CESI No 11517/519

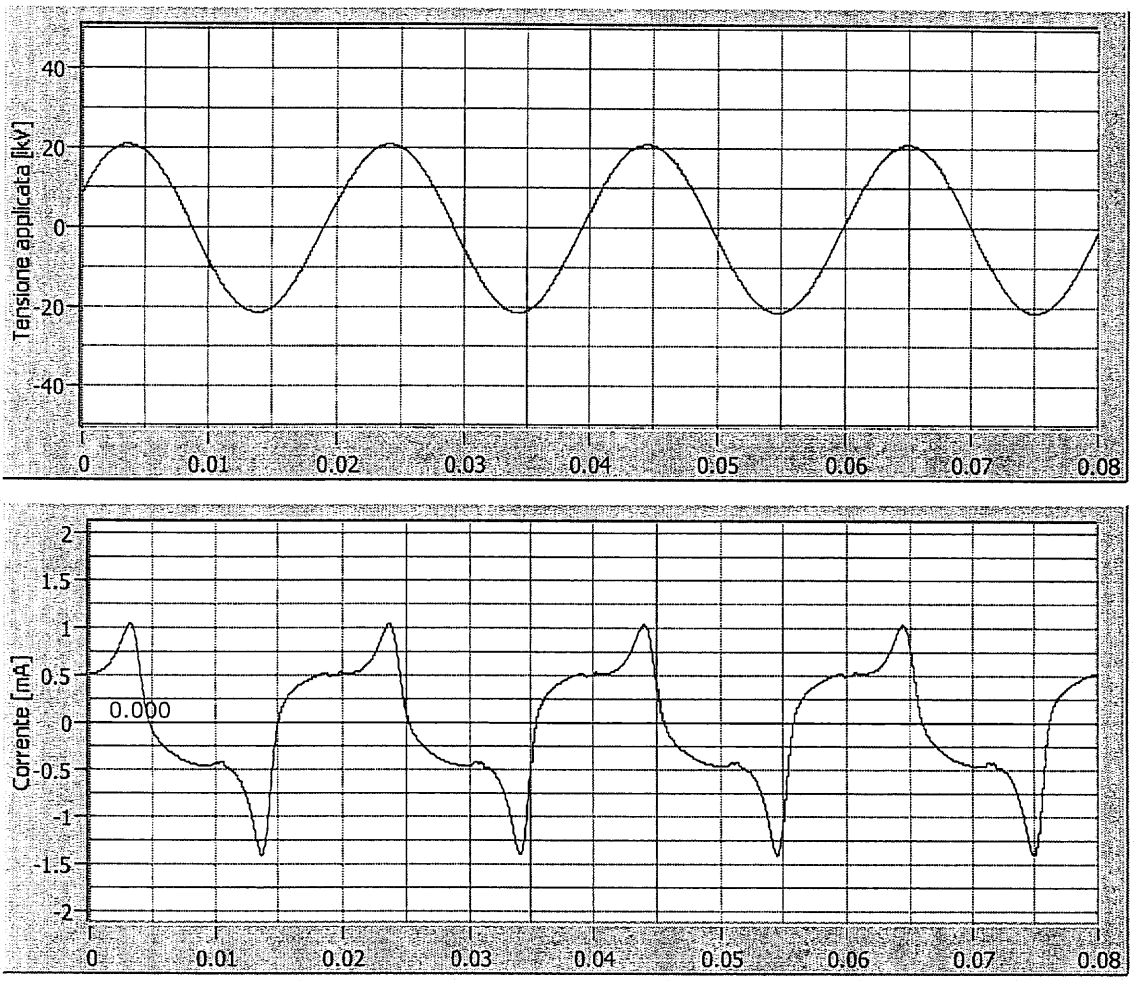
OSC - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)



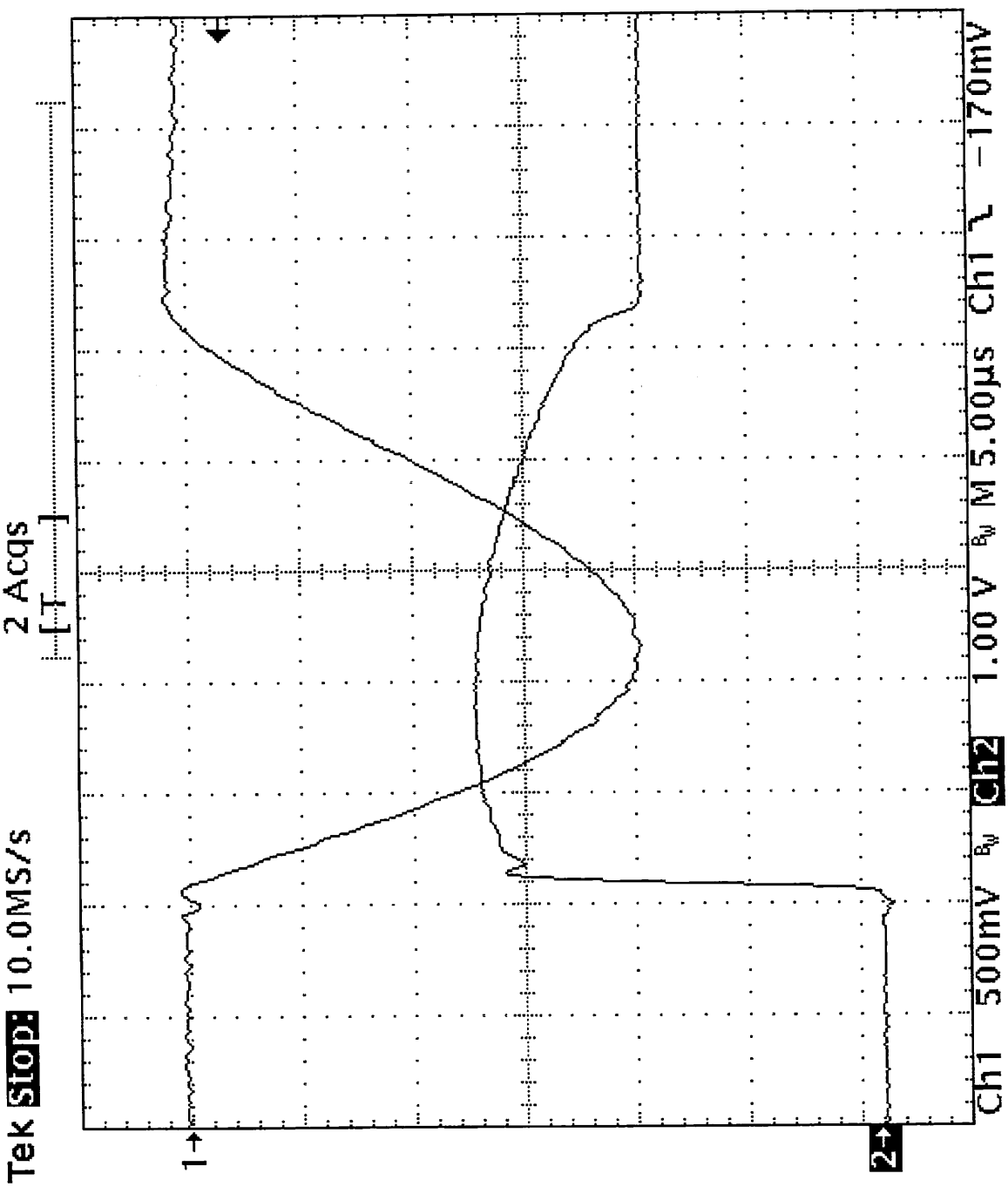
CESI Pec A4522500 oscillogram n. 1



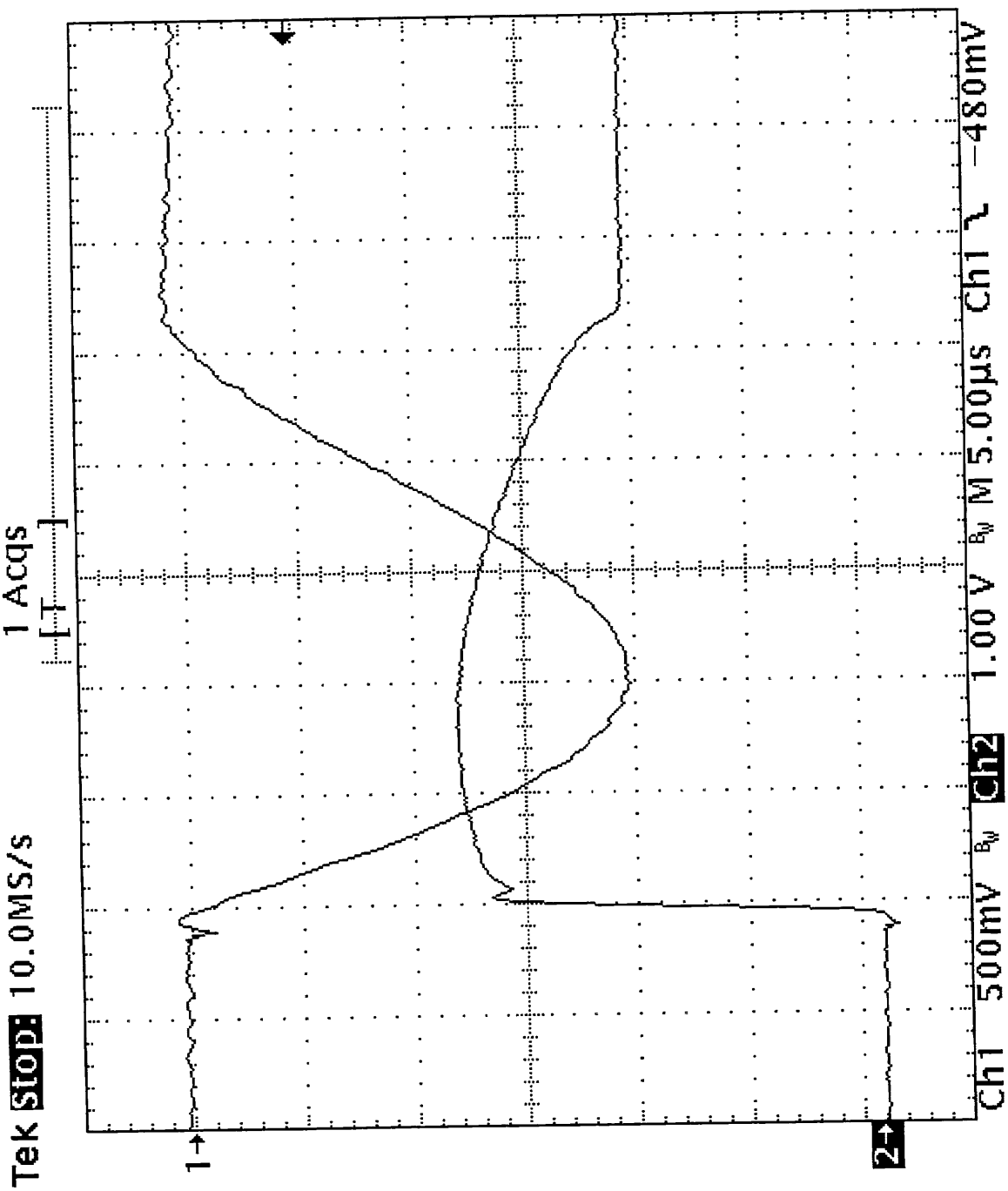
CESI Pec A4522500 oscillogram n. 2



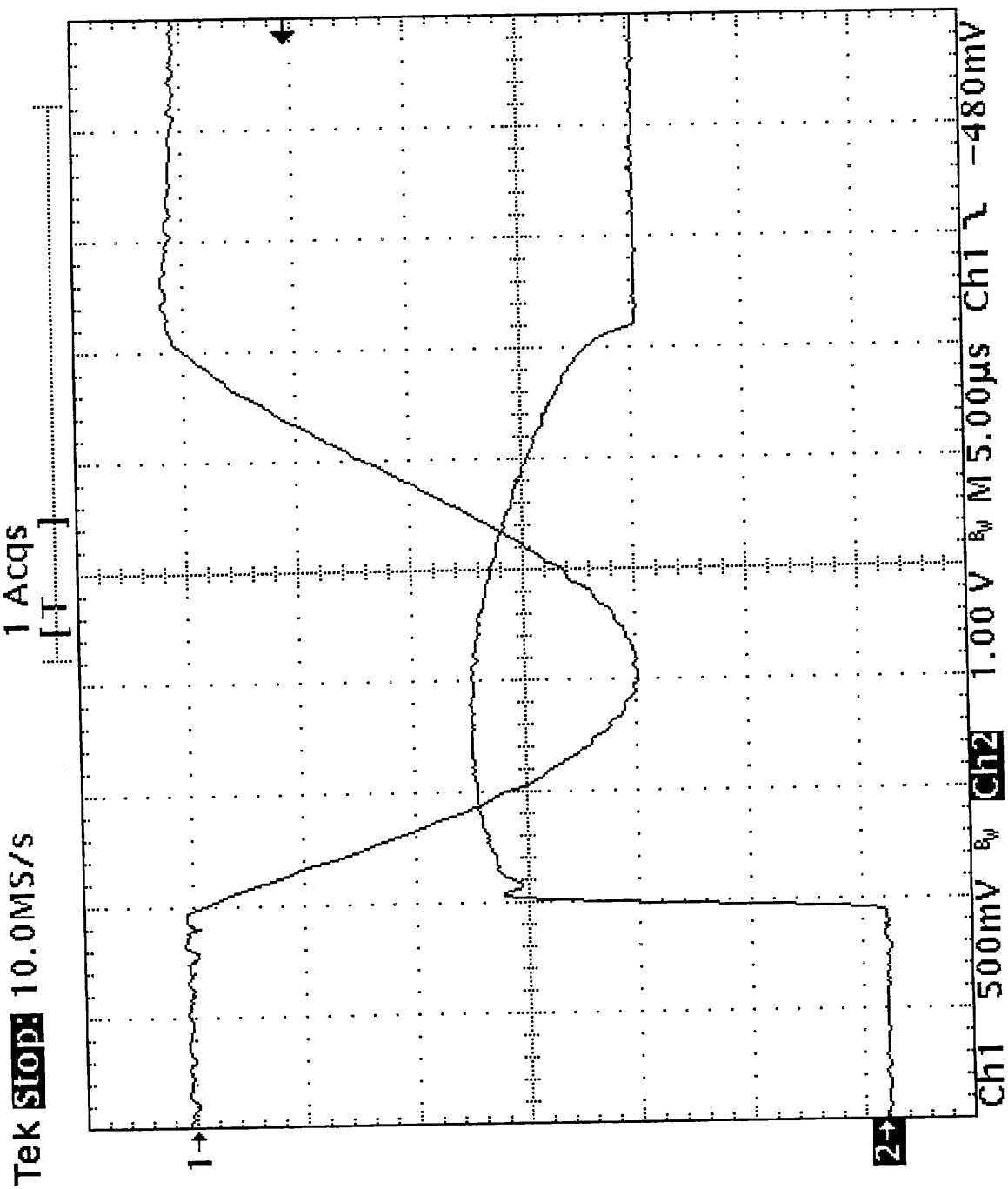
CESI Pec A4522500 oscillogram n. 3



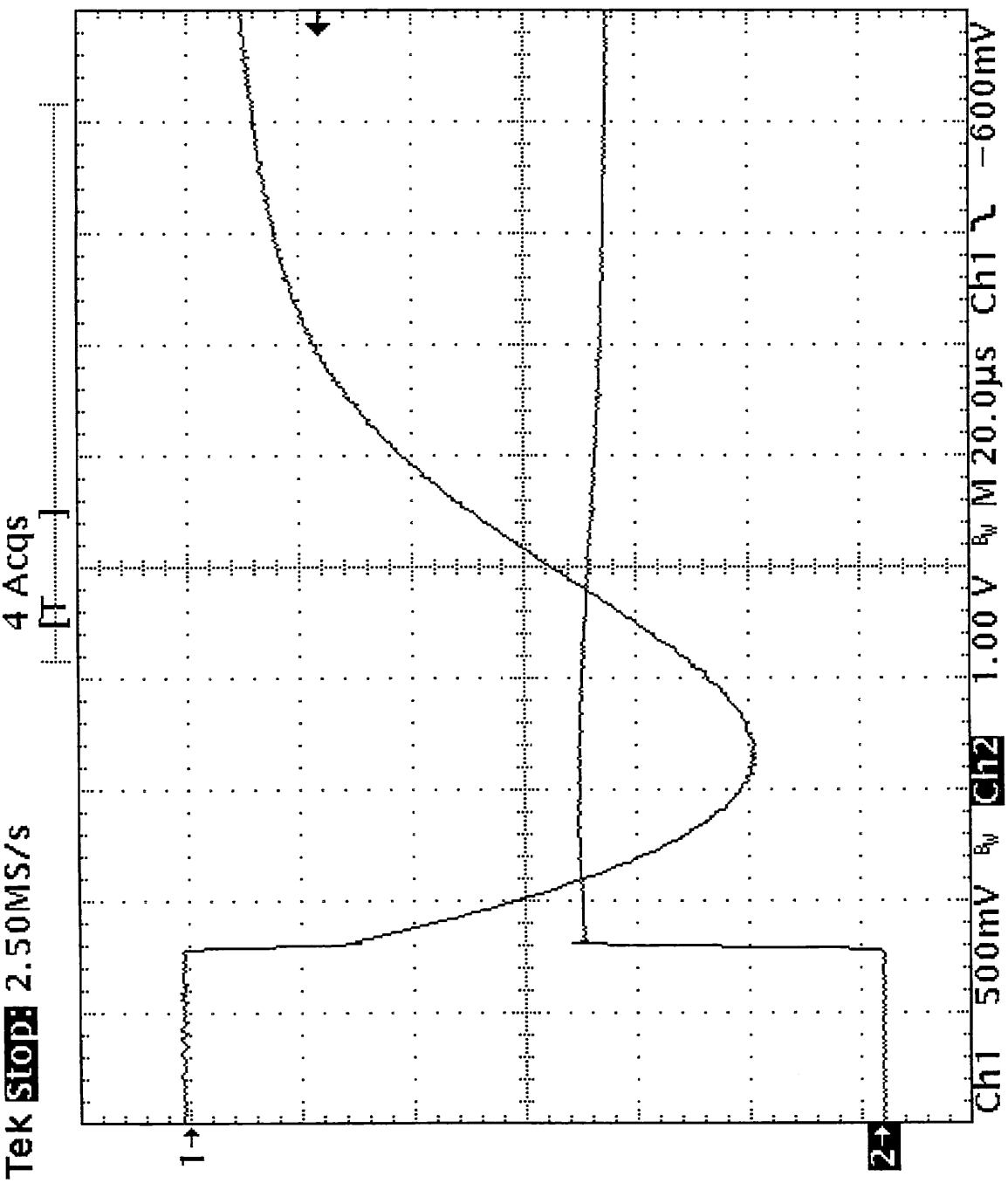
CESI PeC A4522500 oscillogram n. 4



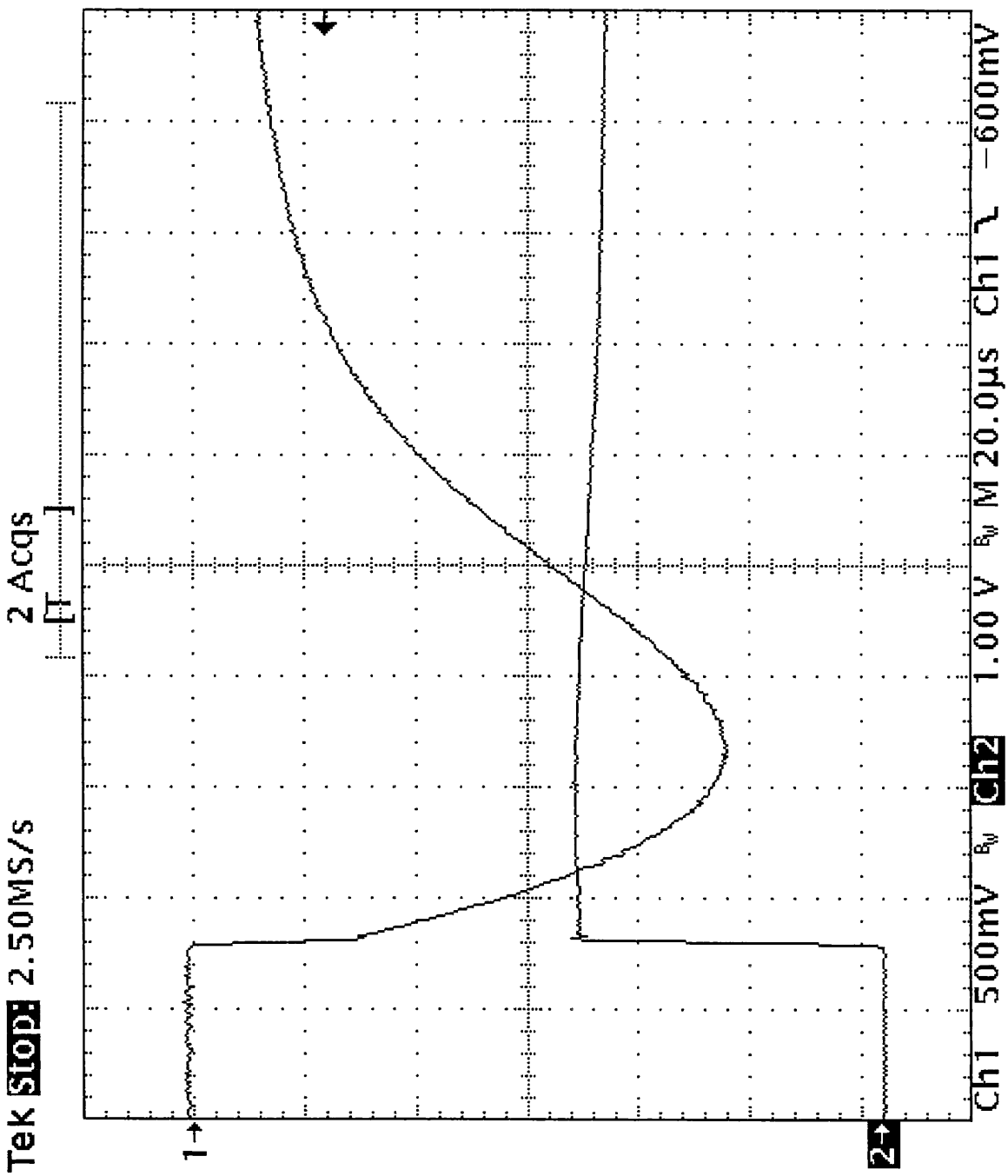
CESI PeC A4522500 oscillogram n. 5



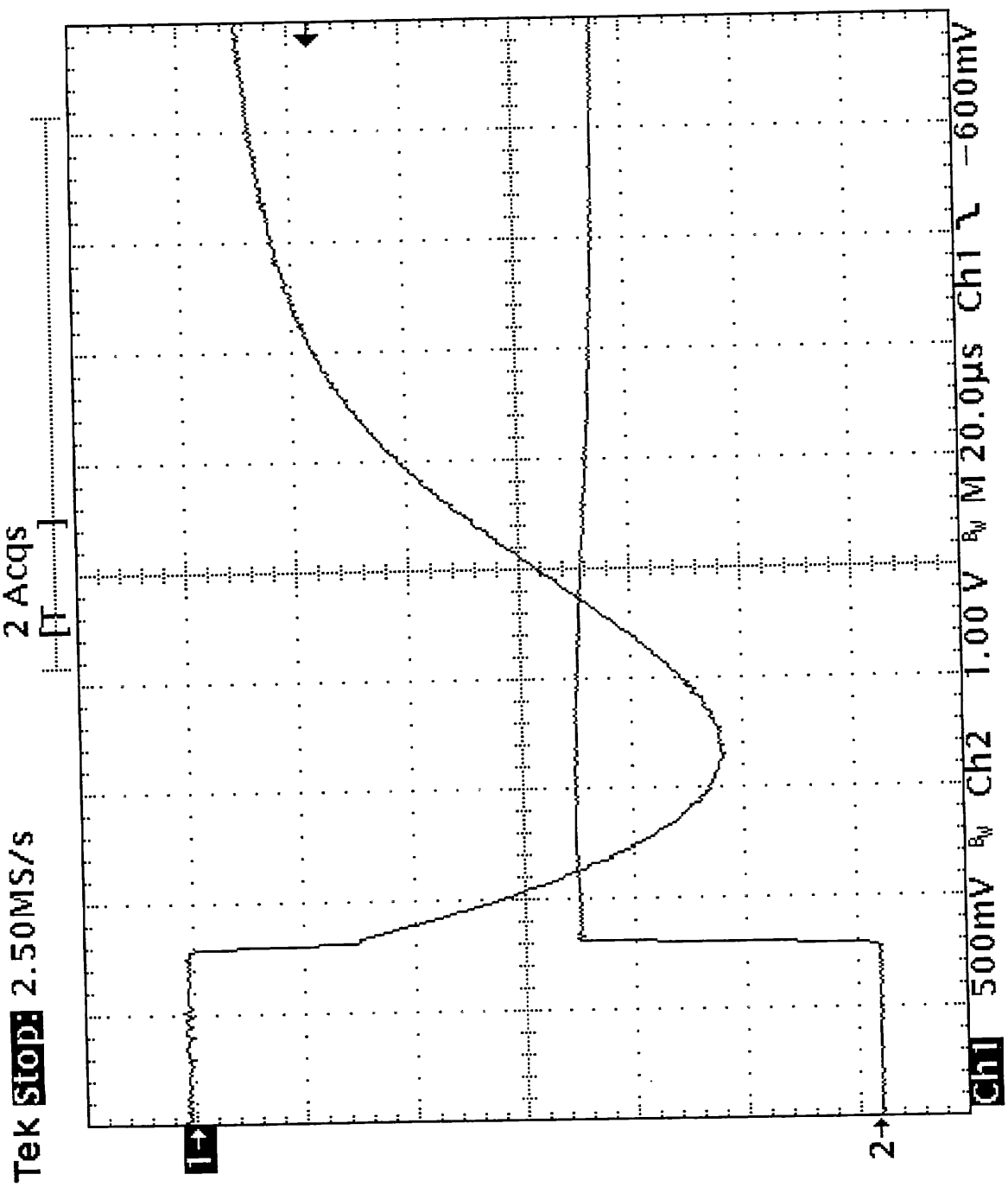
CESI PeC A4522500 oscillogram n. 6



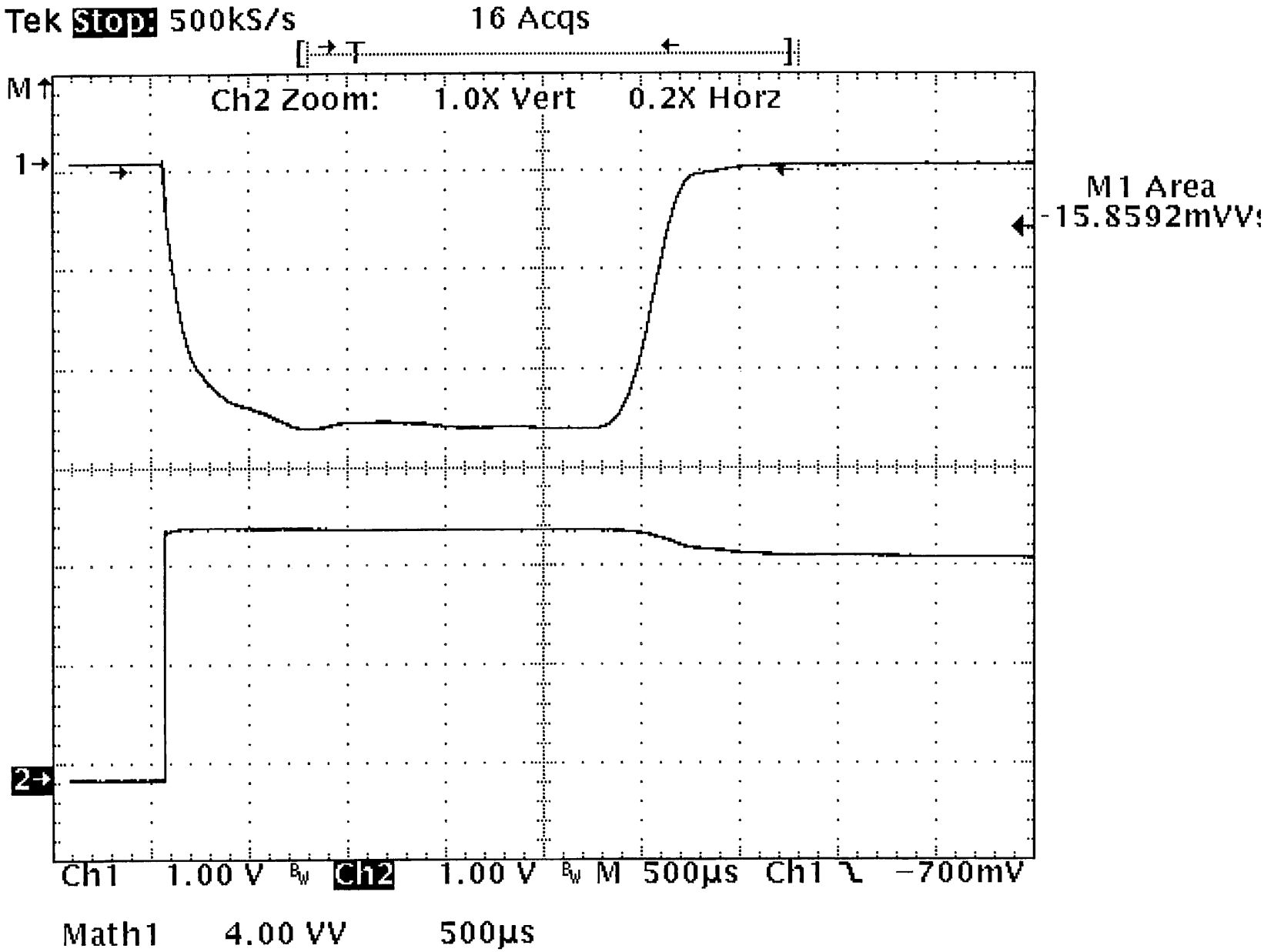
CESI PeC A4522500 oscillogram n. 7



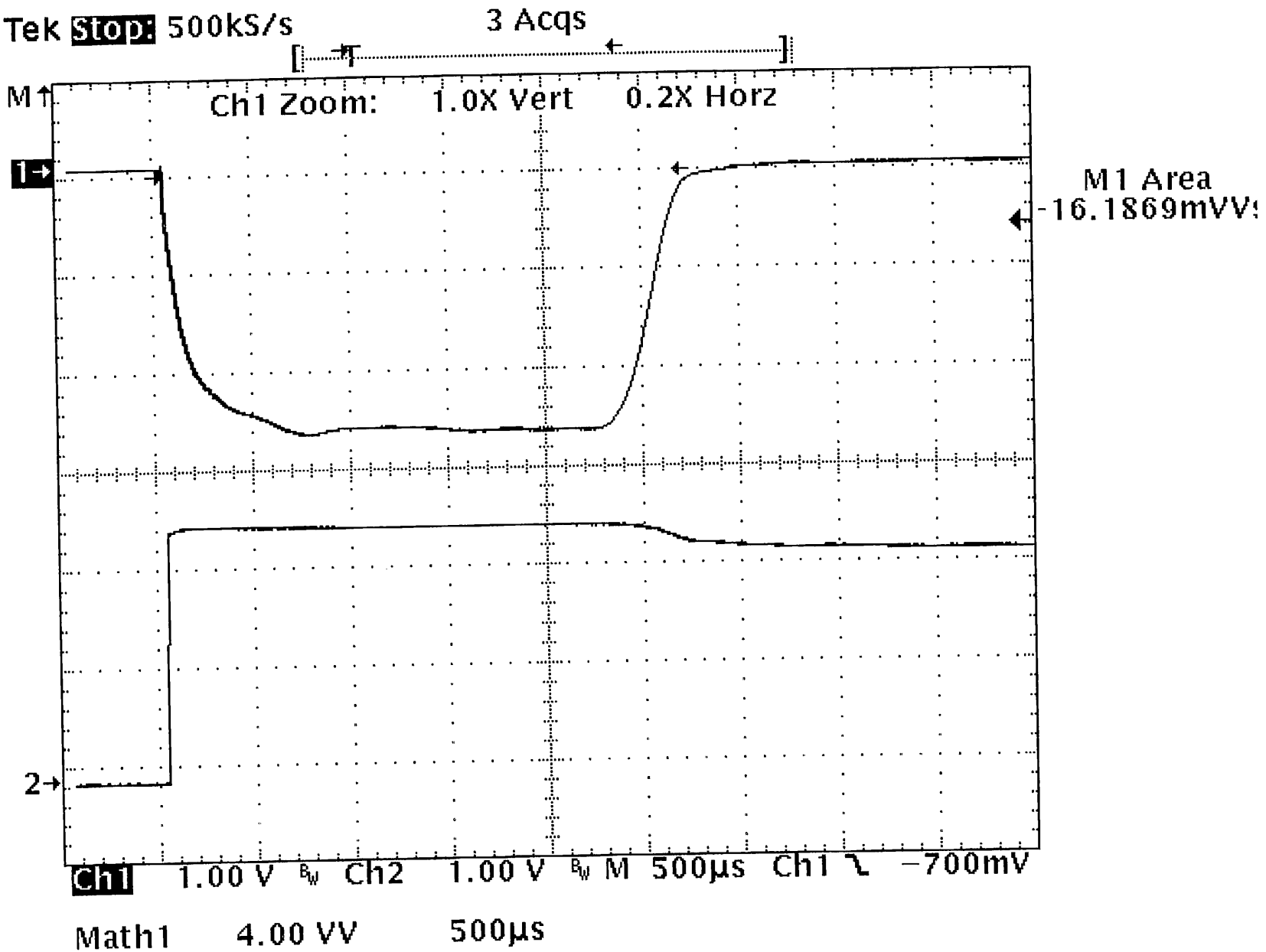
CESI PeC A4522500 oscillogram n. 8



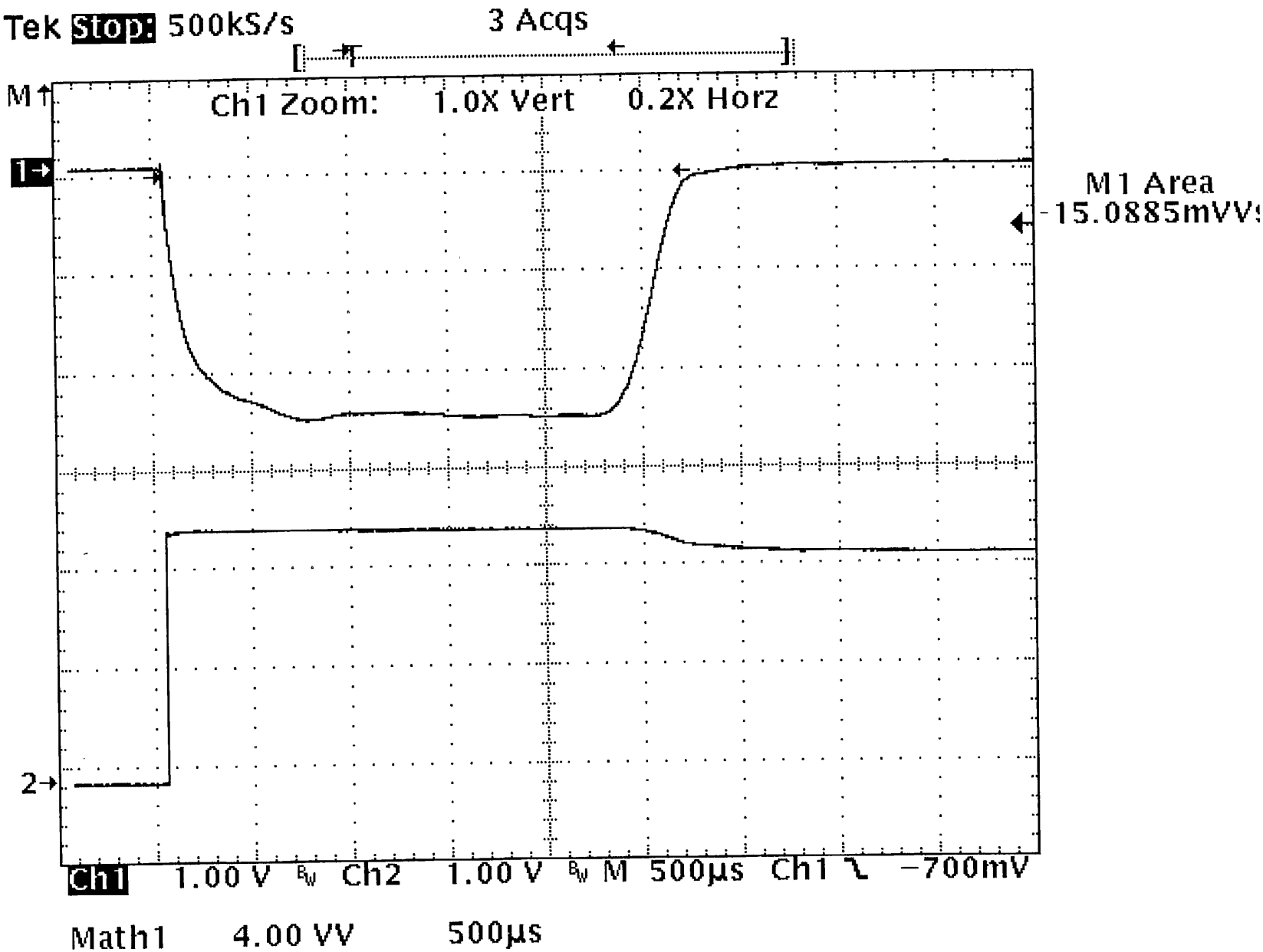
CESI PeC A4522500 oscillogram n. 9



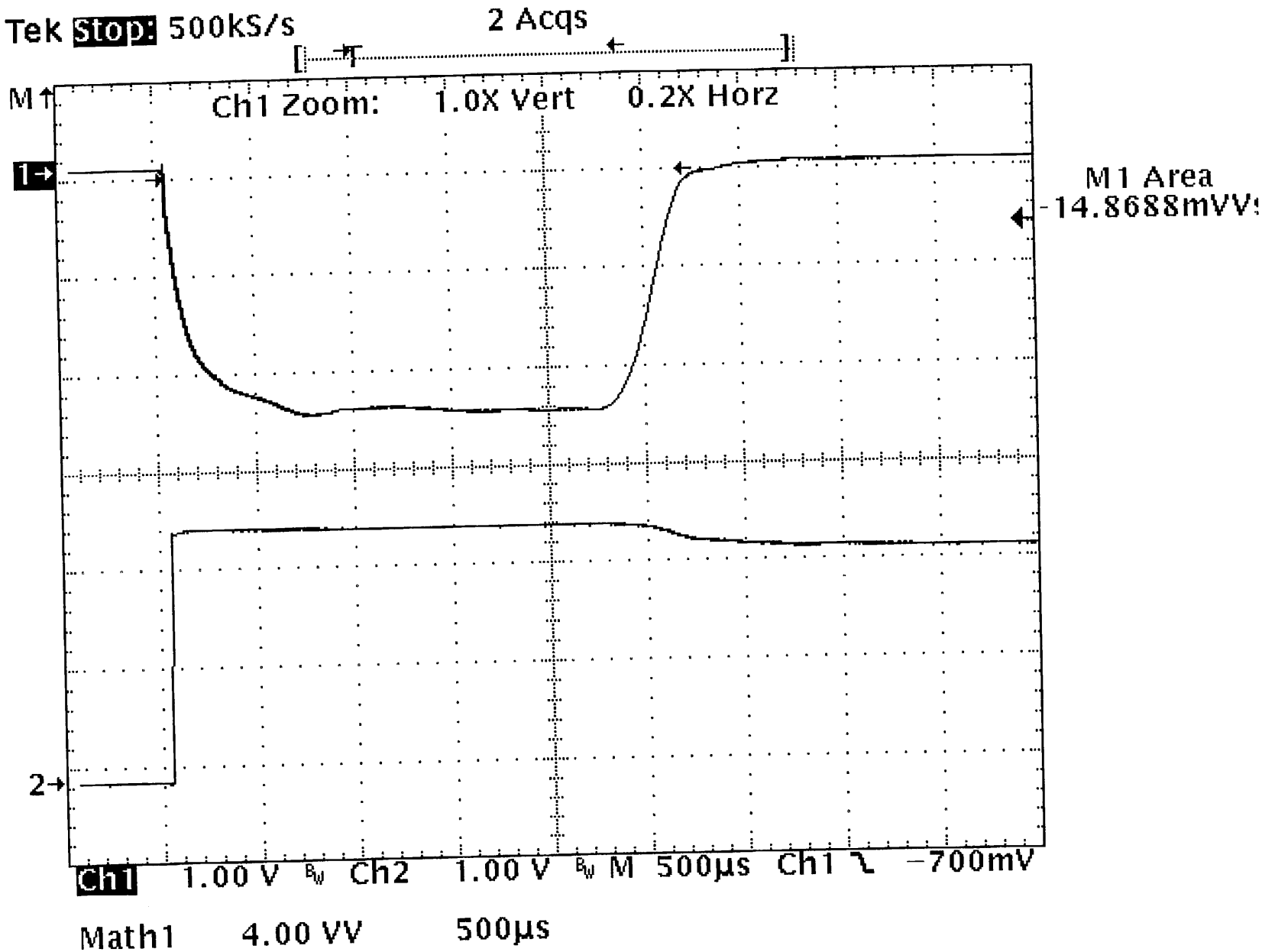
CESI PeC A4522500 oscillogram n. 10



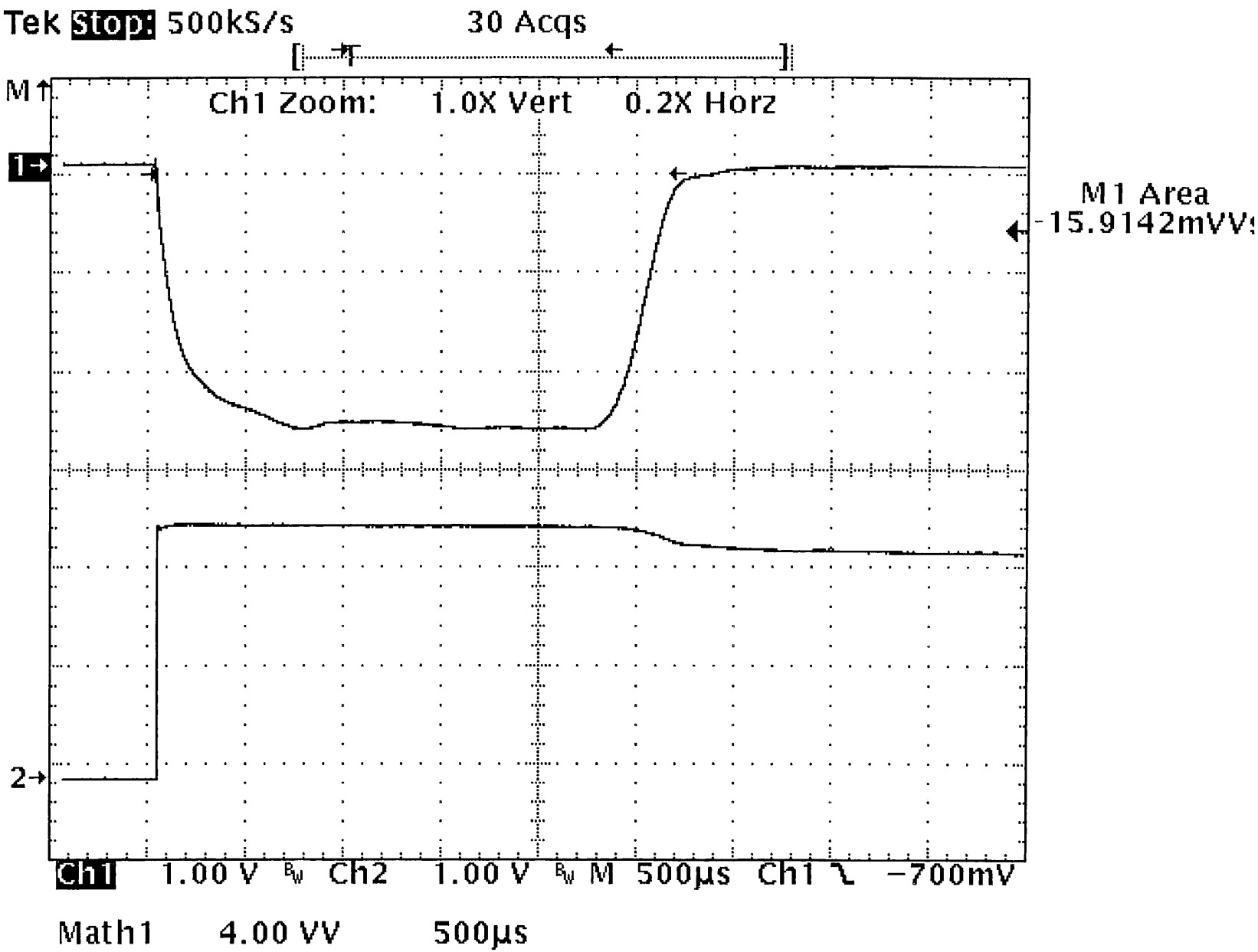
CESI PeC A4522500 oscillogram n. 11



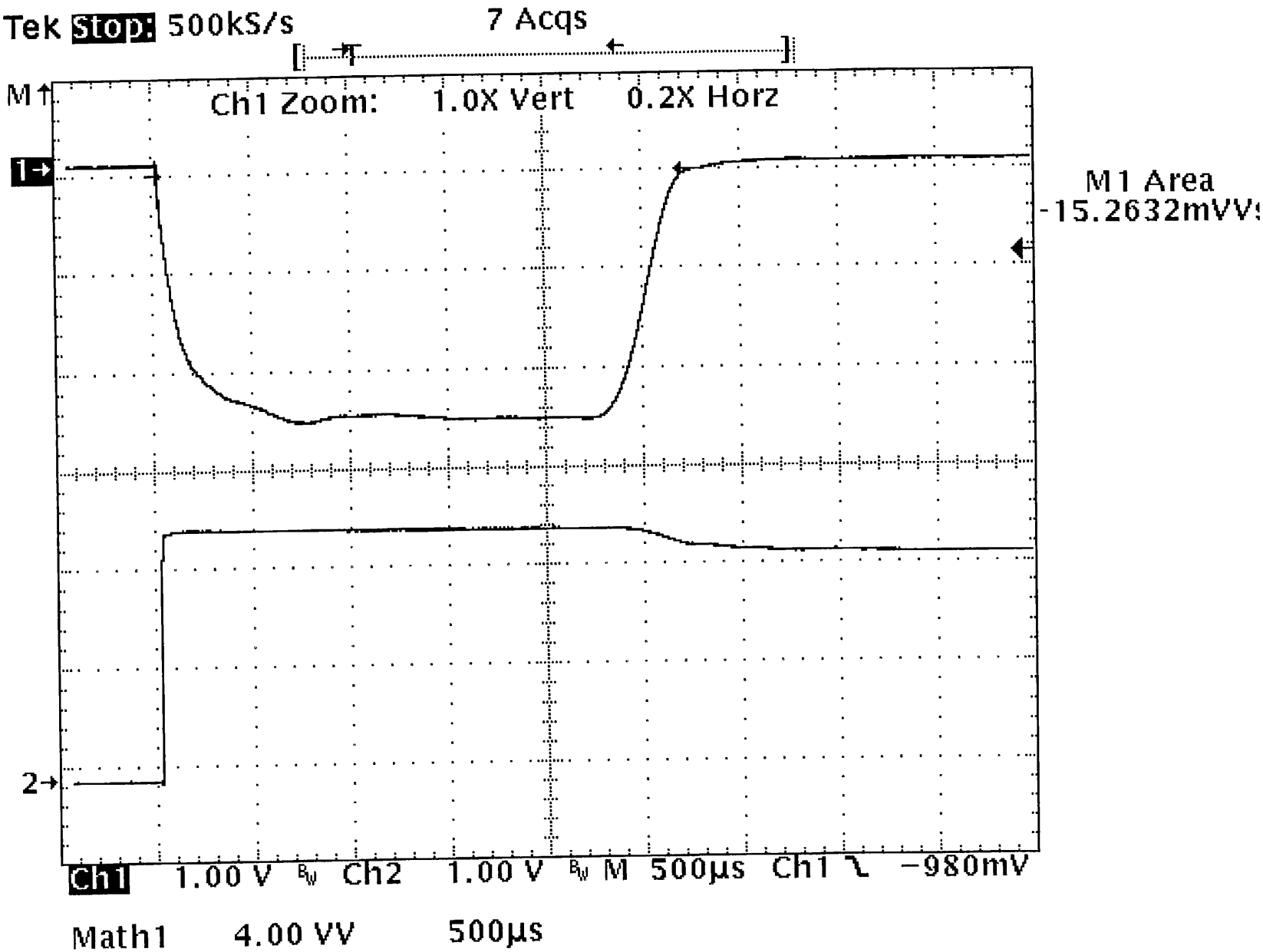
CESI PeC A4522500 oscillogram n. 12



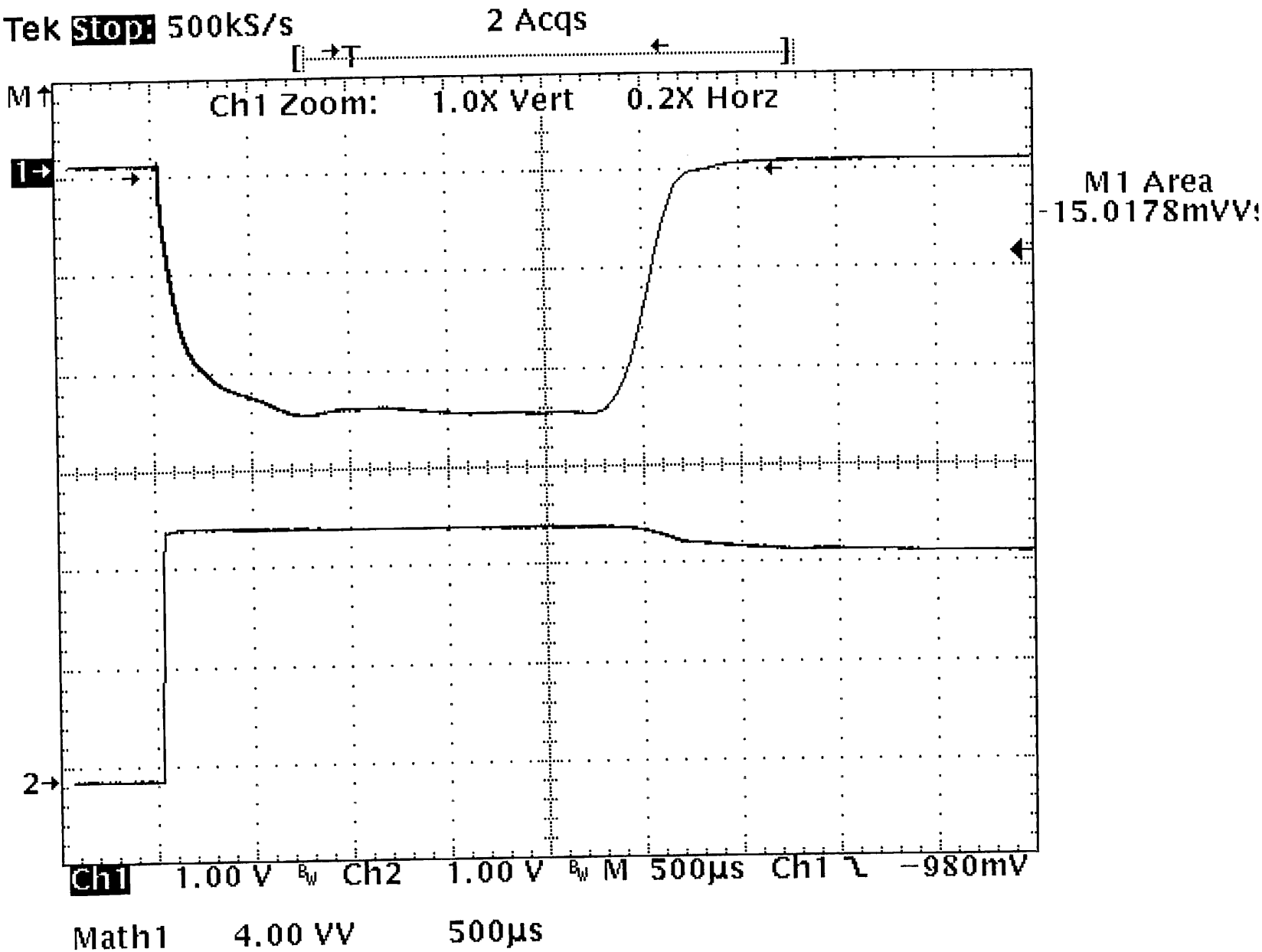
CESI PeC A4522500 oscillogram n. 13



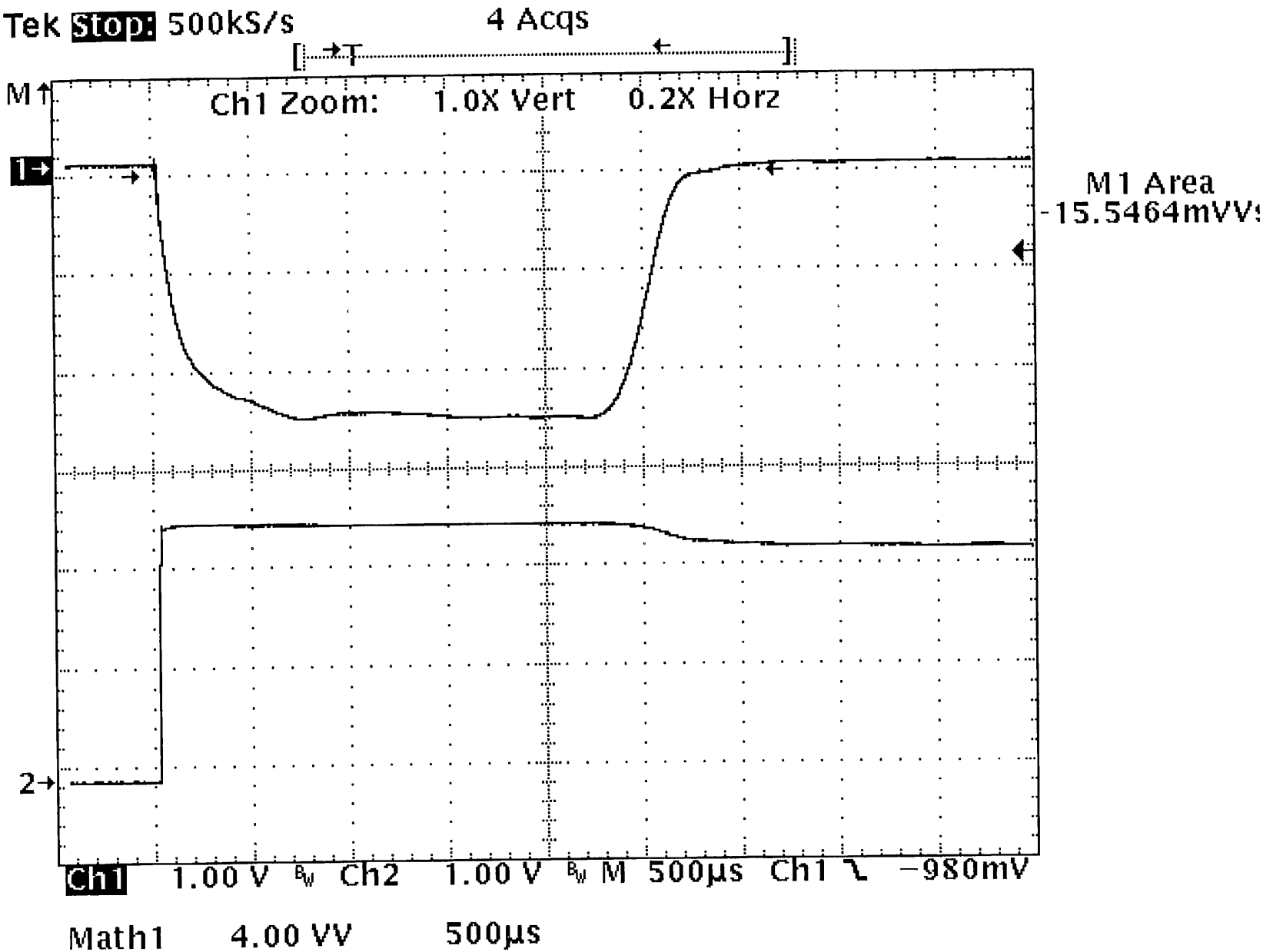
CESI PeC A4522500 oscillogram n. 14



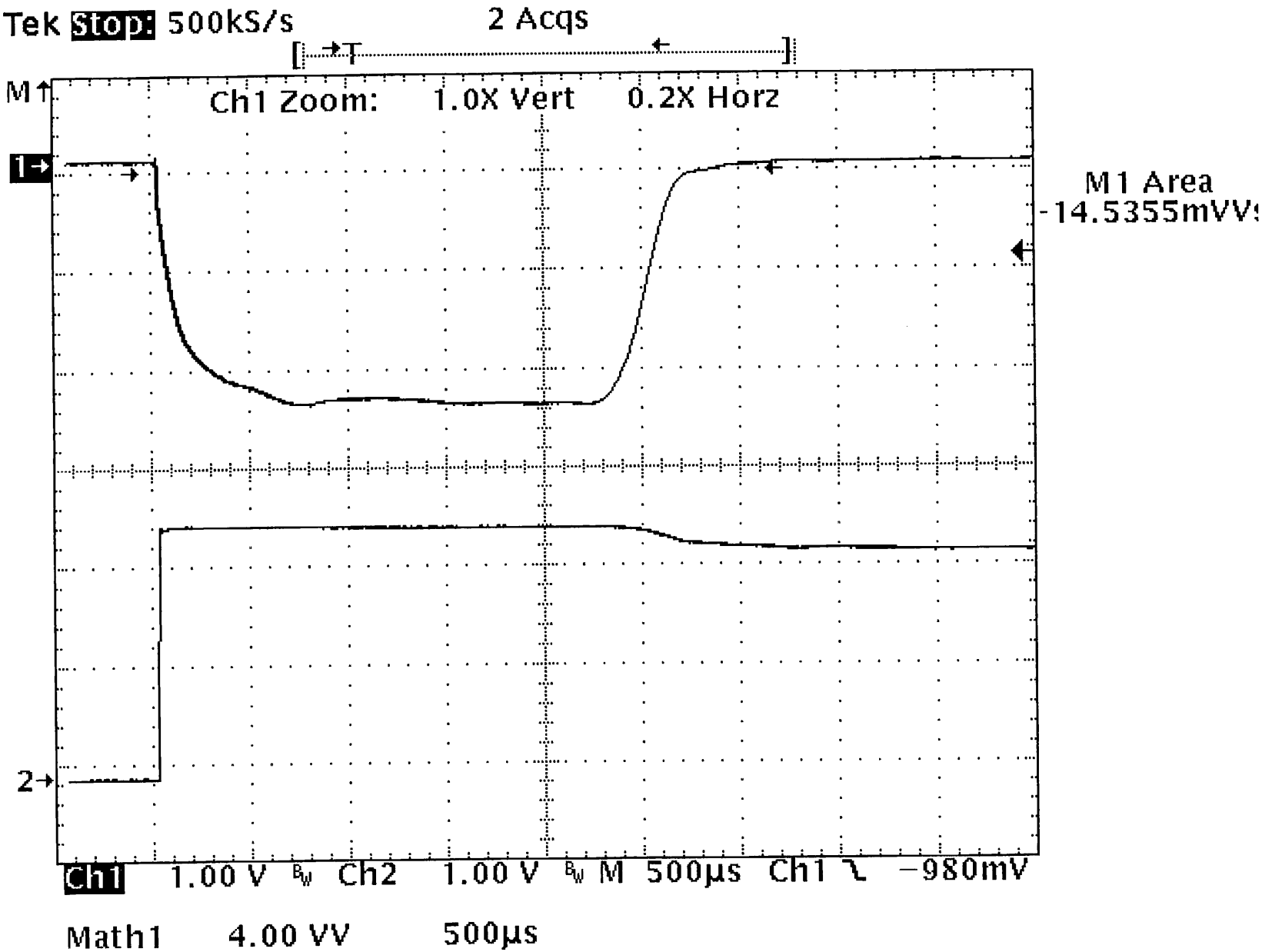
CESI PeC A4522500 oscillogram n. 15



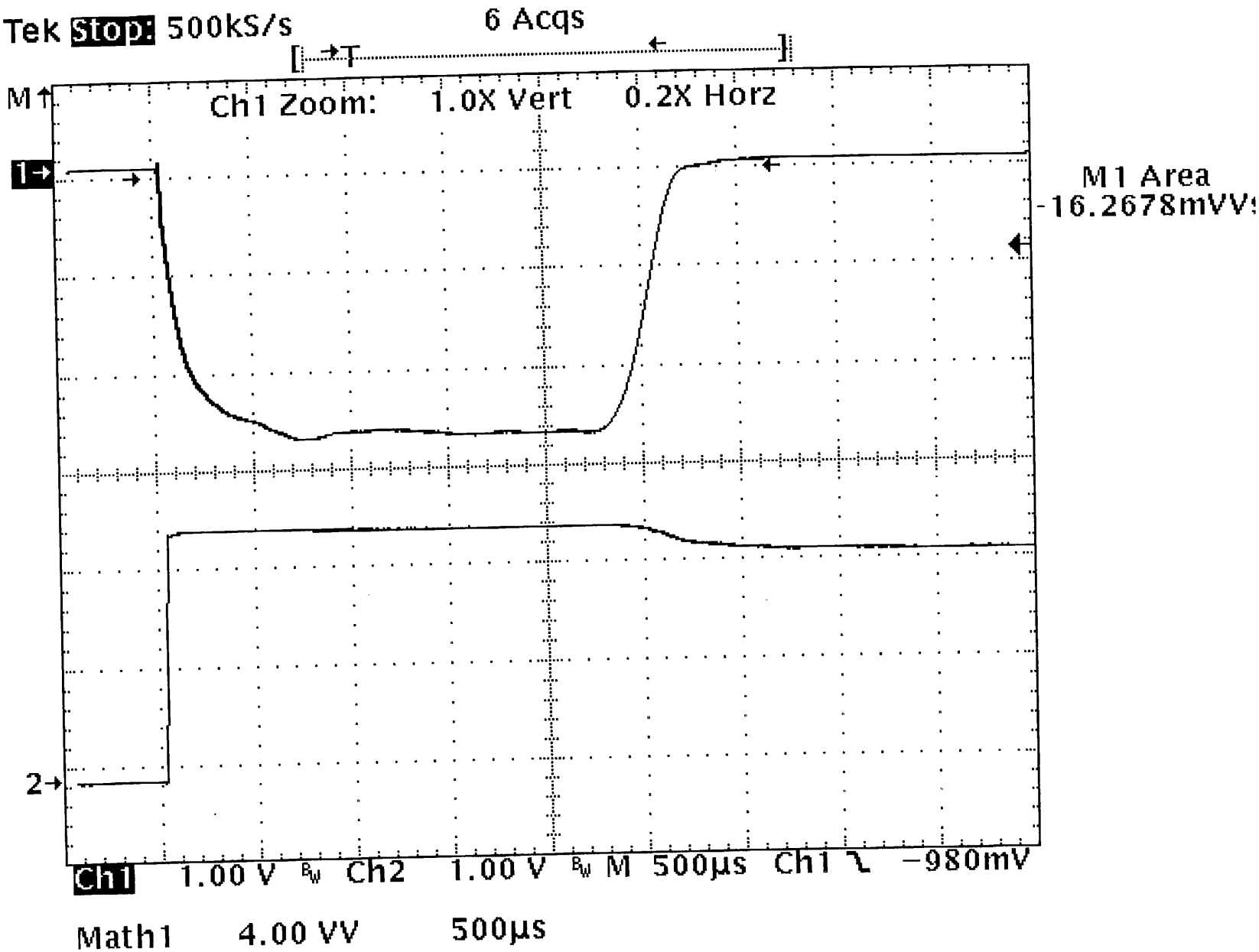
CESI PeC A4522500 oscillogram n. 16



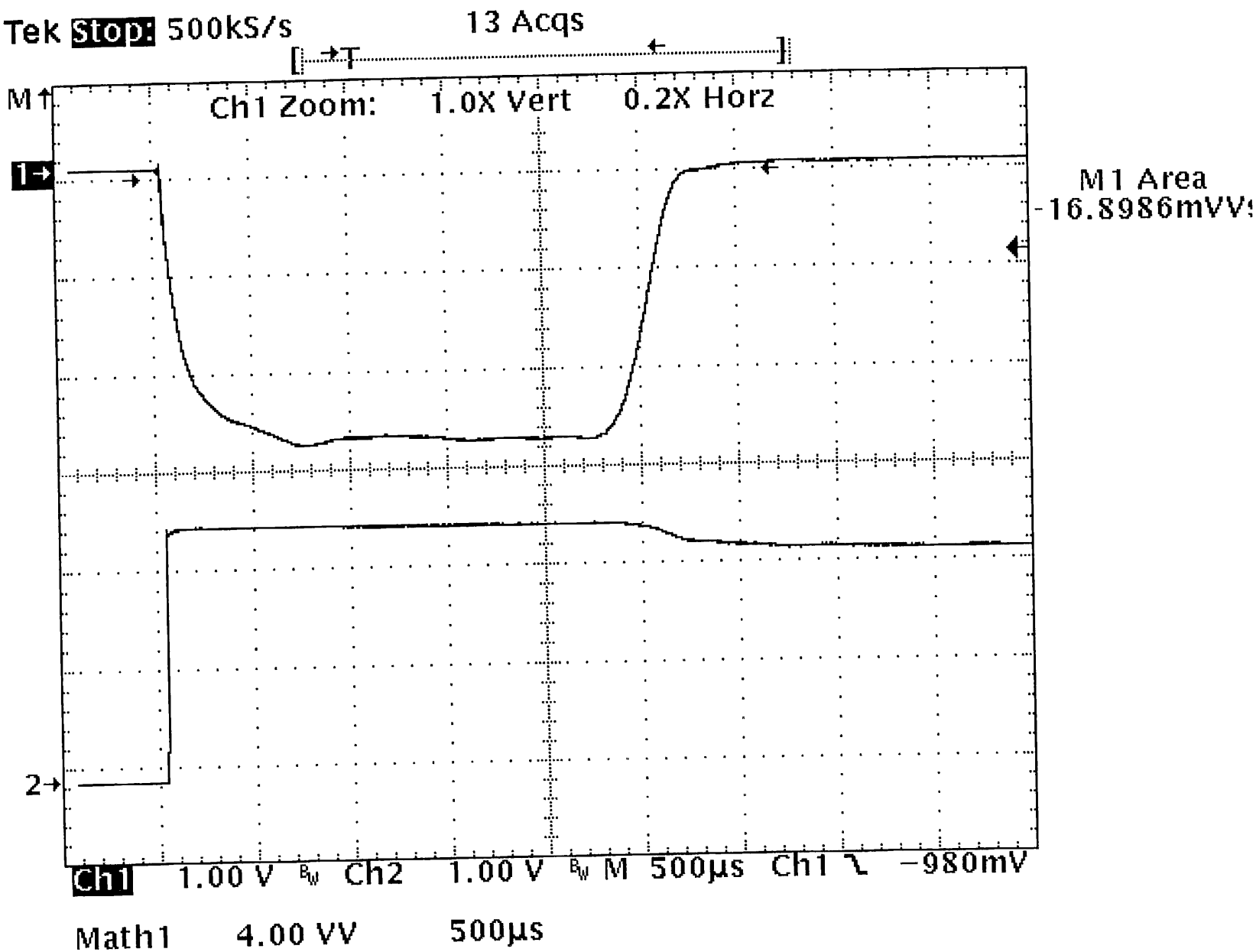
CESI PeC A4522500 oscillogram n. 17



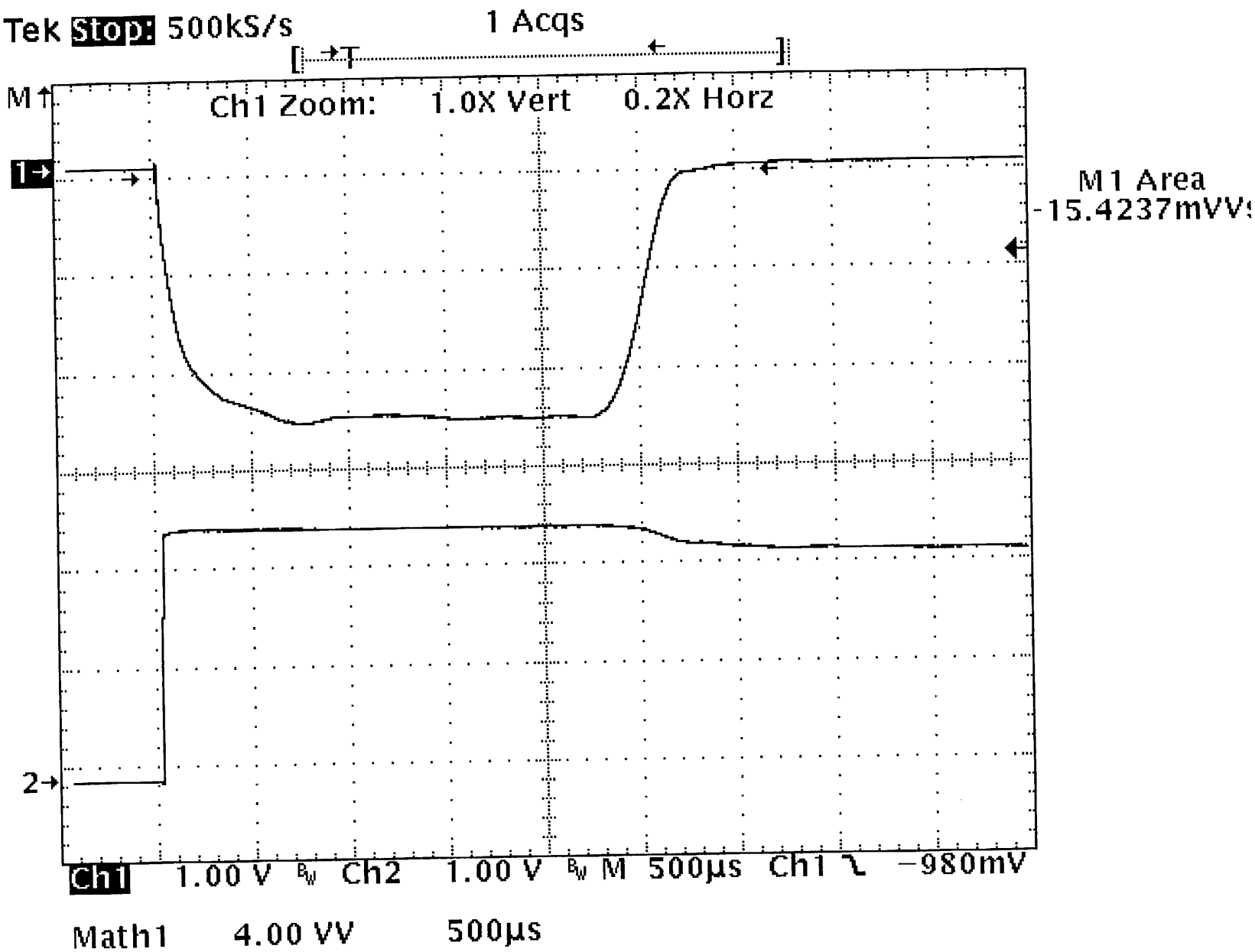
CESI PeC A4522500 oscillogram n. 18



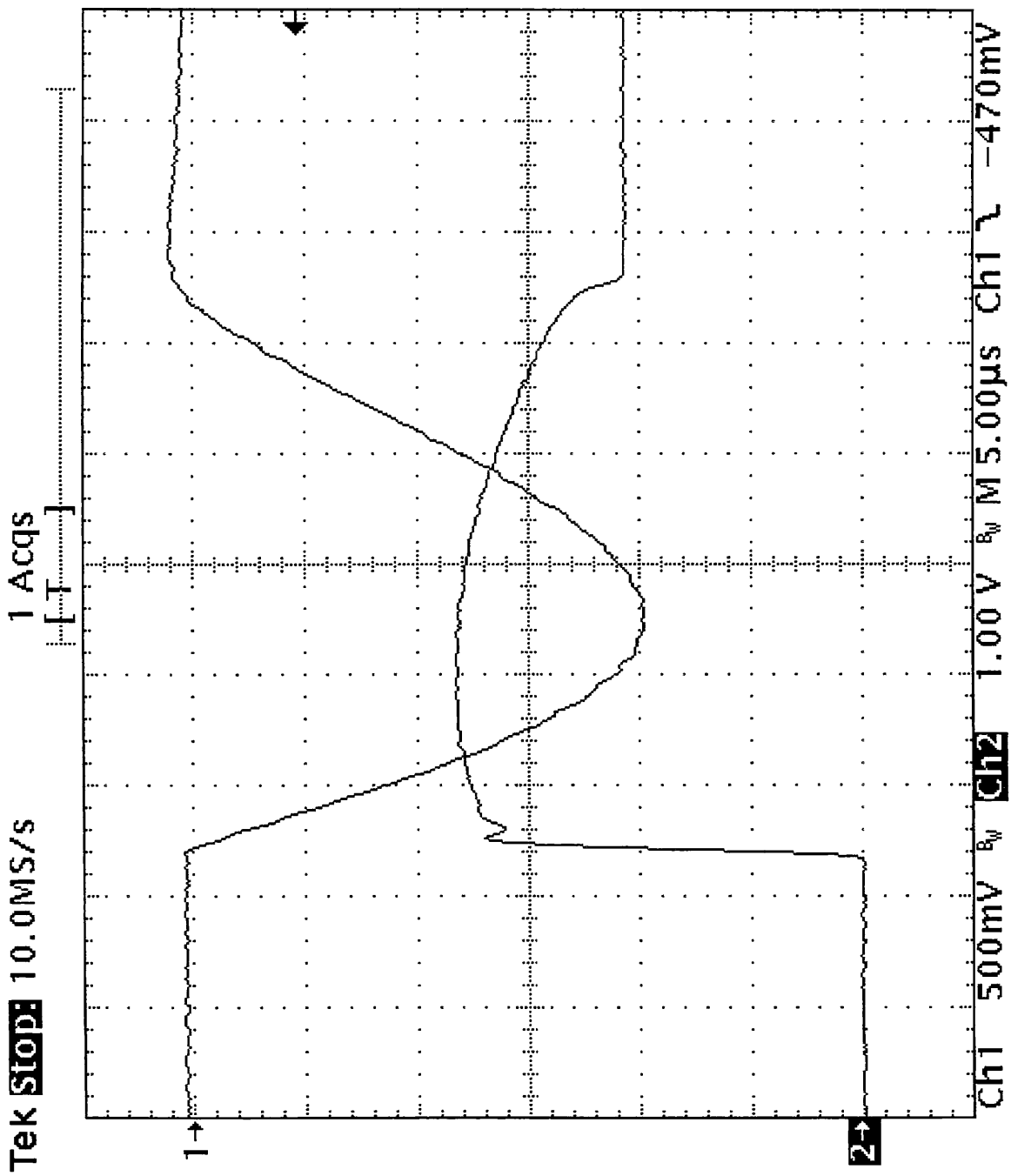
CESI PeC A4522500 oscillogram n. 19



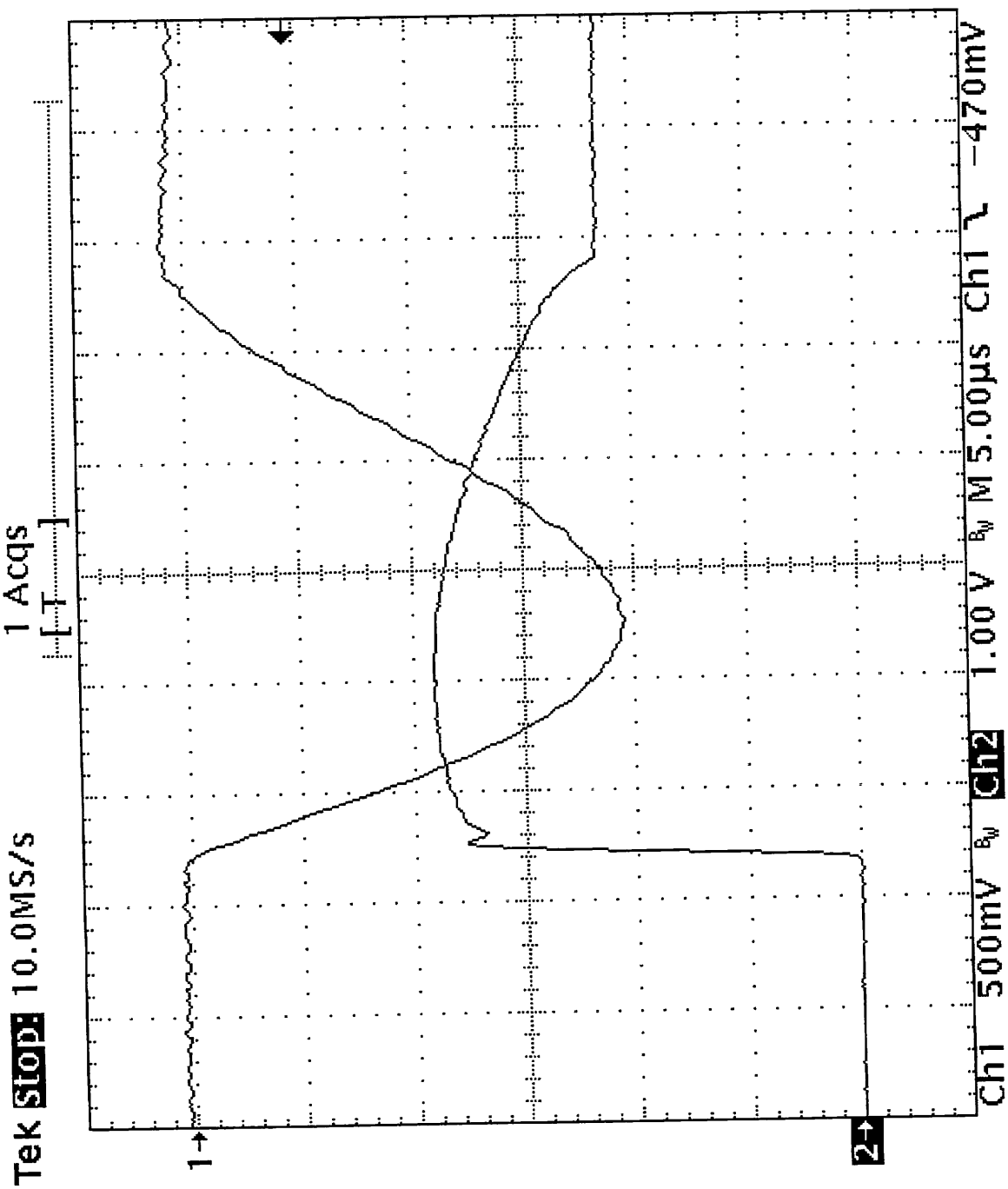
CESI PeC A4522500 oscillogram n. 20



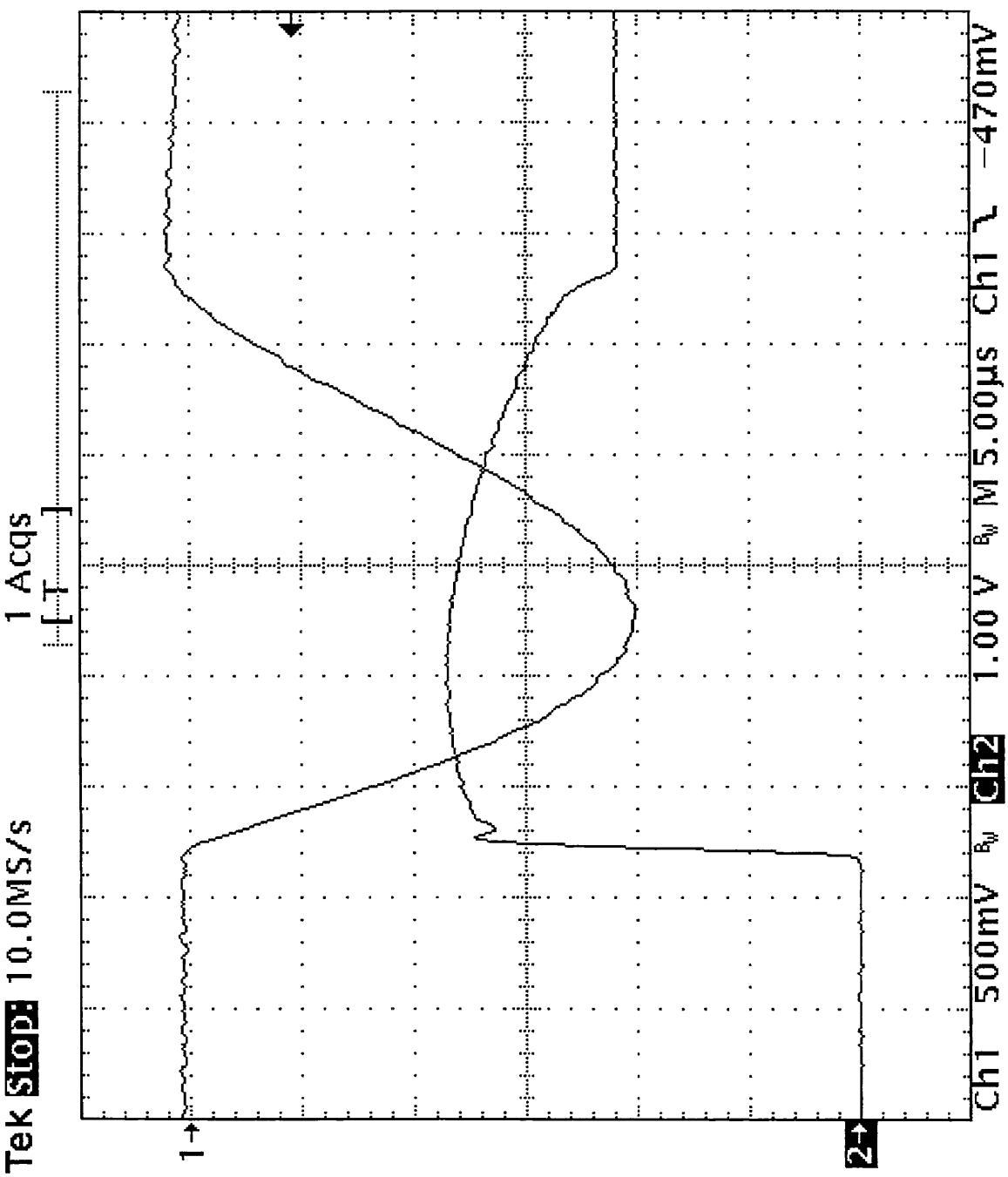
CESI PeC A4522500 oscillogram n. 21



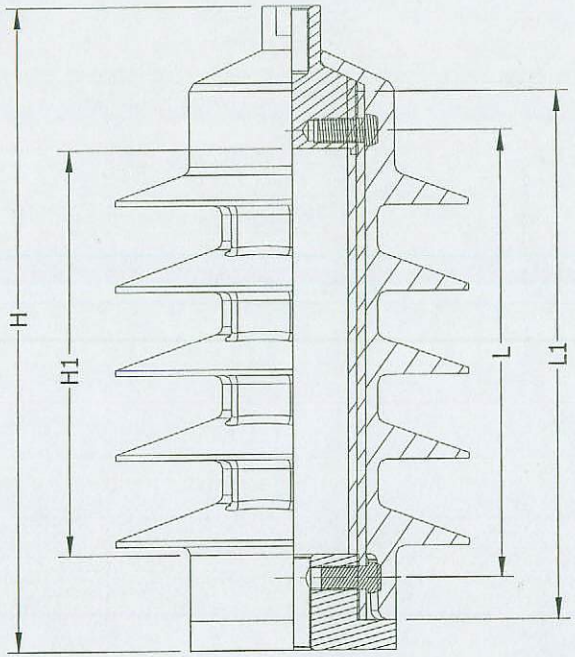
CESI PeC A4522500 oscillogram n. 22



CESI PeC A4522500 oscillogram n. 23



CESI PeC A4522500 oscillogram n. 24



Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks Hl (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
21-48-01	3,75	147	3	67	107	81
21-48-02	5	147	3	67	107	81
21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
21-48-06	15	193	5	113	153	127
21-48-07	17,5	243	6	163	203	177
21-48-08	20	243	6	163	203	177
21-48-09	22,5	243	6	163	203	177
21-48-10	25	270	7	190	230	204
21-48-11	26,25	270	7	190	230	204
21-48-12	27,5	270	7	190	230	204
21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

CESI
PROTOCOLLO A5/0C07 07 n.1
DATA 23 FEB. 2005
Firma

IZO ELEKTRO... ISO2768 -

	Date:	Name:	Signature:
Izdelal:	27.8.03	R. Kurnik	
Pregledal:	1.9.03	P. Pungercar	
Odobril:	1.9.03	P. Pungercar	

Opombe:

Measure: 7:10 Weight:
Material:
Type: SURGE ARRESTER 2SS15N
Code: 21-48-00 Sheet: 1/1
Izdelek: Prip.:

Test Report

CESI Sinal n° 0030 Approved

Client	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Tested equipment	Housing for polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	Insulation withstand tests
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	**from** January 31, 2005 **to** January 31, 2005

No. of pages	13	**No. of pages annexed**	5
Issue date	February 23, 2005		
Prepared	BU PeC - L. Podavitte		
Verified	BU PeC - A. Sironi		
Approved	BU PeC - M. de Nigris		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

Tests witnessed by:-----

Identification of the object:

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5006707 No. 1, is annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 26, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L. Podavitte , Mr I. Guacci, Mr M. Gregori
Test laboratory	P180
Activity code	19774B

Rated characteristics of the tested object assigned by the Client

Metal-oxide surge arrester	
Manufacturer	IZOELEKTRO d.o.o. – Pesnica Pri Maboru (Slovenia).
Year of manufacture	2004

Electrical and mechanical characteristics	
Nominal discharge current (I_r)	10 kA
Line discharge class	1
Rated voltage (U_r)	45 kV
Continuous operating voltage (U_c)	36 kV
Lightning impulse protection level - U_{LIPL}	**114.3 kV**
Rated frequency	50-60 Hz

Geometrical characteristics	
Total height	405 mm
Number of sheds	12
Shed diameter	116 mm
Shed spacing	29 mm
Arcing distance	380 mm
Creepage (leakage)distance	910 mm

Other characteristics	
Housing material	silicone
Housing color	grey

Note 1:
The sample was suitably prepared for the test by replacing active parts with insulating material

Note 2:
The switching impulse protection level U_{SIPL} is calculated on the base of UL_{IPL} claimed by the manufacturer and of the residual voltage test (see CESI report A4/522503) as:

$U_{SIPL} = UL_{IPL}$ X (30.50/38.78) = 114.3 X (30.50/38.78) = 89.9 kV

Name and signature of Client's witness:

Photograph of the test object

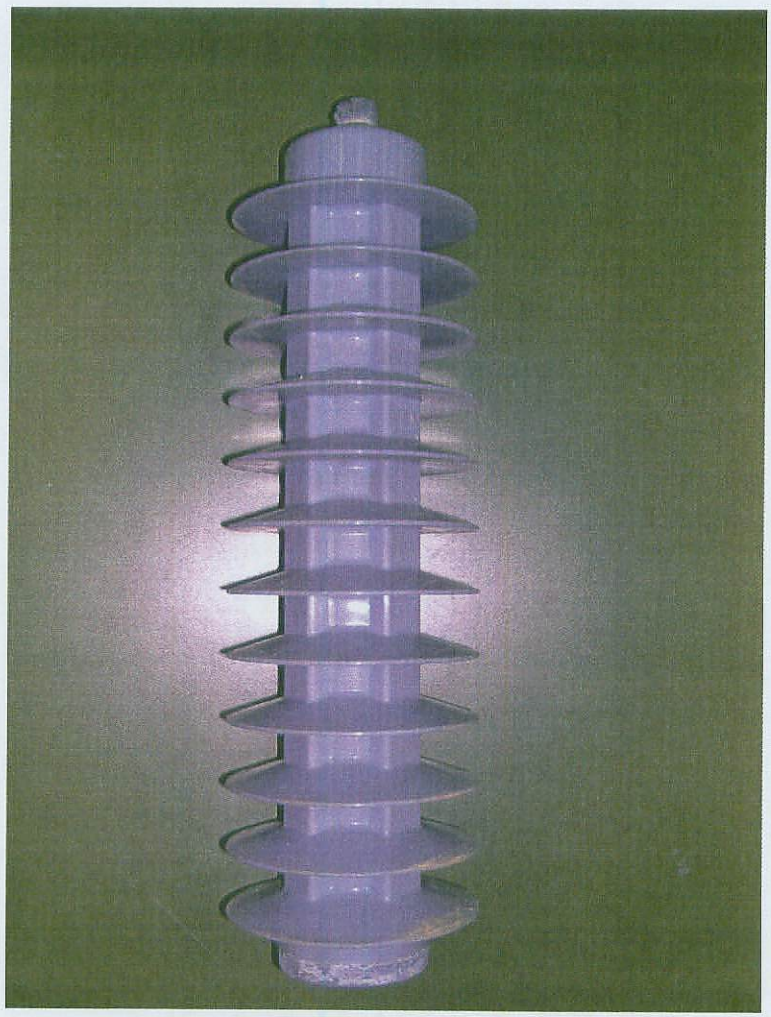


Photo no. 1

Photograph of the test arrangement

Photo no. 2

Reference Standard

IEC 60099-4 (2004-05): "Metal-oxide surge arrester without gaps for a.c. system", clause 8.2

Test carried out and identification of the test objects

Test carried out	Number of test objects	Test object identification
Dry lightning impulse withstand tests	1	IWT1
Wet power frequency withstand tests		

Test procedure

Dry lightning impulse withstand test

The test sample has been submitted to fifteen voltage impulses for each polarity having waweshape 1,2/50 μs and peak value equal to 148,6 kVpeak . The test has been performed in dry condition.

The test voltage is calculated as 1.3 times $\mathbf{UL_{IPL}}$

Wet power frequency withstand test

The power frequency voltage has been applied for 60 second on the sample at the value equal to 95,3 kVpk (67.4 kVrms).
The test has been performed in wet condition (as defined by IEC st. 60060-1 (1989))

The test voltage (peak value) is calculate as 1.06 times $\mathbf{U_{SIPL}}$

Summary of test results

Dry lightning impulse withstand test
No flashover occurred during any of the impulse application

Wet power frequency withstand test
Non flashover occurred

The test result positive

Dry lightning impulse withstand voltage test

Test No.: 1

Test object: HOusing for polymer housed metal-oxide surge arrester
Test circuit: A0002
Arrangement: see photograph pag n.6

Atmospheric conditions and correction factor			
b	t_d/t_w	h	K_t
kPa	°C	g / m³	
101,3	12/5	2,99	0,965

Date: January 31, 2005

test condition	polarity	impulse generator charging voltage	voltage required U	voltage applied U x K_t	A: (o) withstand (x) flashover B: oscillogram No. C: peak voltage [kV] D: time to discharge (μs)														
		kV	kV_{peak}	kV_{peak}															
IWT1	NEG	72,6	148,6	143,4	A	o	o	o	o	o	o	o	o	o	o	o	o	o	o
					B	03													
					C	143,1	143,5	144	143,7	143,5	144	144	143,8	143,6	143,6	144	144	143,8	143,6	144
					D														
IWT1	POS.	72,6	148,6	143,4	A	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
					B	04													
					C	143,4	143,6	144	143,8	144	144	143,9	144	143,6	143	144	143,7	143,5	144	143,7
					D														

continued

Wet power frequency withstand voltage test

Test No.: 2

Test object: Housing for polymer housed metal-oxide surge arrester
Test circuit: A0058-A0059
Arrangement: see photograph pag n.6

Atmospheric conditions and correction factor			
b	t_d/t_w	h	K_t
kPa	°C	g / m³	
101,03	12/5	2,99	1,0

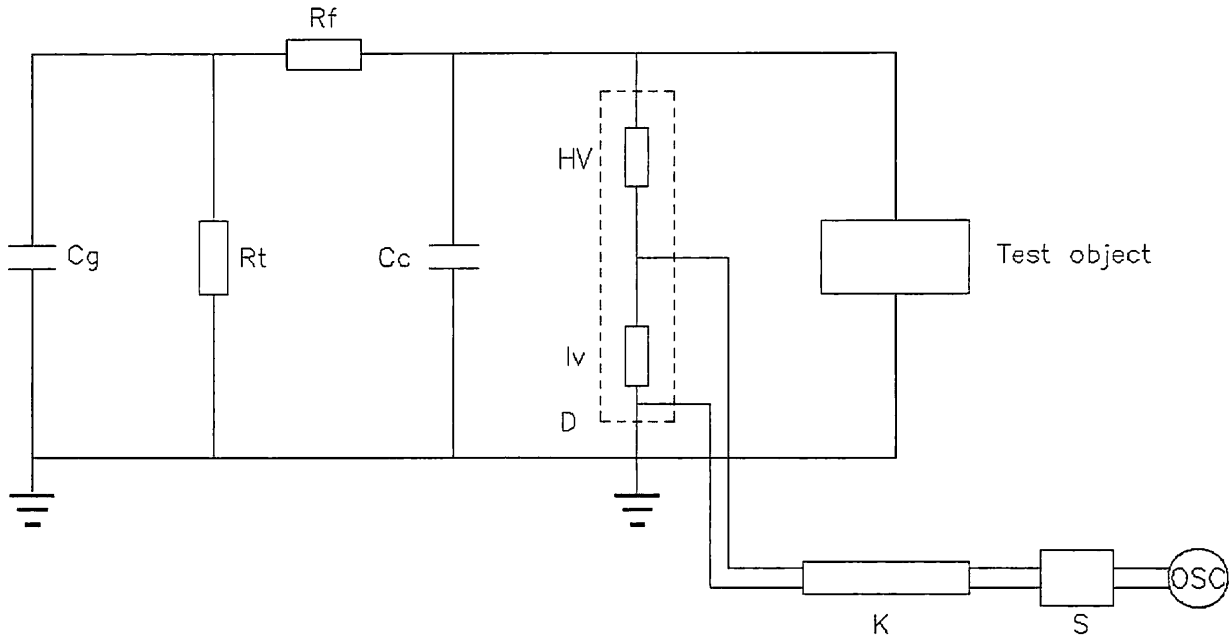
Precipitation conditions					
	Precipitation rate (mm/min)			Water temperature	Water resistivity
	top	center	bottom	°C	Ω * m
vertical	1,2	1,2	1,2	11	100
horizontal	1,2	1,2	1,2		

Date: January 31, 2005

test condition	voltage		test voltage				test duration	Test result	Notes
	required U	applied U x K_t	V_1	$V_{AT} = k_1 V_1$ (k_1 = 3500)	V_2	$V_{AT} = k_2 V_2$ (k_2 = ---)			
	kV_{rms}	kV_{rms}	V_{rms}	kV_{rms}	V_{rms}	kV_{rms}	s		
IWT1	67,4	67,4	19,25	67,4	---	---	60	withstand	

continued

Circuit A0002



Impulse generator

No. of stages: 2
C_g: 250 nF
R_t: 280 Ω (140 x 2)
R_f: 320 Ω (140+60+40+80)
C_C: 0,6 nF

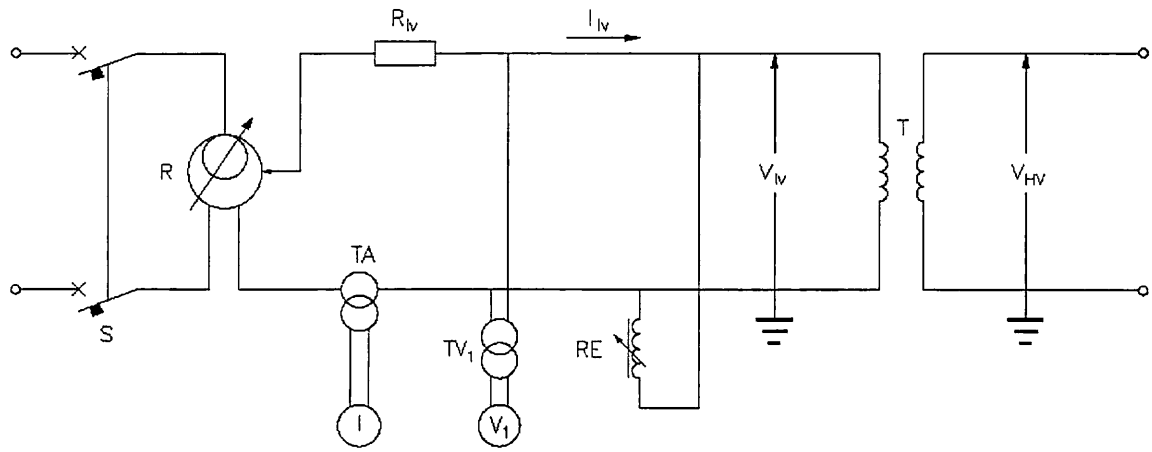
Voltage measuring system CESI No. 9792

D - divider PASSONI & VILLA type RC series CESI No. 6700; scale factor 25662,7
HV - high voltage capacitance 600 pF
lv - low voltage unit CESI No. 6704
K - coaxial cable
S - attenuation and termination unit CESI No. 14924
OSC - digital oscilloscope type TEKTRONIX TDS 430A CESI No. 14232

	Measured waveshape		
	polarity	time	oscillogram
		µs	No.
front	negative	1,06	01
tail		54,6	02

	Check of the test circuit		
	Charging voltage V_c	Measured voltage V_m	η $V_m / (V_c \cdot n_{stages})$
polarity	kV/stage	kV	
negative	58,3	114,5	0,981

Circuit A0058



Power frequency test circuit

R - regulation group PIVI composed by:
- single-phase voltage converter PIVI; power 210 kVA; voltage 380 V/0÷610 V
- booster transformer PIVI; power 200 kVA; voltage 600 V /6 kV

R_{lv} - protection resistor TELEMA; R= 2 Ω

TA - current transformer type CGS; ratio 50 A/5 A; CESI No. 03399

I - direct reading digital amperometer

TV_1 - voltage transformer type ALSTOM; ratio 6 kV/100 V

V_1 - digital voltmeter AGILENT 34401A; CESI No. 23082

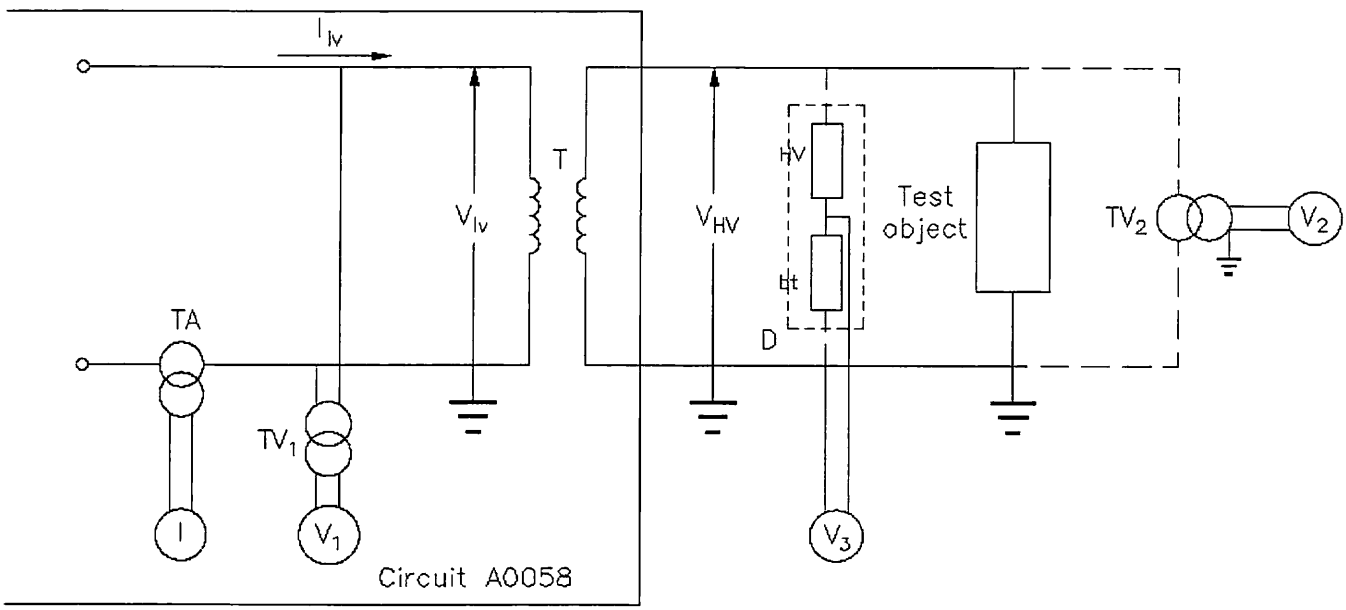
T - booster transformer CGE mod. KOC; secondary winding power 700 kVA; voltage 6 kV /350 kV; No. of units 1; ratio /

RE - variable reactor PIVI; power 600 kVA; voltage / kV; No. of units /

Tripping of the circuit breaker S

I_N	k_{TA}	instantaneous tripping			time delayed tripping		
		setting			setting		
		s_1	$s_1 \times I_N$	t_1	s_2	$s_2 \times I_N$	t_2
5	10	1	5	0,05	0,5	2,5	0,05

Circuit A0059



Power frequency measuring circuit

TA - current transformer type CGS; ratio 50 A/5 A; CESI No. 03399
I - direct reading digital amperometer
TV_1 - voltage transformer type ALSTOM; ratio 6 kV/100 V
V_1 - digital voltmeter AGILENT 34401A CESI No. 23082

D - voltage divider / type RC series; voltage / kV; HV capacitance / pF; CESI No. /; low voltage arm CESI No. / scale factor /
V_3 - voltmeter CESI No. Not used

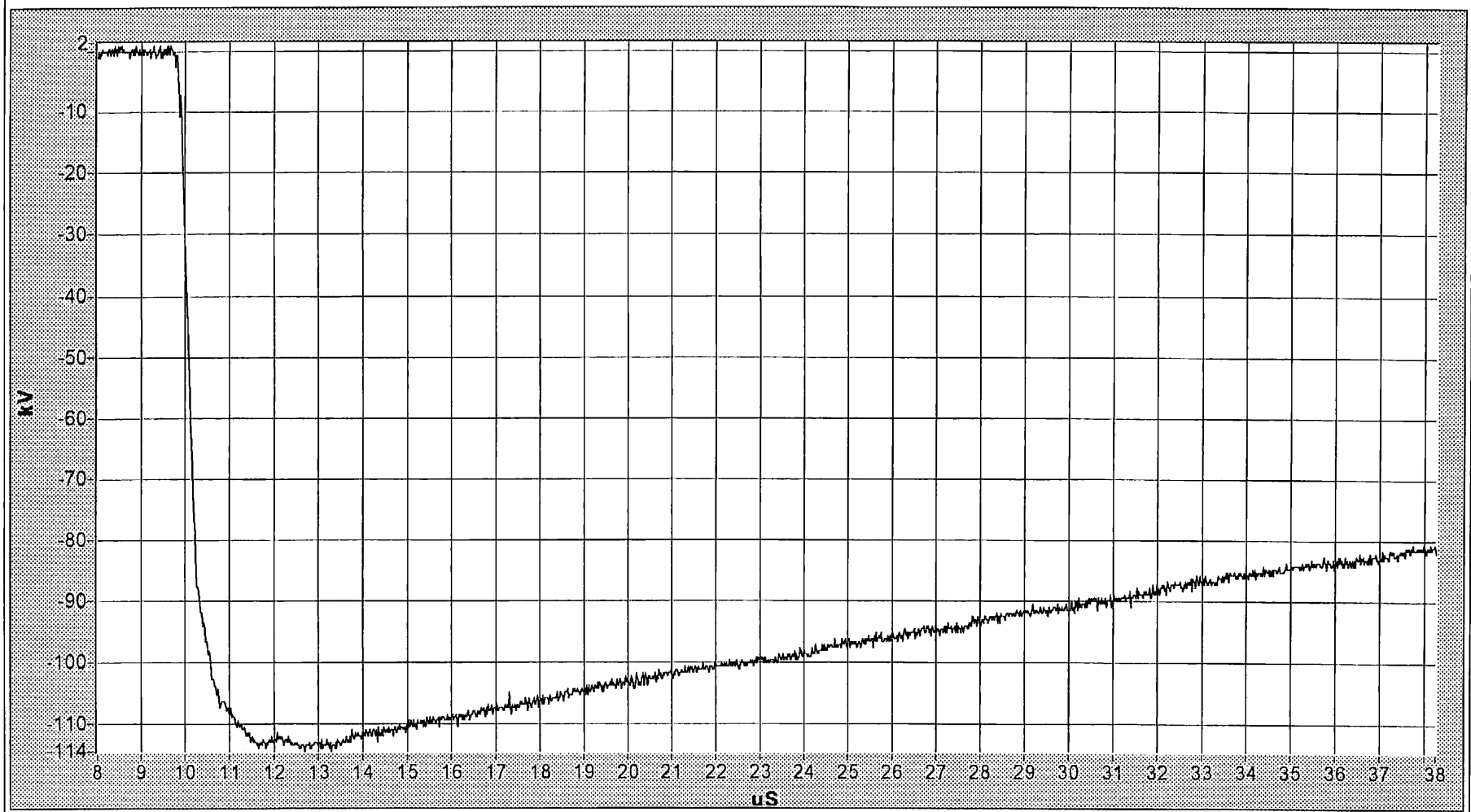
TV_2 - voltage transformer type SCARPA & MAGNANO; ratio 130/100 V; CESI No.5133
V_2 - digital voltmeter AGILENT 34401A CESI No. 23083

Functional check of the test circuit Date: January 31, 2005

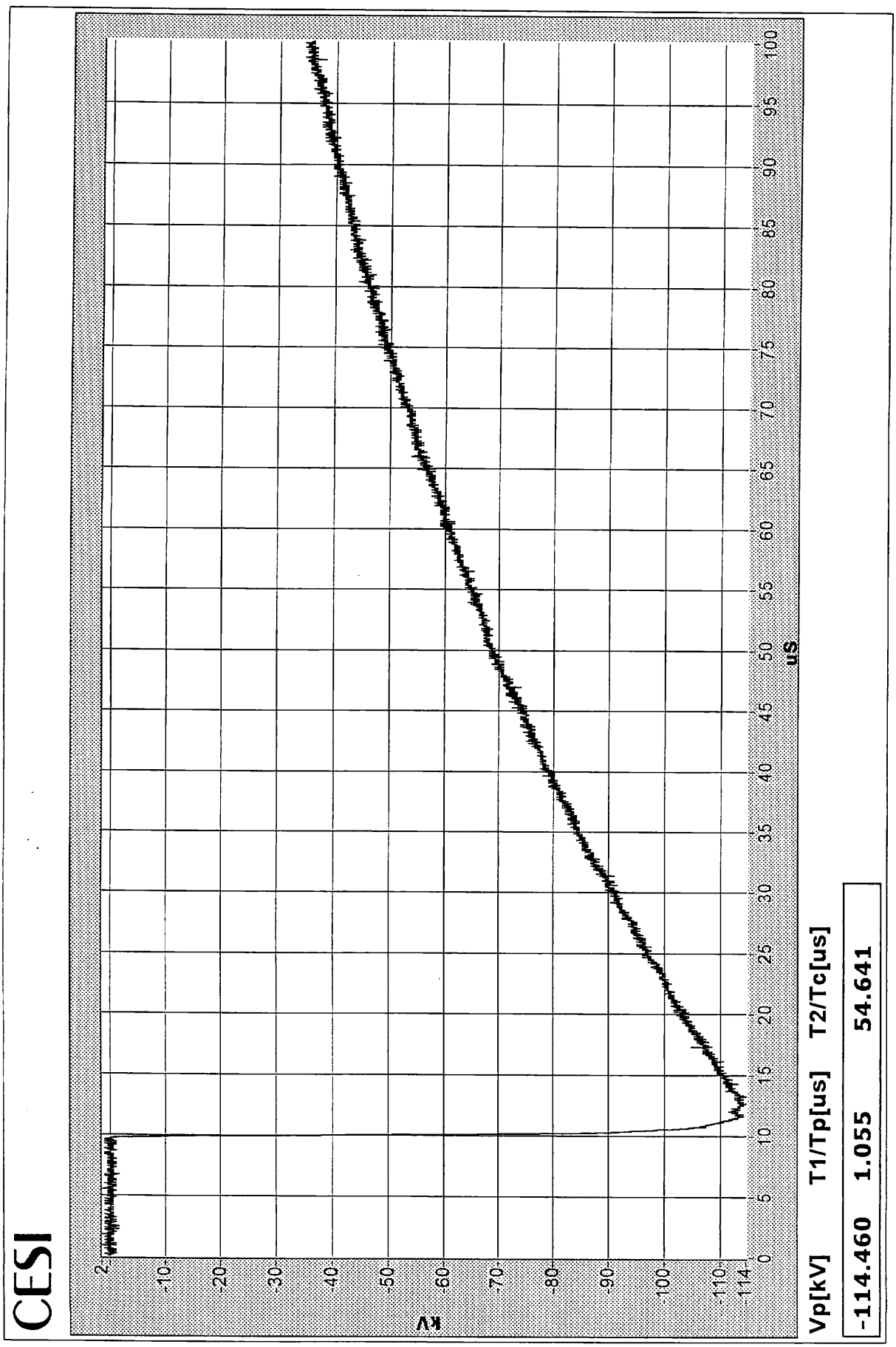
Low voltage				High voltage k_2 = 1300		k_3 =		k_t
V_1	V_{lv}	I	I_{lv}	V_2	V_{HV}	V_3	V_{HV}	V_{HV} / V_1
V	V	A	A	V	kV	V	kV	3500
14,27	856,2	--	1,0	38,34	48,83	-	-	3492

CESI PeC A5003349 oscillogram n. 1

CESI



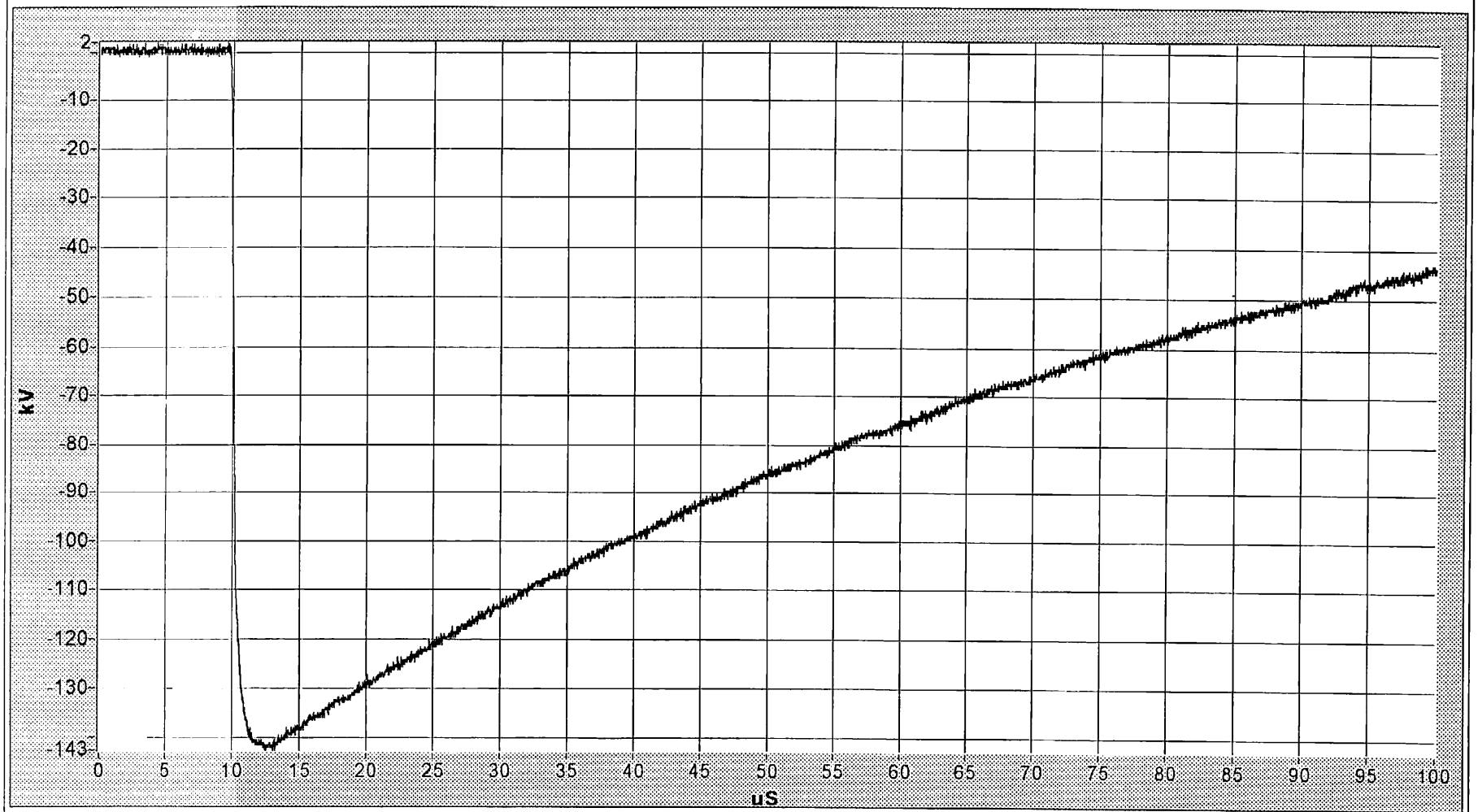
Vp[kV]	T1/Tp[us]	T2/Tc[us]
-114.460	1.055	54.641



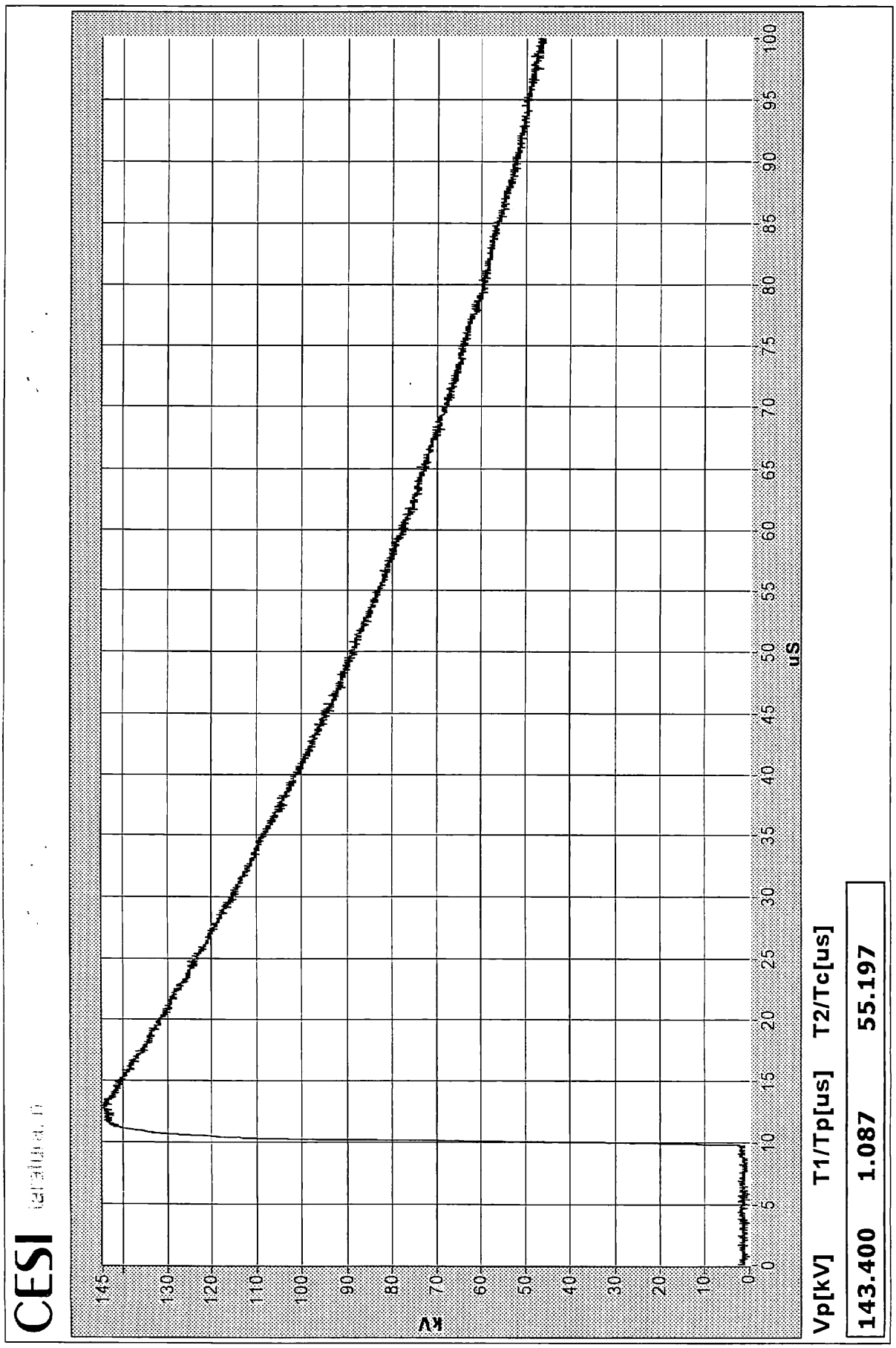
CESI PeC A5003349 oscillogram n. 2

CESI PeC A5003349 oscillogram n. 3

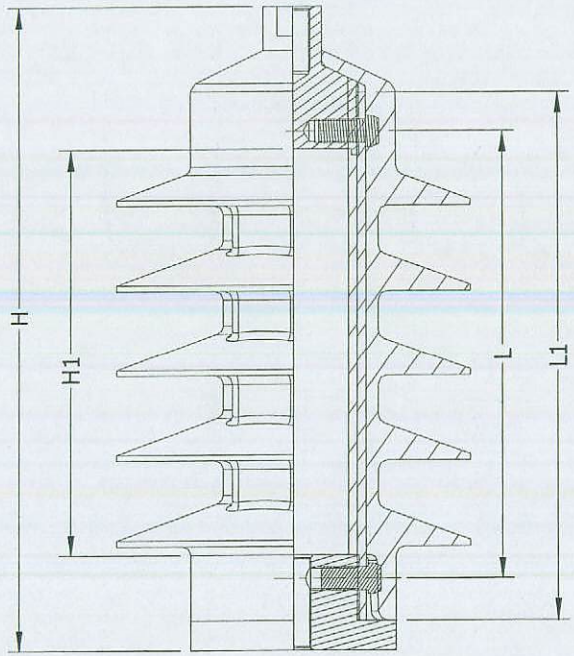
CESI



Vp[kV]	T1/Tp[us]	T2/Tc[us]
-143.105	1.050	54.500



CESI PeC A5003349 oscillogram n. 4



Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks Hl (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
21-48-01	3,75	147	3	67	107	81
21-48-02	5	147	3	67	107	81
21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
21-48-06	15	193	5	113	153	127
21-48-07	17,5	243	6	163	203	177
21-48-08	20	243	6	163	203	177
21-48-09	22,5	243	6	163	203	177
21-48-10	25	270	7	190	230	204
21-48-11	26,25	270	7	190	230	204
21-48-12	27,5	270	7	190	230	204
21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

CESI
PROTOCOLLO DATA
A 5/ 0 0 6 7 07 n.1 23 FEB. 2005
Firma Marco Gregori

	Date:	Name:	Signature:
Izdelal:	27.8.03	R. Kurnik	
Pregledal:	1.9.03	P. Pungercar	
Odobril:	1.9.03	P. Pungercar	

ZO ELEKTRO... ISO2768 -
Measure: 7:10 Weight:
Material:
Type: SURGE ARRESTER 2SS15N
Code: 21-48-00 Sheet: 1/1
Izdelek: Prip.:
Opombe:

Test Report

CESI Sinal n° 0030 Approved

Client	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Tested equipment	Polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	Partial discharge test
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	**from** January 26, 2005 **to** January 26, 2005

No. of pages	11	**No. of pages annexed**	4
Issue date	February 23, 2005		
Prepared	BU PeC - M. Gregori Marco Gregori		
Verified	BU PeC - A. Sironi All. S.		
Approved	BU PeC - M. de Nigris		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

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Giacinto Motta spa

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20134 Milano - Italia
Telefono +39 022125.1
Fax +39 0221255440
http://www.cesi.it

Capitale sociale 8 550 000 Euro
interamente versato
Codice fiscale e numero
iscrizione CCIAA 00793580150

Registro Imprese di Milano
Sezione Ordinaria
N. R.E.A. 429222
P.I. IT00793580150

Tests witnessed by:-----

Identification of the object:

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5006707 No. 1, is annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 26, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L. Podavitte
Test laboratory	P177
Activity code	19774B

Rated characteristics of the tested object assigned by the Client

Metal-oxide surge arrester	
Manufacturer	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia).
Year of manufacture	2004
Electrical characteristics	
Nominal discharge current (I_r)	10 kA
Line discharge class	1
Rated voltage (U_r)	45 kV
Continuous operating voltage (U_c)	36 kV
Rated frequency	50-60 Hz
Geometrical characteristics	
Total height	405 mm
Number of sheds	12
Shed diameter	116 mm
Shed spacing	29 mm
Other characteristics	
Housing material	silicone
Housing color	grey

Name and signature of Client's witness:

Photograph of the test object

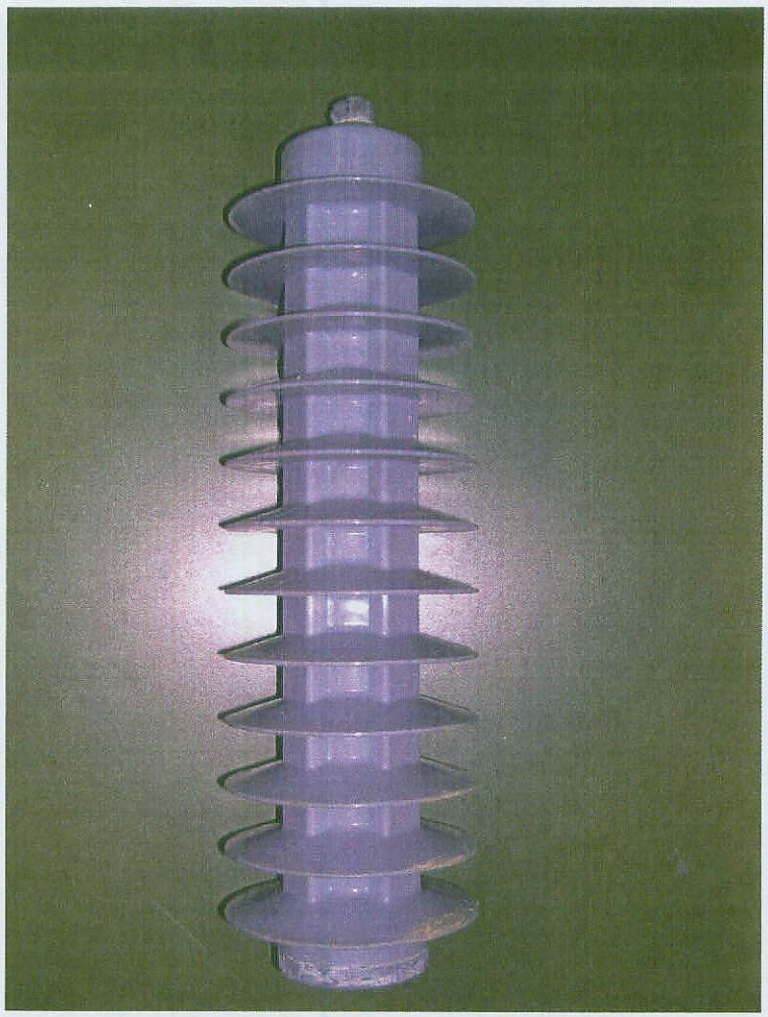


Photo no. 1

Reference Standard

IEC 60099-4 (2004-05): "Metal-oxide surge arrester without gaps for a.c. system", clause 10.8.8.,

Test carried out and identification of the test objects

Test carried out	Number of test objects	Test object identification
Partial discharge test	1	PD1

Test procedure

The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec.
The voltage has been decreased to 1.05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard (IEC 60270).

Summary of test results

The partial discharge level found was less than 1 pC (background noise).
The test result is to be considered positive.

Test setting for the test

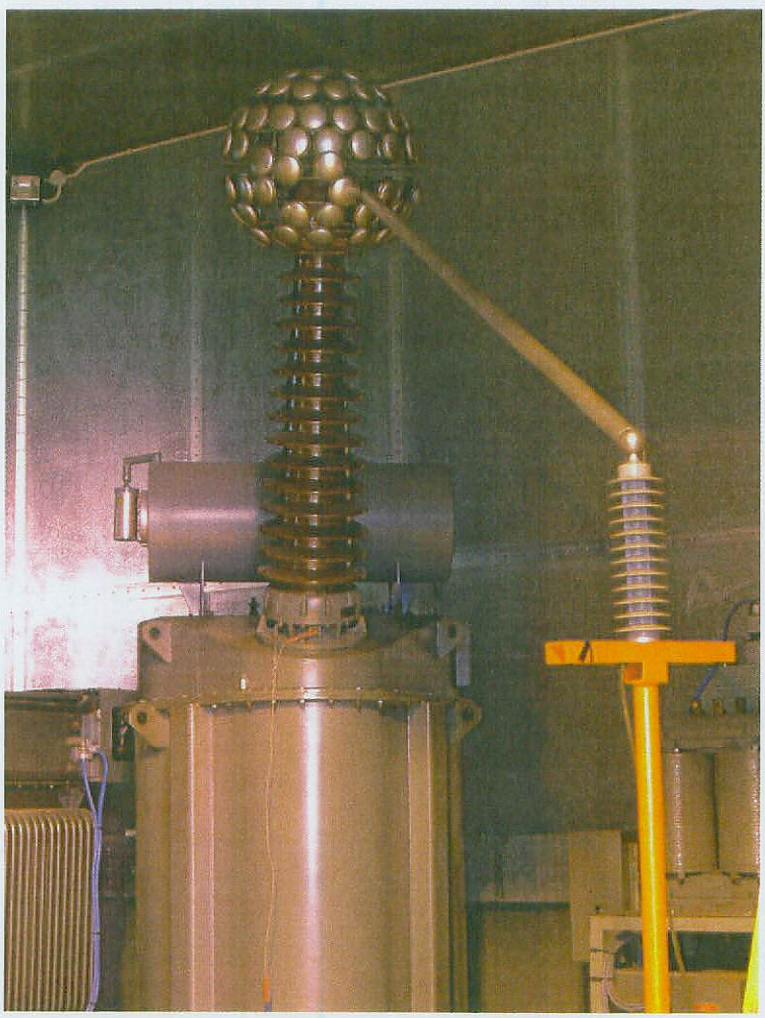


Photo no. 2

Measurement of partial discharges

Test circuit: A0127
Measurement circuit: A0022 "direct" calibration:55 pC/mV see oscillogram. no.01 – background noise ≤ 1 pC see oscillogram no.02
Arrangement: see pag. 8

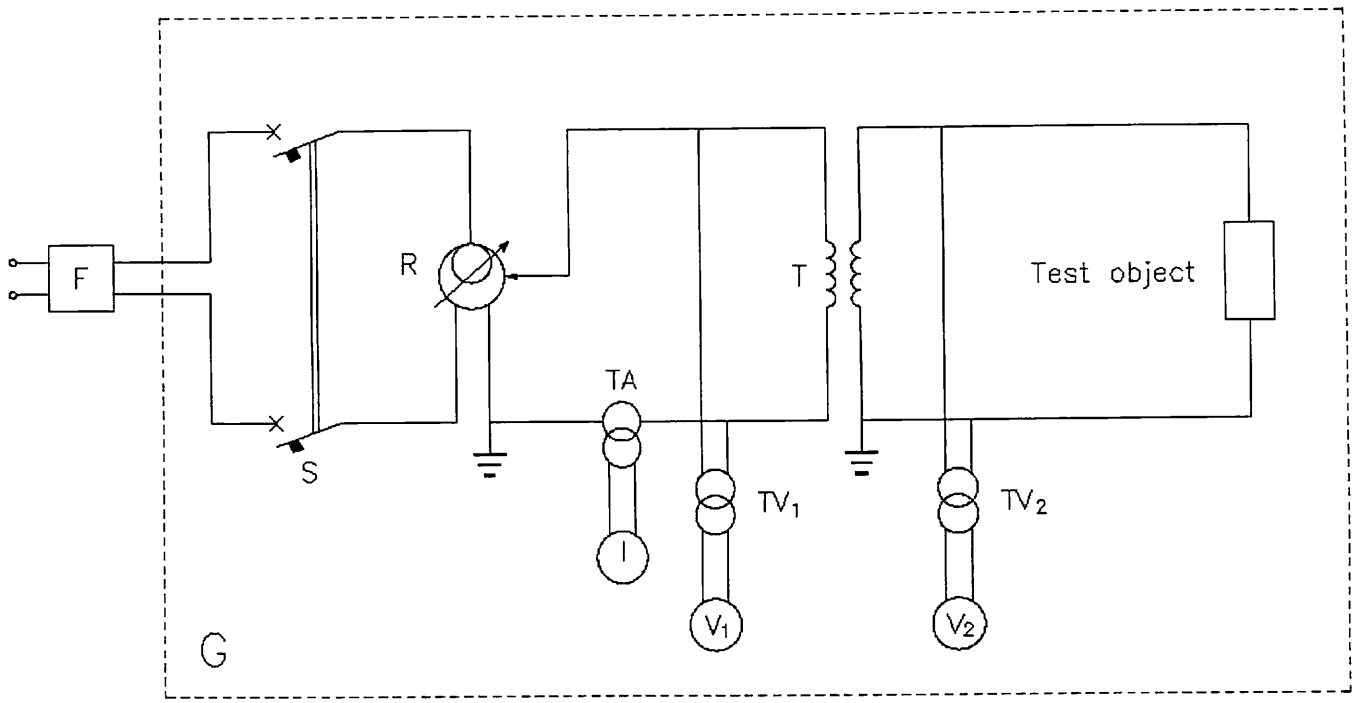
Atmospheric conditions and correction factor			
b	t_d/t_w	h	Relative umidity
kPa	°C	g / m^3	%
99,83	18 (13)	8,60	56,1

Date: January 26, 2005

Test sample	Applied voltage	Duration of voltage application	Temperature of the test object	Partial discharge measurement		Oscillogram	Notes
				voltage increase Q max	voltage decrease Q max		
	kV_{rms}	s	°C	pC	pC	No.	
MI	45,0	2-10	18	---	----	----	
MI	37,8	60	18		≤ 1	03	

continued

Circuit A0127

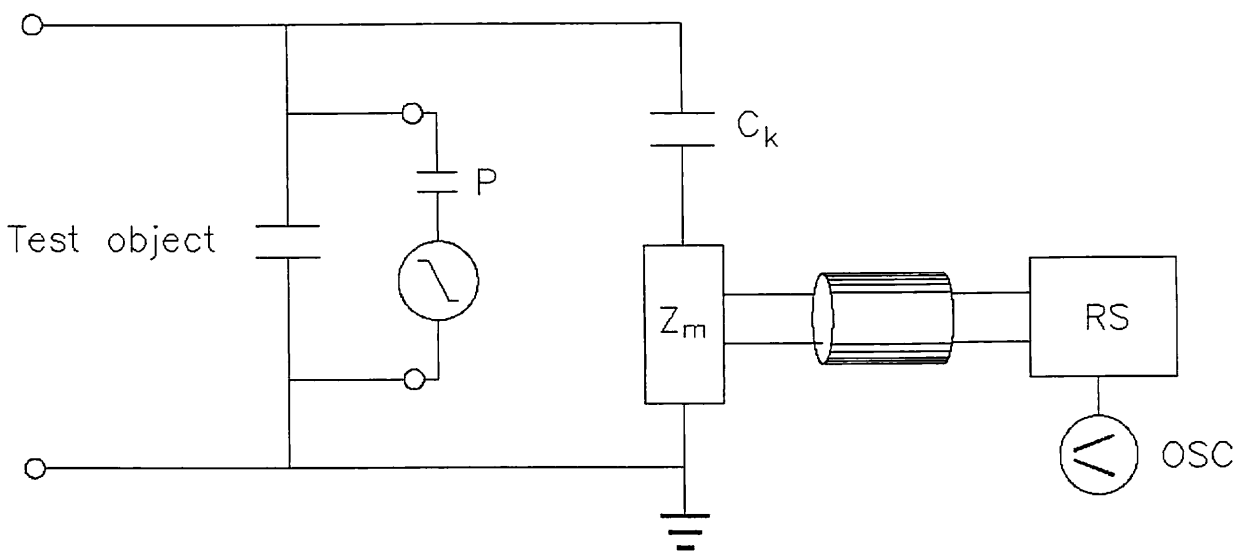


Power-frequency high voltage circuit.

F	- wide band rejection filter TELEC; 380 V; 100 A
G	- Faraday cage
S	- single phase circuit breaker SACE; 600 V; 800 A
R	- regulator CORMES; power 66 kVA; voltage 380 V/0÷220 V
TA	- current transformer CGS, ratio 150-300 A/5 A
I	- analogic amperometer
TV_1	- voltage transformer; ratio 440 V/ 100 V
V_1	- analogic voltmeter
T	- booster transformer PIVI; power 250 kVA; voltage 200-400 V/250 kV
TV_2	- voltage transformer PIVI; ratio 250 kV/ 100 V
V_2	- direct reading digital voltmeter FLUKE; CESI No. 06393

Circuit A0022

Partial discharges measurement
Direct circuit - Scheme 1a



P	- calibrator CESI; CESI No. 346
C_k	- coupling capacitor 0,3 nF
Z_m	- coupling impedance
RS	- partial discharge detector HAEFELY TRENCH type TE 571; CESI No. 13281
OSC	- (not used)

HAEFELY TRENCH TETTEX

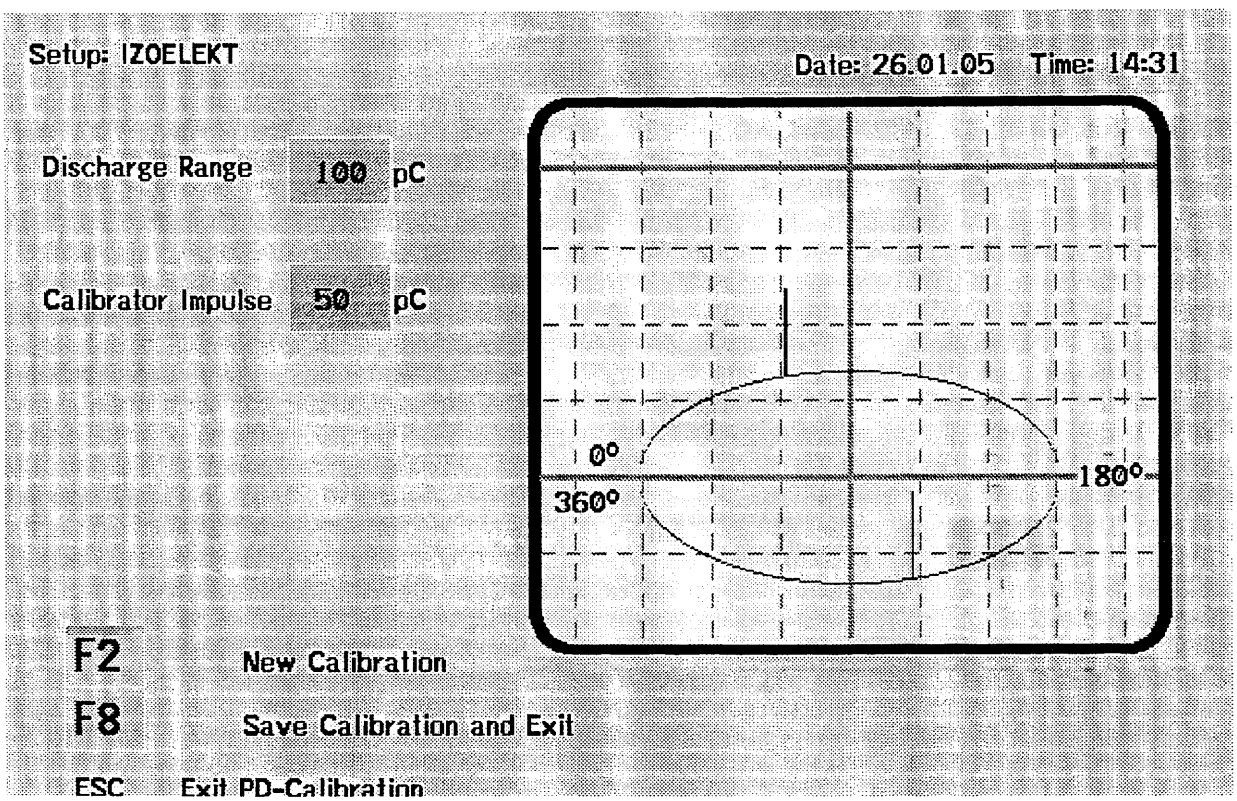
PD-DETECTOR

Info: 1
Measurement name:
Comment:
1st PD Range: 100 pC
Noise Suppression: 5 %
Test Measuring Time: 15 s

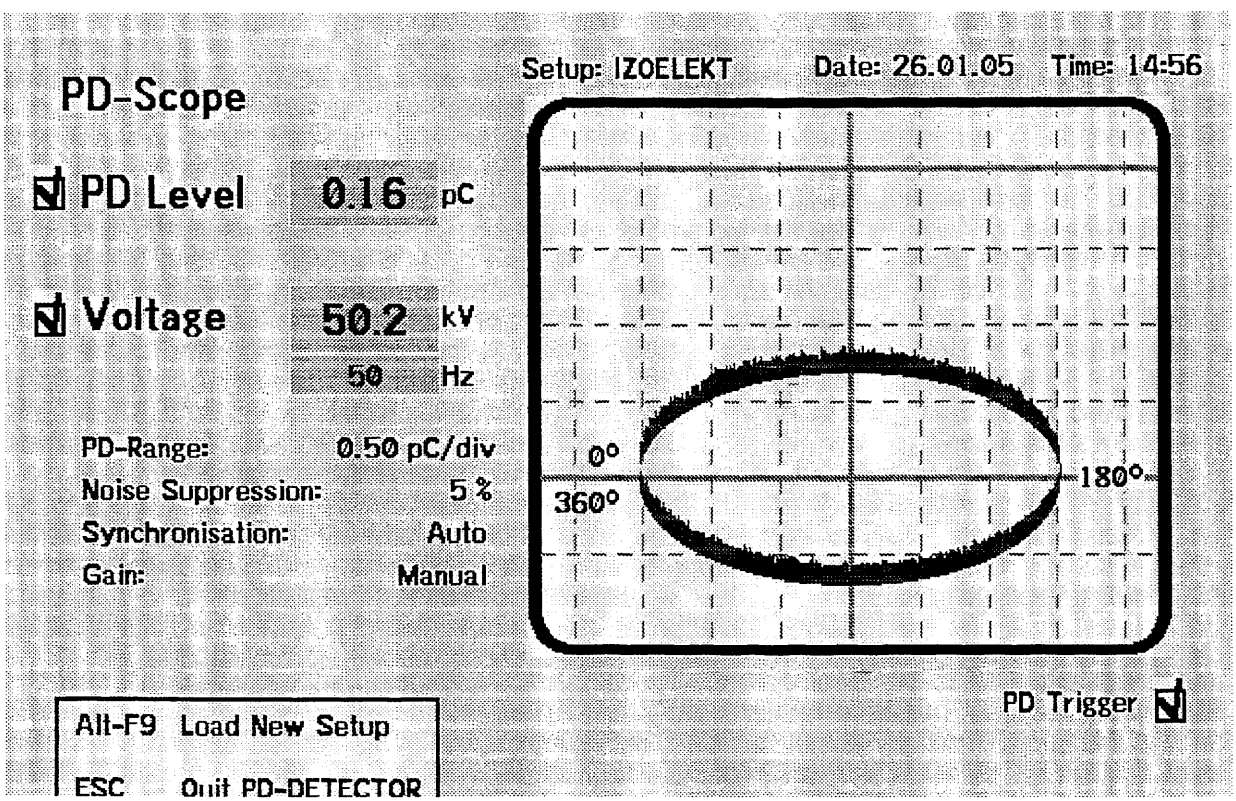
Start date: 00.00.00
Start time: 00:00

2nd PD Range: Not applied
Lockout Time: 7.3 usec
Voltage Range: 36 kV

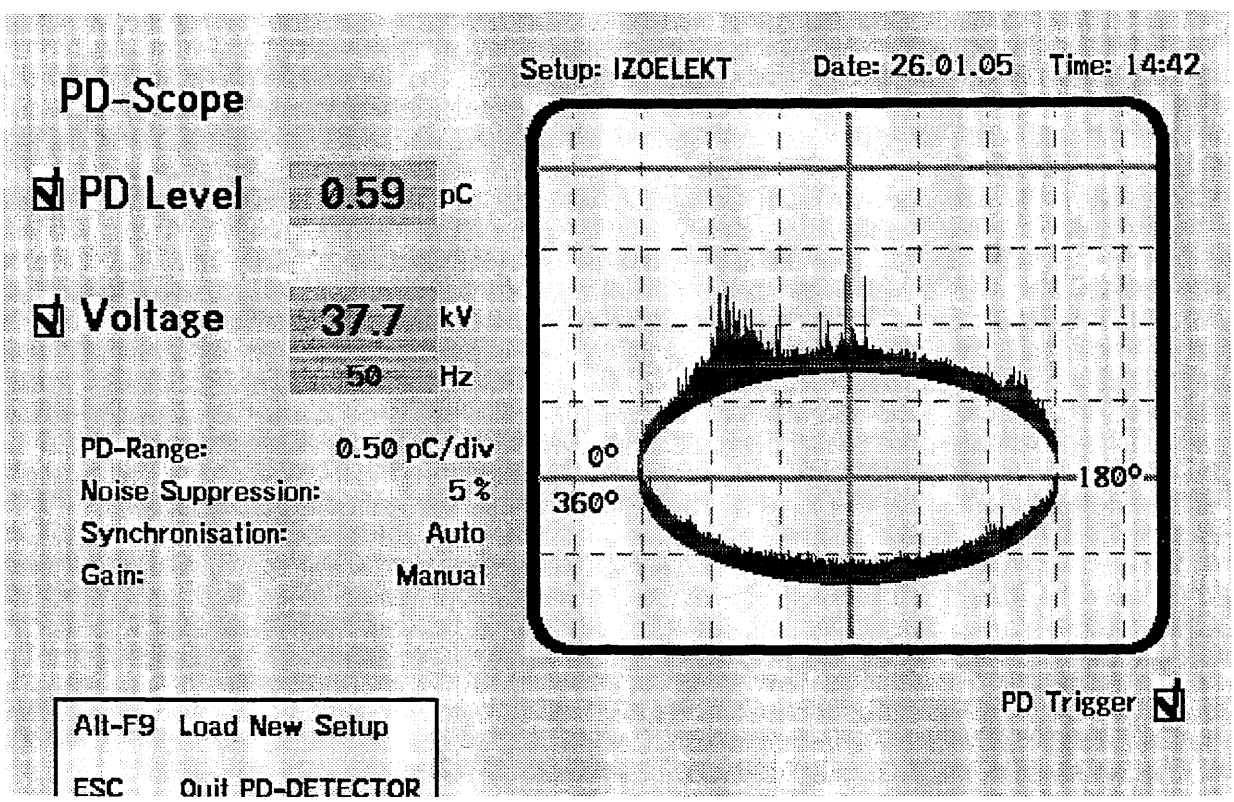
Remarks:



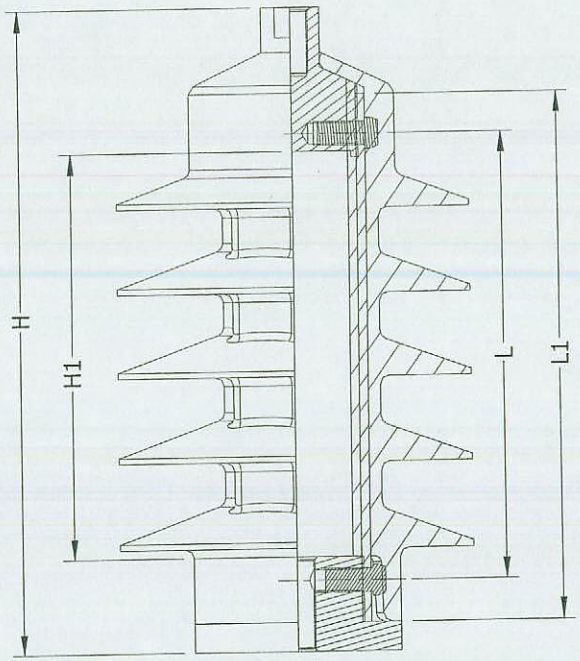
CESI PeC A5002464 oscillogram n. 1



CESI PeC A5002464 oscillogram n. 2



CESI PeC A5002464 oscillogram n. 3



Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks H1 (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
21-48-01	3,75	147	3	67	107	81
21-48-02	5	147	3	67	107	81
21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
21-48-06	15	193	5	113	153	127
21-48-07	17,5	243	6	163	203	177
21-48-08	20	243	6	163	203	177
21-48-09	22,5	243	6	163	203	177
21-48-10	25	270	7	190	230	204
21-48-11	26,25	270	7	190	230	204
21-48-12	27,5	270	7	190	230	204
21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

CESI
PROTOCOLLO A 5/0 0 0 7 0 7 n.1
DATA 23 FEB. 2005
Firma Marco Gopo

IZO ELEKTRO... ISO2768 -

	Date:	Name:	Signature:
Izdelal:	27.8.03	R. Kurnik	
Pregledal:	1.9.03	P. Pungercar	
Odobril:	1.9.03	P. Pungercar	

Opombe:

Measure: 2:10 Weight:
Material:
Type: SURGE ARRESTER 2SS15N
Code: 21-48-00 Sheet: 1/1
Izdelek: Prip.:

Client	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Tested equipment	Polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	High current impulse operating duty test
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	**from** September 20, 2005 **to** September 23, 2005

No. of pages	23	**No. of pages annexed**	45
Issue date	November 14, 2005		
Prepared	BU PeC - M. Gregori		
Verified	BU PeC - R. Malgesini		
Approved	BU PeC - M. de Nigris		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

Tests witnessed by:-----

Identification of the object: The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5006707 No. 1, is annexed to this document.

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	May 10, 2005
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	L. Podavitte, S. Carboni
Test laboratory	P177
Activity code	42836L

Test object characteristics

type: Polymer housed metal-oxide surge arrester section (thermal equivalent)

electrical characteristics (assigned by the client)

Manufacturer's name	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Nominal discharge current - I_N [kA]	10,0
Rated voltage – U_r [kV]	0,9912 x Uref.
Continuous operating voltage - U_c [kV]	0,7930 x Uref.
Reference current - $I_{ref.}$ [mA]	1,4
Line discharge class	1
Rated frequency - [Hz]	50 – 60
year of manufacture	2004

geometrical characteristics (measured on the test sample without thermal insulation)

Height [mm]	195
Number of sheds	5
Shed diameter [mm]	117

other characteristics

Housing material	Silicone
Housing color	grey

Photo no. 1
Photograph of the test object

Reference standard

The test was carried according to the IEC 60099-4 (2004) Standard – Clause 8.5

" Metal-oxide surge arrester without gaps for a.c. system "

Test carried out

test carried out	number of sample tested
High current impulse operating duty test	3

Test object identification

test object names	identification of test sample
polymer housed metal-oxide surge arrester section	OD1 – OD2 - OD3

Test procedure (Foreseen by the relevant standard)

- The power frequency voltage at reference current (I_{ref} = 1,4 mA) has been measured
- The lightning impulse residual voltage at I_N = 10 kA has been measured
- The voltage correction factors have been calculated according to reference standard (see note 1)
- The preconditioning has been performed on surge arrester at ambient temperature according to reference standard as per the following procedure:
  - Twenty shots 8/20 μs at I_N have been applied superimposed to the power frequency at the voltage level 1,2*U_{sc}'. The shots have been applied in four groups of five impulses. The interval between impulses of the same group was 50-60 seconds while the interval between groups was 30 minutes. The polarity of the impulses was the same as that of the half cycle of power frequency voltage during which it occurred (positive) and they were applied 60 electrical degrees before the peak of the power frequency.
  - The samples have been let to cool down to ambient temperature
  - The first high current impulse having waveshape 4/10 μs and peak value equal to 100 kA has been applied
- The surge arrester section kept in an oven at the temperature of 60 °C till thermal equilibrium
- The second high current impulse having waveshape 4/10 μs and peak current equal to 100 kA has been applied. A time shorter than 100 ms after the application of the second high current impulse the sample has been energized at U_{sr}' for 10 sec. and then at the voltage U_c' for 30 min. to verify the thermal stability.
- The lightning impulse residual voltage at I_N = 10,0 kA has been measured during two consecutive shots.

Note:
The corrected test voltages have been calculated according to IEC standard and base on the CESI test report A5009883 (accelerated ageing test), in the following steps

- **The reference voltages have been measured and the test voltages have been determined according to the values claimed by the clients. (U_c'=0,8xUref. and U_r'= 0,98xUref.)**
- **The power losses have been measured on the three samples at the U_r' and U_c' and then the voltages have been increased by the higher ratio P_{2ct} / $P_{1ct)}$ (see CESI test report A5009883)**
- **The new test voltage have been called U_{sc} ' and U_{sr} '**

Visual inspection and summary 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	%
OD1	10,05	40,72	9,90	40,59	- 0,32
OD2	10,00	40,84	10,00	40,88	0,10
OD3	10,10	40,78	10,00	40,38	- 0,98

High current impulse operating duty test.

Power frequency voltage-current characteristics.

Test circuit: A0019

Date: September 20 ,2005

Sample No. OD1						
oscillogram	voltage	current	current	Current	power	
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
1	16,34	1,40	1,32	0,64	6,21	Uref
	12,94	0,474	0,382	0,308	0,672	0,7930xUref
	14,28	0,477	0,466	0,347	1,17	Ucs*
	16,21	1,14	1,04	0,57	5,19	0,9912xUref
	16,58	2,21	2,12	0,85	9,17	Urs*

Sample No. OD2						
oscillogram	voltage	current	current	Current	power	
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
2	16,41	1,42	1,40	0,659	6,58	Uref
	13,04	0,436	0,431	0,311	0,723	0,7930xUref
	14,33	0,474	0,465	0,355	1,263	Ucs*
	16,26	1,10	1,09	0,576	5,304	0,9912xUref
	16,64	2,13	2,10	0,847	9,21	Urs*

Sample No. OD3						
oscillogram	voltage	current	current	Current	power	
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	
3	16,28	1,42	1,40	0,659	6,47	Uref
	12,91	0,445	0,421	0,310	0,697	0,7930xUref
	14,22	0,483	0,461	0,354	1,226	Ucs*
	16,14	1,15	1,11	0,584	5,363	0,9912xUref
	16,51	2,22	2,19	0,868	9,37	Urs*

High current impulse operating duty test.

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: September 20, 2005

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
OD1	I_N	53,5	4	8,6/19,5	10,05	40,72
OD2		53,5	5		10,00	40,84
OD3		53,5	6		10,10	40,78

	Oscilloscope settings		
	sampling division	Input	attenuation
	µs	V_{div}	
Current	5	0,5	50:5
Voltage	5	1,0	50:5

Notes:

Voltage correction factor

Date: September 21, 2005

Sample	U_{ref} [1]	U_{rs}' [2]	U_{sc}' [3]	U_*' [4]
No.	kV	kV	kV	kV
OD1	16,34	16,58	14,28	17,136
OD2	16,41	16,64	14,33	17,196
OD3	16,28	16,51	14,22	17,064

[1] U_{ref} : measured reference voltage
[2] U_{sr}' : corrected rated voltage [4] = [1] × [2]
[3] U_{sc}' : corrected continuous operating voltage [3] = [1] × [3]
[4] U'_* : corrected voltage to be applied during the conditioning [4] = 1.2 × [3]

High current impulse operating duty test.

Conditioning

Test circuit: A0015

Date: September 21, 2005

Imp.	Osc.	Sample No.OD1		Osc.	Sample No OD2		Osc.	Sample No. OD3	
		Charging	peak current		Charging	Peak		charging	peak current
No.	No.	kV	kA	No.	kV	kA	No.	kV	kA
1	7	40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
2		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
3		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
4		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
5	8	40,5 x 2	10,0	9	40,5 x 2	10,0	10	40,5 x 2	10,0
6		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
7		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
8		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
9		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
10	11	40,5 x 2	10,0	12	40,5 x 2	10,0	13	40,5 x 2	10,0
11		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
12		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
13		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
14		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
15		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
16		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
17		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
18		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
19		40,5 x 2	10,0		40,5 x 2	10,0		40,5 x 2	10,0
20	14	40,5 x 2	10,0	15	40,5 x 2	10,0	16	40,5 x 2	10,0

Power frequency voltage applied to the test sample	Sample No. OD1	Sample No. OD2	Sample No. OD3
	17,136	17,196	17,064

	Oscilloscope settings		
	sampling division	Input	attenuation
	ms	V_{div}	
Current	10	0,5	50:5
Voltage	10	2,0	50:5

Notes:

High current impulse operating duty test. IEC 60099-4 Standard

Application of the first high current impulse

Test circuit: A0121

Date: September 22, 2005

Sample	Impulse	Charging voltage	Oscillogram	Residual voltage	Discharge current	Current waveshape
No.	No.	kV	No.	kV	kA	
OD1	1	89 x 2	17	---	96	4,5/9,6µs opposite polarity 4 %
OD2		89 x 2	18	---	95	
OD3		89 x 2	19	---	97	

	Oscilloscope settings		
	sampling division	Input	attenuation
	µs	V_{div}	
Current	2	0,5	300:5
Voltage	---	---	----

Notes:

High current impulse operating duty test. IEC 60099-4 Standard

Application of the second high current impulse, of the rated voltage U_{rs}' and evaluation of thermal stability

Test circuit: A0123-A0020-A0131

Sample No.: OD1

Preheating temperature: 61 °C

Date: September 22, 2005

Second high current impulse application

Oscillogram	Charging voltage	Residual voltage	Discharge current	Current waveshape
No.	kV	kV	kA	µs
20	89 x 2	---	95	4,5/9,6

U_{rs}' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA_{cr}	- mA_{cr}	W
21	0	16,58	117	163	---
22	10		70	115	---

U_{sc}' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA_{cr}	- mA_{cr}	W
23	0	14,28	12,3	21,0	82,0
	5		6,40	12,90	46,12
	10		4,80	9,70	34,50
24	15		4,50	9,20	33,10
	20		4,15	8,50	30,10
	25		4,10	8,30	29,50
25	30		4,00	8,10	29,00

Continued

Sample No.: OD2

Preheating temperature: 61 °C

Date: September 22, 2005

Second high current impulse application

Oscillogram	Charging voltage	Residual voltage	Discharge current	Current waveshape
No.	kV	kV	kA	µs
26	89 x 2	---	95	4,5/9,6

U_{rs}' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA_{cr}	- mA_{cr}	W
27	0	16,64	108	173	---
28	10		79	108	---

U_{sc}' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA_{cr}	- mA_{cr}	W
29	0	14,33	11,2	20,0	80,0
	5		8,1	15,2	57,9
	10		7,8	14,1	51,8
30	15		7,4	13,1	51,4
	20		7,3	13,0	51,1
	25		7,2	12,8	51,0
31	30		7,1	12,7	50,8

Continued

Sample No.: OD3

Preheating temperature: 61 °C

Date: September 22, 2005

Second high current impulse application

Oscillogram	Charging voltage	Residual voltage	Discharge current	Current waveshape
No.	kV	kV	kA	µs
32	89 x 2	---	95	4,5/9,6

U_{rs}' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	s	kV	+ mA_{cr}	- mA_{cr}	W
33	0	16,51	106	178	---
34	10		75	100	---

U_{sc}' voltage application

Oscillogram	Time	Voltage	Current	Current	Power
No.	min	kV	+ mA_{cr}	- mA_{cr}	W
35	0	14,22	12,4	20,7	77,0
	5		5,27	9,95	37,0
	10		4,60	8,70	31,70
36	15		4,30	8,16	29,60
	20		4,08	7,78	28,1
	25		3,85	7,45	26,7
37	30		3,60	7,10	26,0

High current impulse operating duty test. IEC 60099-4 Standard

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

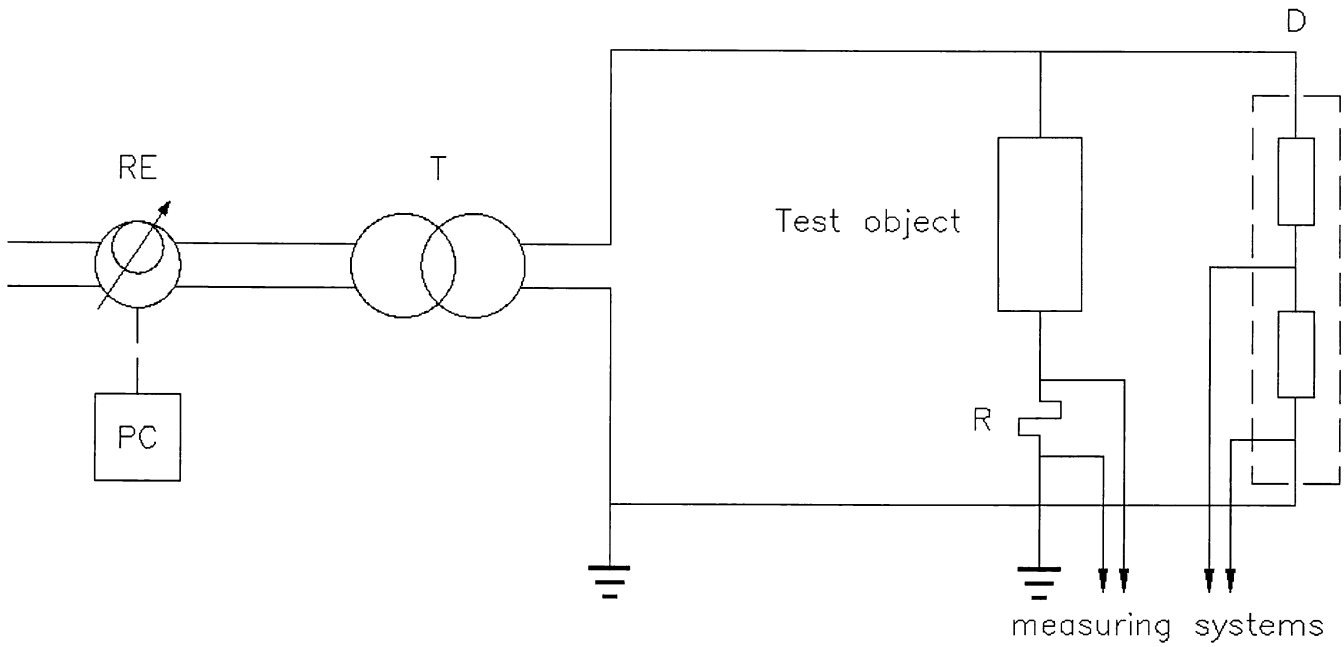
Date: September 23, 2005

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
OD1	I_N	53,5	38	8,6/19,5	10,00	40,50
		53,5	39		9,90	40,59
OD2		53,5	40		10,00	40,76
		53,5	41		10,00	40,88
OD3		53,5	42		10,00	40,26
		53,5	43		10,00	40,38

	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	5	0,5	50:5
Voltage	5	1,0	50:5

Notes:

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

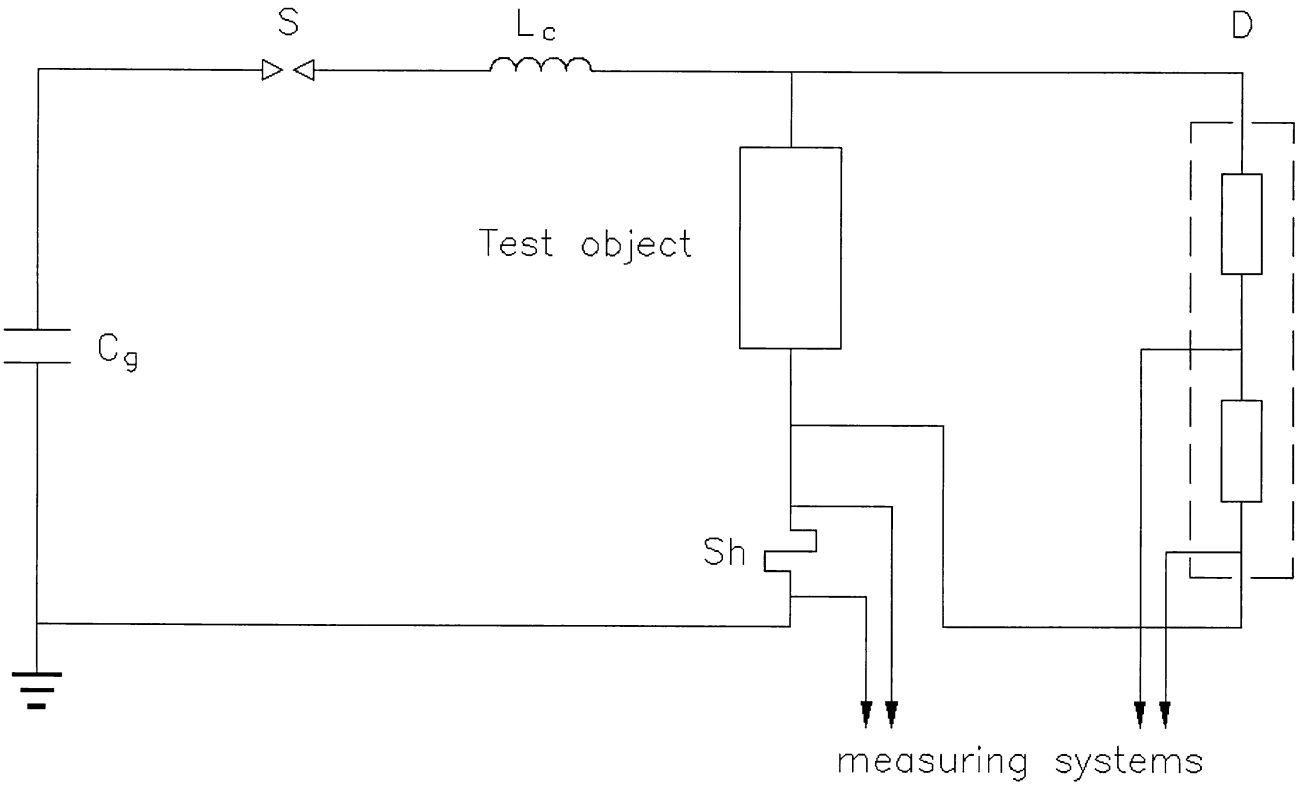
Current measuring system

R - Current shunt CESI N°.31120; R= 941,4 Ω
- Electro optical system CESI N°.--; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710; CESI N°. 6318

Voltage measuring system

D - Voltage divider SAGI; CESI N°.11120
- Electro optical system CESI N°.11520/11524; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710; CESI N°.6318

Circuit A0120



Impulse generator

No. of stages	1
Cg	4,98 µF
Lc	10 µH
S	- Spark-gap

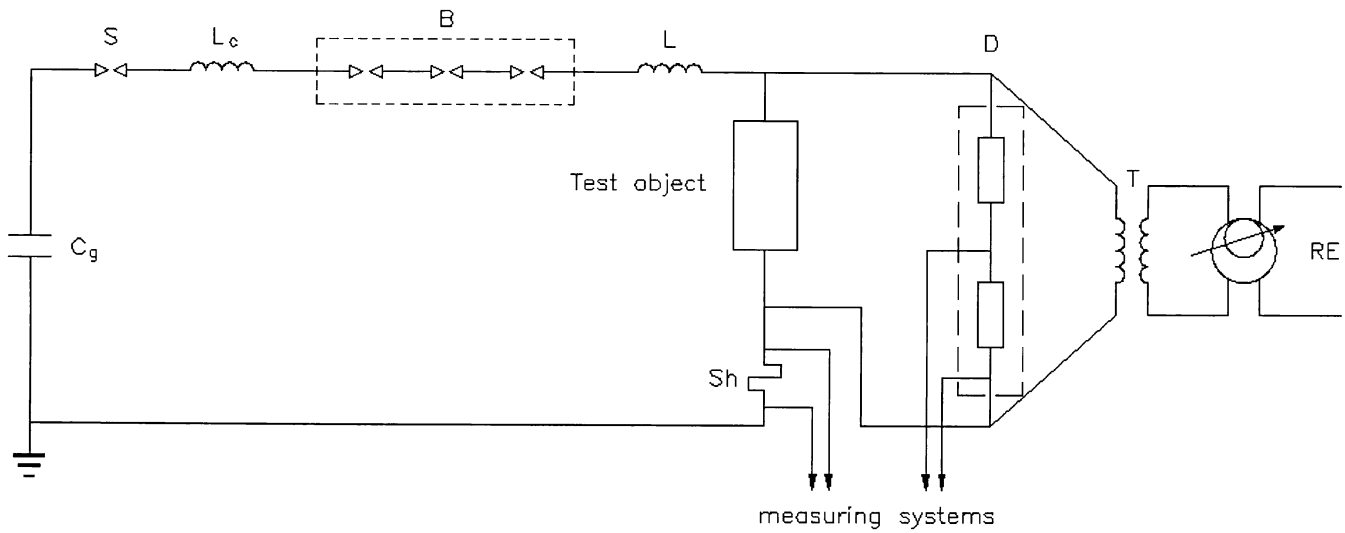
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.11120
	- Electro optical system CESI No.11521/522
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
	- Electro optical system CESI No.11517/518
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0015



Impulse generator

No. of stages: 1
C_g - Capacitor 1,66 µF
L - Inductance of the circuit
L_c - Inductor 30 µH
S - Spark gap

Power frequency supply

RE - Regulator type specialtrasfo; power 20 kVA; voltage 380 V/ 220 V
T - Transformer type Pivi; power 30 kVA; voltage 220 V/ 15 kV
B - Blocking gap

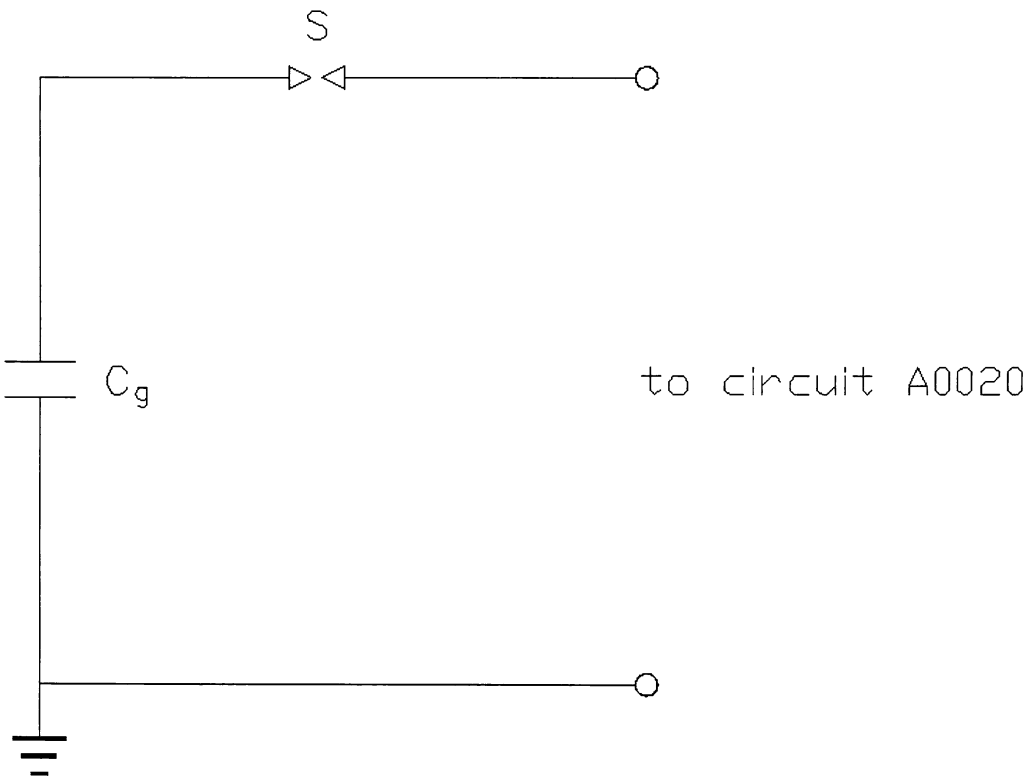
Current measuring system

Sh_1 - Current shunt CESI No.6042; R = 0,002 Ω
- Electro optical system CESI No.11517/11518
OSC - Oscilloscope type Tektonix 540A; CESI No.13217 (on channel No.1)

Voltage measuring system

D - Voltage divider SAGI ; CESI No.1120; k = 1010
- Electro optical system CESI No.11520/11521
OSC - Oscilloscope type Tektonix 540A; CESI No.13217 (on channel No.2)

Circuit A0123

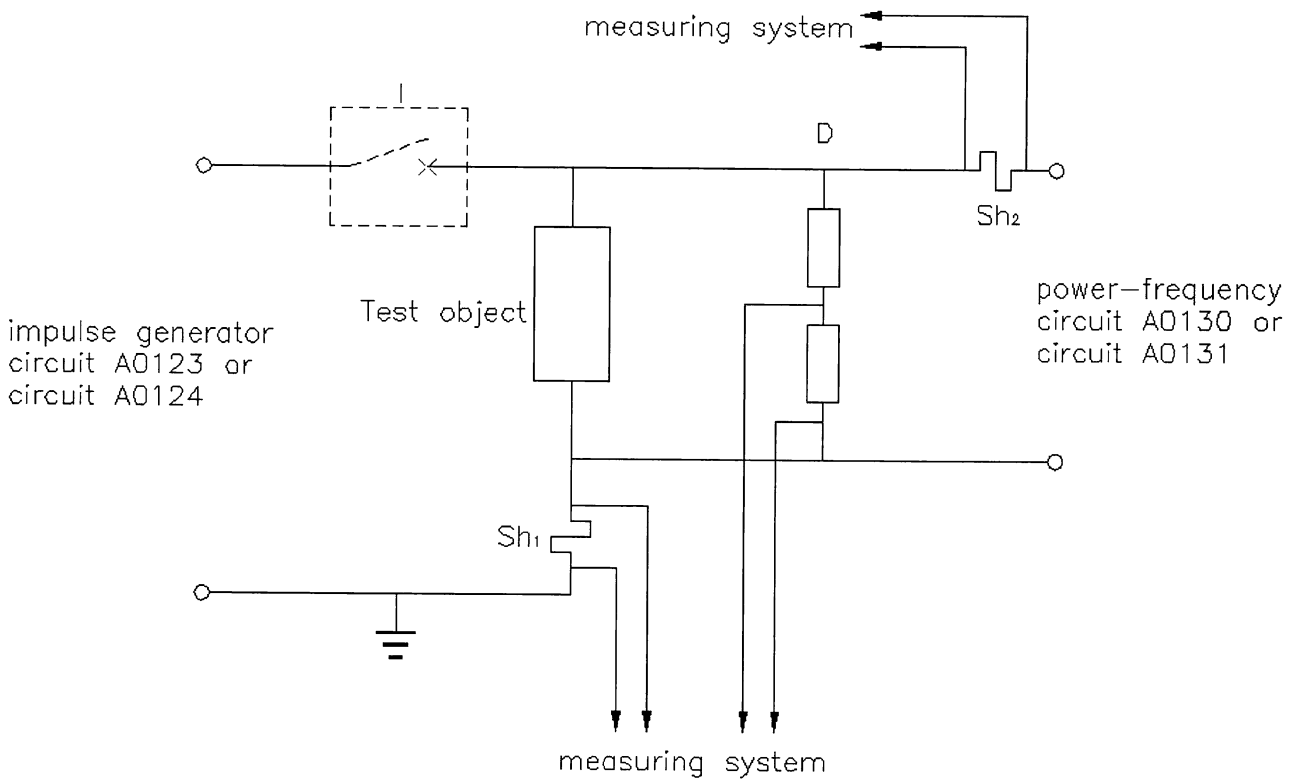


Impulse generator circuit

No. of stages 2
Cg 2,49 µF

S - spark-gap
two blocks in parallel has been added

Circuit A0020



Impulse generator circuit A0123

I - Circuit-breaker

Impulsive current measuring system

Sh_1 - Current shunt CESI No.60,42; R= 2 m Ω
- Electro optical system CESI No.11517/518; attenuation 300:5

OSC_1 - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Power frequency circuit A0131

Voltage measuring system.

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.8009/8015; attenuation 50:5

OSC_1 - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

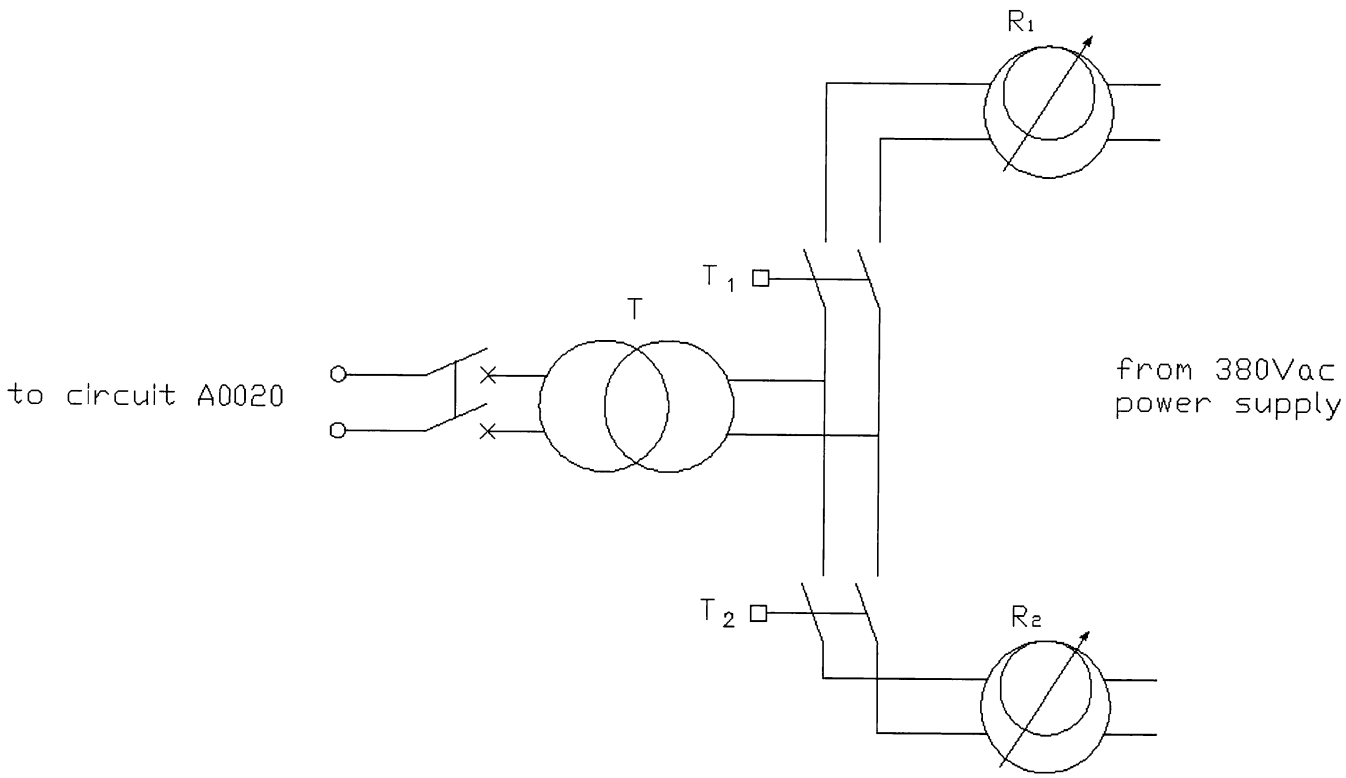
OSC_2 - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090 (on channel No.2)

Power frequency current measuring system

Sh_2 - Current shunt CESI R= 100 Ω - Electro optical system CESI No.8011/8017; attenuation 300:5 – 5:5

OSC_2 - Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0131



Power-frequancy circuit

from 380Vac power supply

R_1 single-phase voltage regulator CORMES; power 20 kVA; voltage 380/04220 Vac

R_2 single-phase voltage regulator CORMES; power 10 kVA; voltage 380/04220 Vac

T_1 voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200-400 V/15-30 kV

Test Report

CESI

Client	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Tested equipment	Polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	Moisture ingress test
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	**from** November 26, 2004 **to** December 10, 2004

No. of pages	23	**No. of pages annexed**	8
Issue date	February 23, 2005		
Prepared	BU PeC - M. Gregori		
Verified	BU PeC - A. Sironi		
Approved	BU PeC - M. de Nigris		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

Tests witnessed by:-----

Identification of the object:

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5006707 No. 1, is annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 26, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L. Podavitte – F. Mazzarella
Test laboratory	P177
Activity code	19774B

Rated characteristics of the tested object assigned by the Client

Metal-oxide surge arrester	
Manufacturer	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia).
Year of manufacture	2004
Electrical and mechanical characteristics	
Nominal discharge current (I_r)	10 kA
Line discharge class	1
Rated voltage (U_r)	45 kV
Continuous operating voltage (U_c)	36 kV
terminal torque (Nxm)	**80**
static cantilever (Nxm)	**250**
Rated frequency	50-60 Hz
Geometrical characteristics	
Total height	403 mm
Number of sheds	12
Shed diameter	116 mm
Shed spacing	29 mm
Other characteristics	
Housing material	silicone
Housing color	grey

Name and signature of Client's witness:

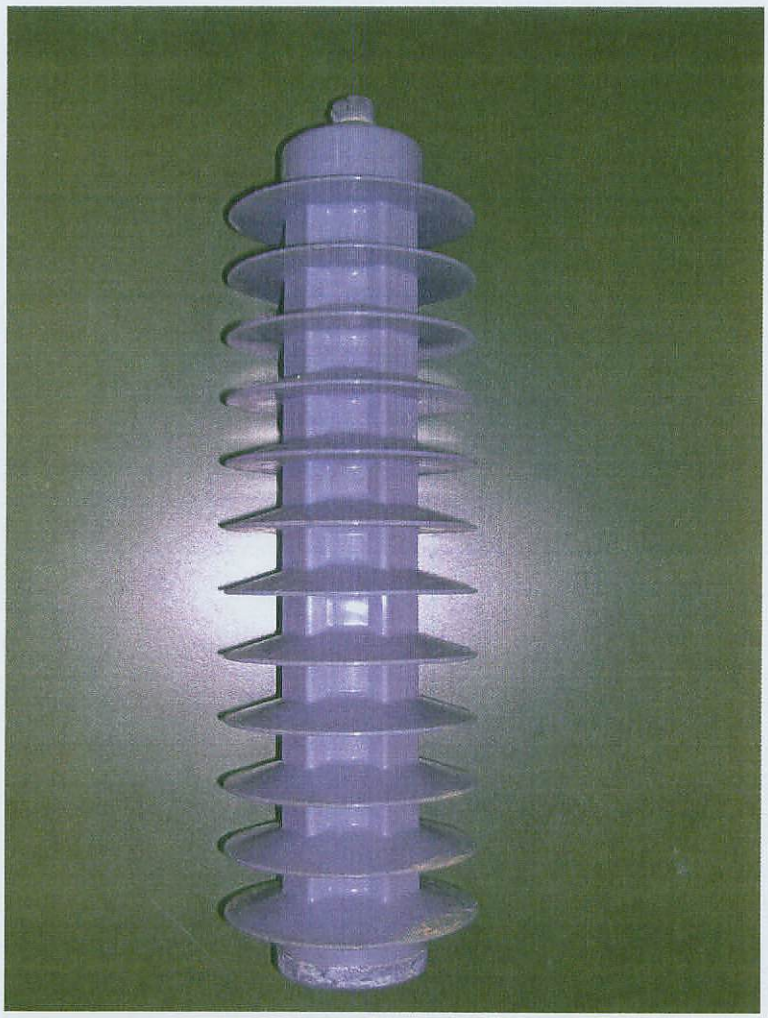


Photo no. 1
Photograph of the test object

Reference Standard

IEC 60099-4 (2004-05): "Metal-oxide surge arrester without gaps for a.c. system", clause 10.8.13,

Test carried out and identification of the test objects

Test carried out	Number of test objects	Test object identification
initial measurement	1	MI
mechanical preconditioning		
water immersion test		
verification test		

Test procedure on sample MI

The test consisted of the following steps:

Initial measurements

- Watt losses have been measured at $0,8 \times U_c = 37,8$ kV
- Internal partial discharges has been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 s. Then the voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.
- The lightning impulse residual voltage has been measured at the discharge current $0,5 x I_N$

Terminal torque preconditioning

The terminal torque at the value, specified by the manufacturer (80 N×m), has been applied.

Thermomechanical preconditioning

- The specimen has been submitted to two 48 hours thermal cycles of heating and cooling (see figure 6 of the reference standard) while mechanically loaded. The temperature was raining from +60°C to -40°C. The mechanical load consisted of a cantilever load at the value specified by the manufacturer (250N×m). The direction of the load was changed every 24 hours as specified on figure 6 of the reference standard.
- The surge arrester was tested in the thermal chamber together with another sample of different design.

Water immersion

The sample has been immersed in a vessel, in boiling deionized water with 1 kg/m^3 of NaCl, for 42 hours. At the end the sample remained in the vessel until the water cooled to 50 °C

Verification test at ambient temperature

- Visual inspection
- Watt losses measurement at $0,8 \times U_c$ has been repeated
- Partial discharges measurement has been repeated at $1,05 \times U_c$
- The lightning impulse residual voltage test has been repeated at discharge current $0,5 \times I_N$

Summary of test results

Visual inspection

The visual inspection of the polymer housed metal oxide surge arrester after test has revealed no sign of physical damage.

Electrical measurement

- Variation of watt losses at $0,8 \times U_c$

sample	before test		after test		variation
	voltege	power	voltage	power	
	kV	W	kV	W	%
MI	28,93	0,564	28,90	0,595	5,50

The variation of the watt losses before and after the test was less than 20% (maximum allowed variation according to reference standard is 20%).

- Variation of lighting impulse residual voltage at $0,5 \times I_N$

sample	before test		after test		variation
	discharge current	residual voltage	discharge current	residual voltage	
	kA	kV	kA	kV	%
MI	4,95	106,3	4,95	106,9	0,56

The variation of the lighting impulse residual voltage before and after the test was less than 5% (maximum allowed variation according to reference standard is 5%).

- Partial discharges

The measured partial discharge value was below the specified limit of 10 pC before and after the test.

Conclusion:

The test result is positive.

Power frequency voltage-current characteristics before the test .

Test circuit: A019

Date: November 26, 2004

Sample No. MI						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
01	28,93	0,35	0,35	0,248	0,564	----

Measurement of partial discharges before the test

Test circuit: A012
Measurement circuit: A022 "direct" calibration:55 pC/mV
Arrangement: ---

Atmospheric conditions and correction factor			
b	t_d/t_w	h	Relative umidity
kPa	°C	g / m^3	%
99,83	18/13	8,60	56,1

Date: November 26, 2004

Test sample	Applied voltage	Duration of voltage application	Temperature of the test object	Partial discharge measurement		Oscillogram	Notes
				voltage increase Q max	voltage decrease Q max		
	kV_{rms}	s	°C	pC	pC	No.	
MI	45,0	2-10	18	---	----		
MI	37,8	60	18		≤ 1	---	

continued

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: November 26, 2004

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	μs	kA	kV
MI	0,5 x I_N	59,3 x 2	02	7,9/21,4	4,95	106,3

	Oscilloscope settings		
	sampling division	input	attenuation
	μs	V_{div}	
Current	5	0,5	50:5
Voltage	5	1,0	50:5

Notes: Due to limitation of the test circuit, the residual voltage has been measured at the reduced current equal to 0,5 x I_N

Preconditioning tests

Terminal torque preconditioning

Test date: November 29,2004

The terminal torque at the value, specified by the manufacturer (80 N×m), has been applied for 30 seconds.

Thermomechanical preconditioning

Test date: December 01, 2004

sample	applied load	lower temperature	upper temperature	duration of temperature application	cycle	load duration
No.	N×m	°C	°C	h	No.	degree
MI	250	---	+60	24	1	0
MI	250	-25	---	24	1	180
MI	250	---	+45	24	2	270
MI	250	-40	---	24	2	90

Photo no. 2
Test setting for terminal torque preconditioning

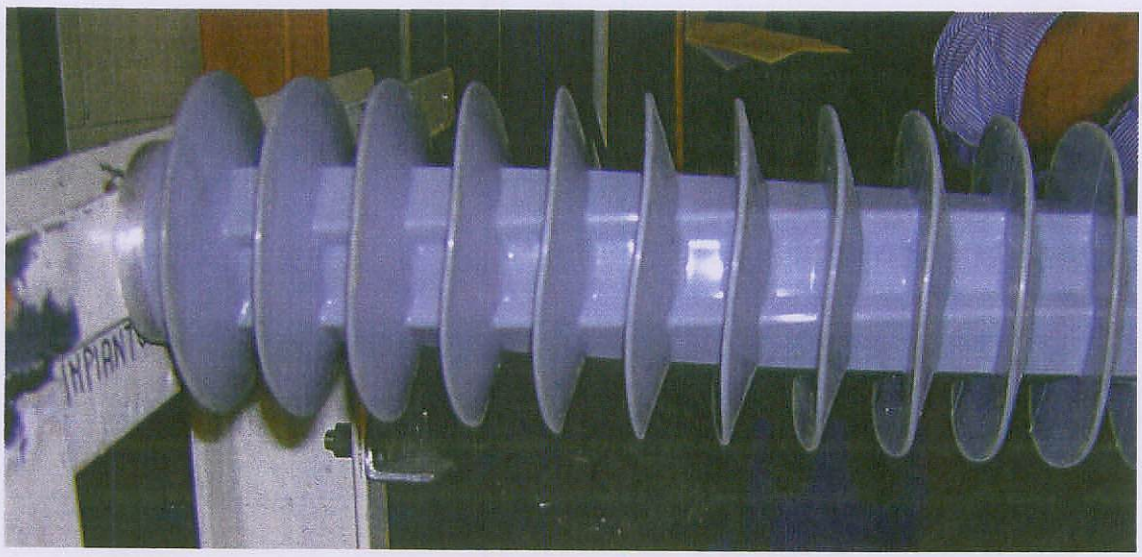


Photo no. 3
Test setting for terminal torque preconditioning

Photo no. 4
Test setting for thermomechanical preconditioning

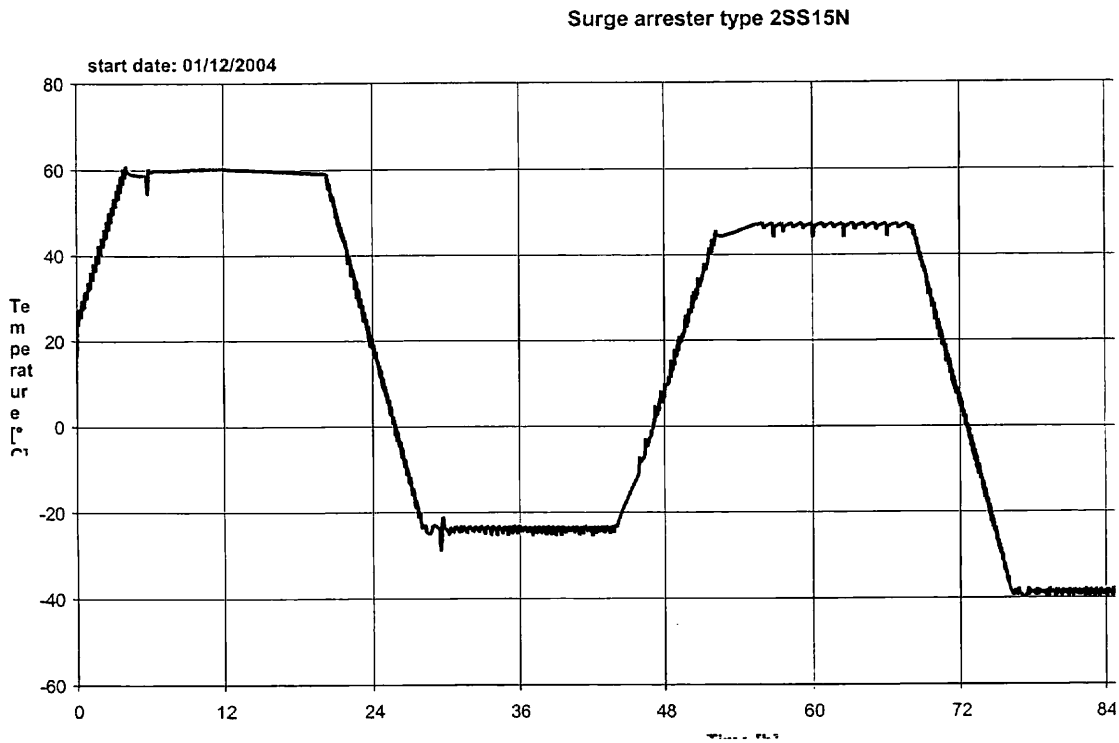


Photo no. 5
Temperature cycle about thermomechanical preconditioning

Water immersion test

Test date: December 08-10, 2004

The samples have been immersed in a vessel, in boiling deionized water with 1 kg/m^3 of NaCl, for 42 hours. At the end the samples remained in the vessel until the water cooled to 50 °C and maintained at this temperature in the vessel until verification tests.

Power frequency voltage-current characteristics after the test.

Test circuit: A019

Date: December 10, 2004

Sample No. MI						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
03	28,90	0,341	0,371	0,227	0,595	----

Measurement of partial discharges after the test.

Test circuit: A012
Measurement circuit: A022 "direct" calibration:55 pC/mV, oscillogram No. 4 - background noise ≤ 1 oscillogram No. 5
Arrangement: ---

Atmospheric conditions and correction factor			
b	t_d/t_w	h	Relative umidity
kPa	°C	g / m^3	%
100,1	18/12	7,38	48,2

Date: December 10, 2004

Test sample	Applied voltage	Duration of voltage application	Temperature of the test object	Partial discharge measurement		Oscillogram	Notes
				voltage increase Q max	voltage decrease Q max		
	kV_{rms}	s	°C	pC	pC	No.	
Mi	45,0	2-10	18	---	---		
	37,8	60	18		≤ 6	6	

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

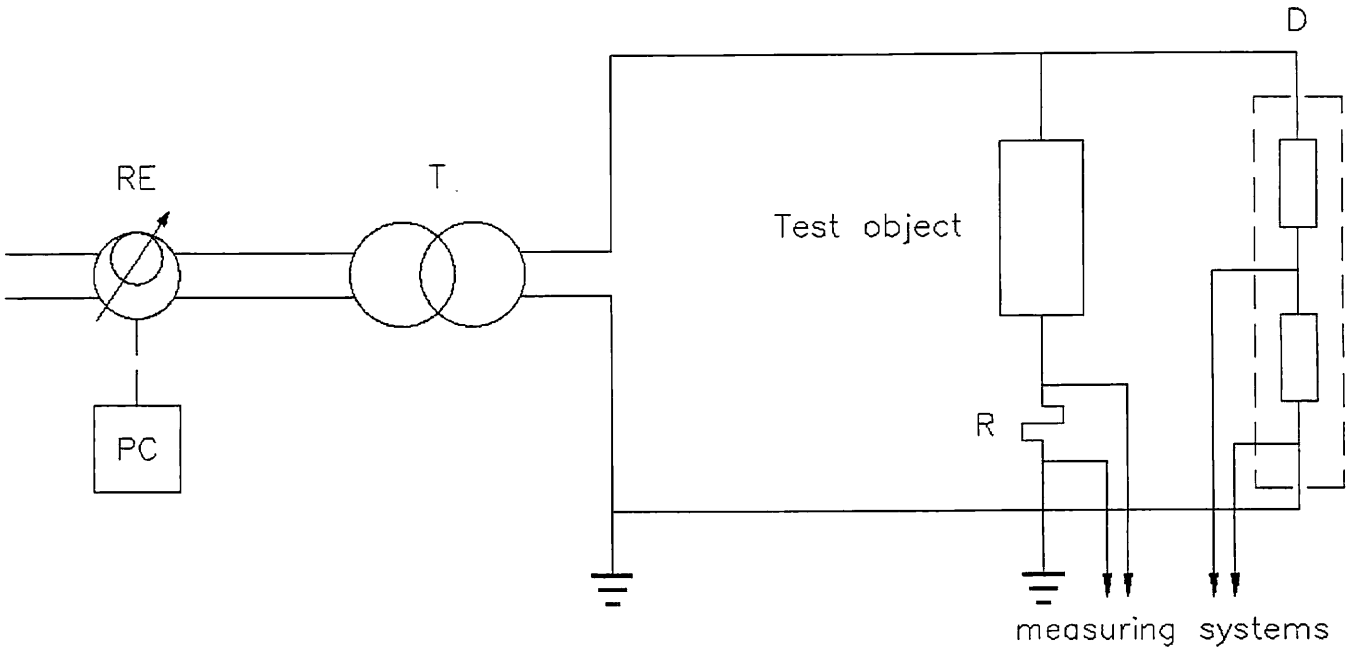
Date: December 10, 2004

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
MI	0,5 x I_N	59,3 x 2	7	7,9/21,4	4,95	106,9

	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	5	0,5	50:5
Voltage	5	1,0	50:5

Notes: Limitation of the test circuit, the residual voltage has been measured at the reduced current equal to 0,5 x I_N

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

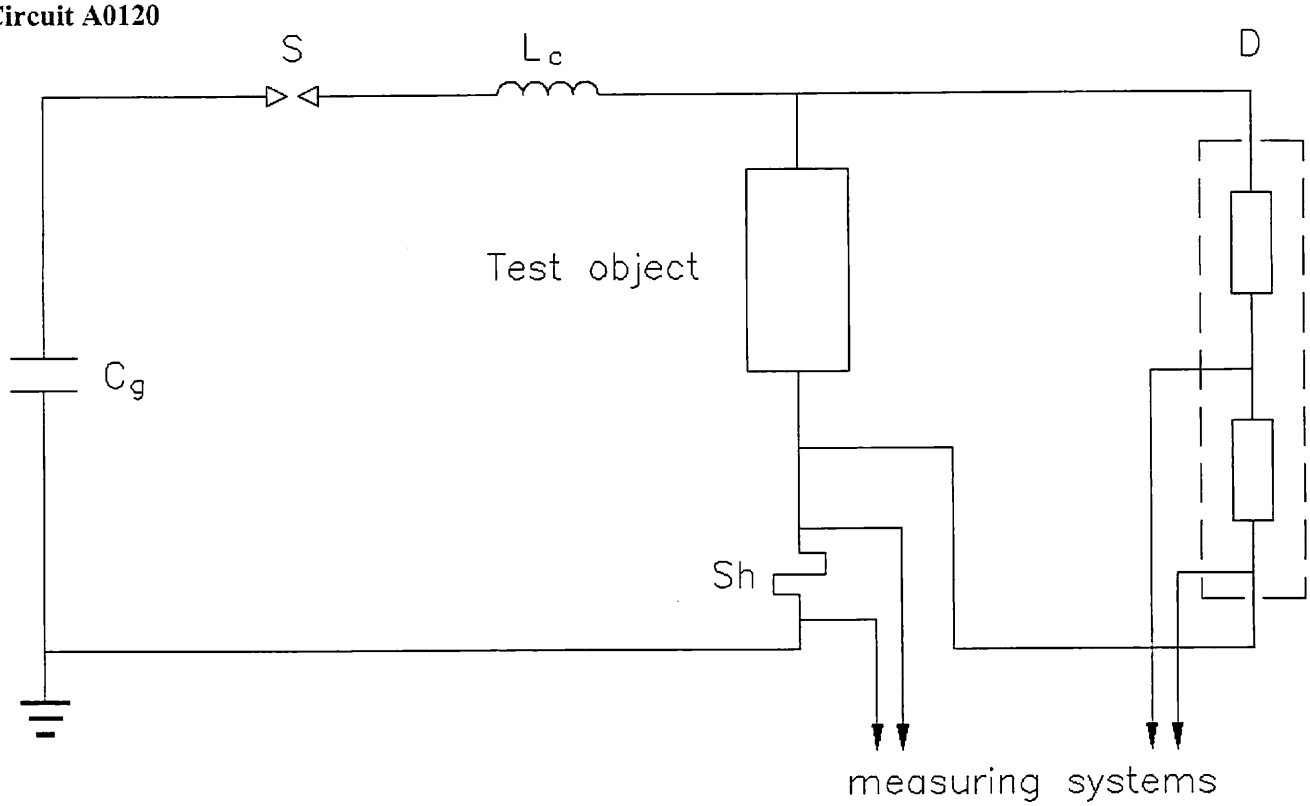
Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system CESI No.11521/522; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11517/518; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Circuit A0120



Impulse generator

No. of stages	2
Cg	4,98 µF
Lc	18 µH
S	- Spark-gap

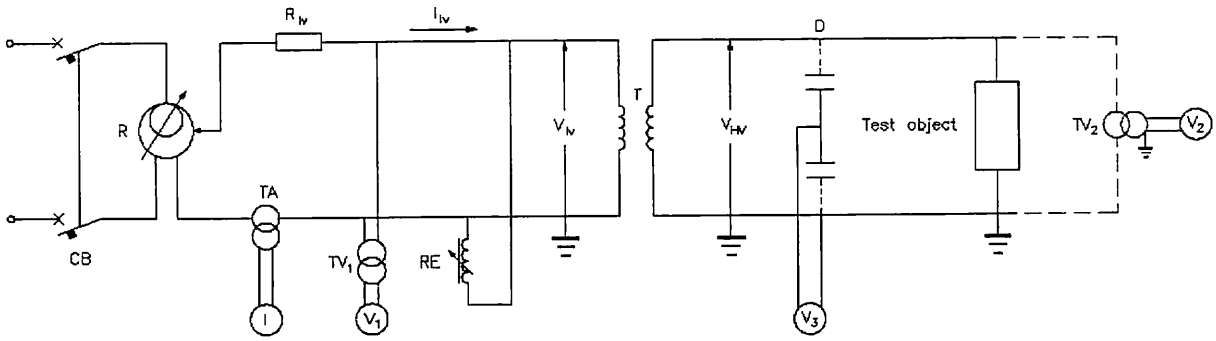
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.13027
	- Electro optical system CESI No.11521/522
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
	- Electro optical system CESI No11517/518
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0012

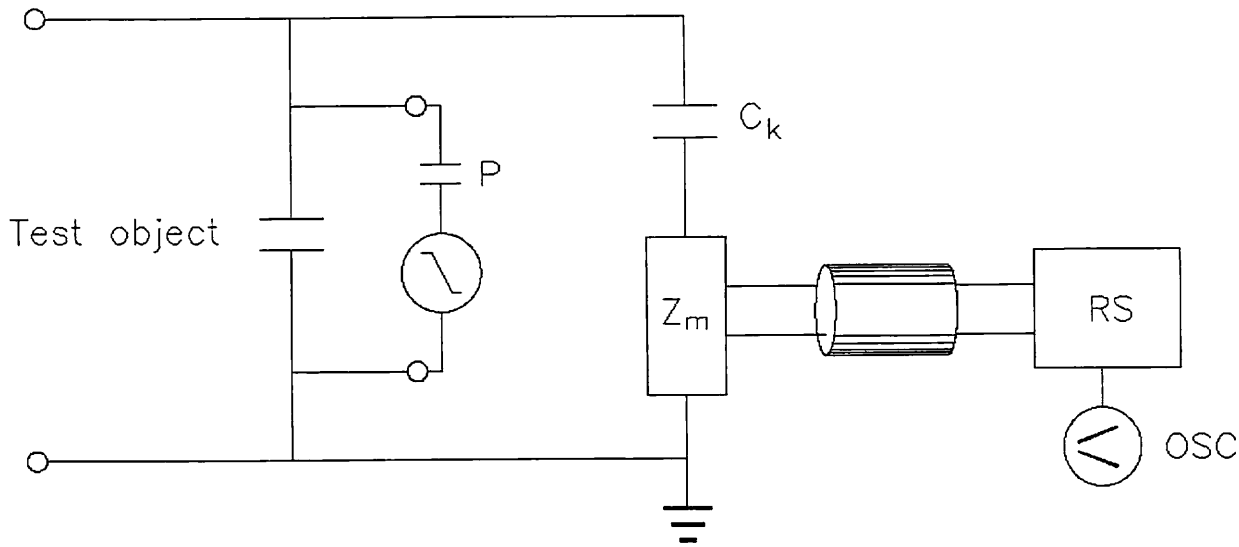


Power frequency test circuit

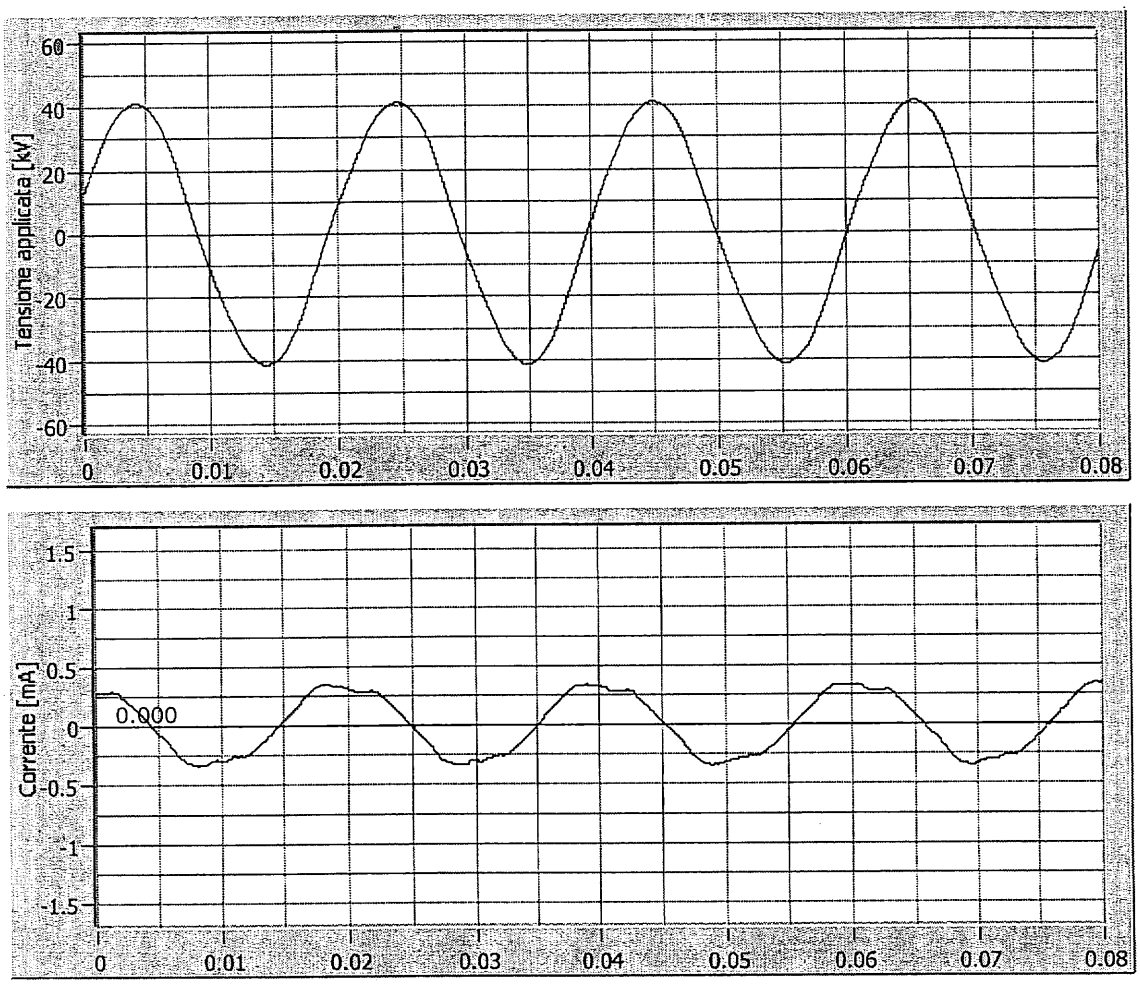
R	- regulator type CORMES; power 66 kVA; voltage 380 V/0-0,22 kV
TA	- current transformer CGS; ratio 150/5 A/300/5 A
I	- amperemeter
TV_1	- voltage transformer CGS; ratio 220-440 V/100 V
V_1	- voltmeter direct reading TSE
RE	- (not used)
T	- booster transformer PIVI; power 250 kVA; voltage 200-400V/250 kV
D	- (not used)
V_3	- (not used)
TV_2	- voltage transformer type PIVI; ratio 25000 V/100 V
V_2	- voltmeter CESI No.6393

Circuit A0022

Partial discharges measurement
Direct circuit - Scheme 1a

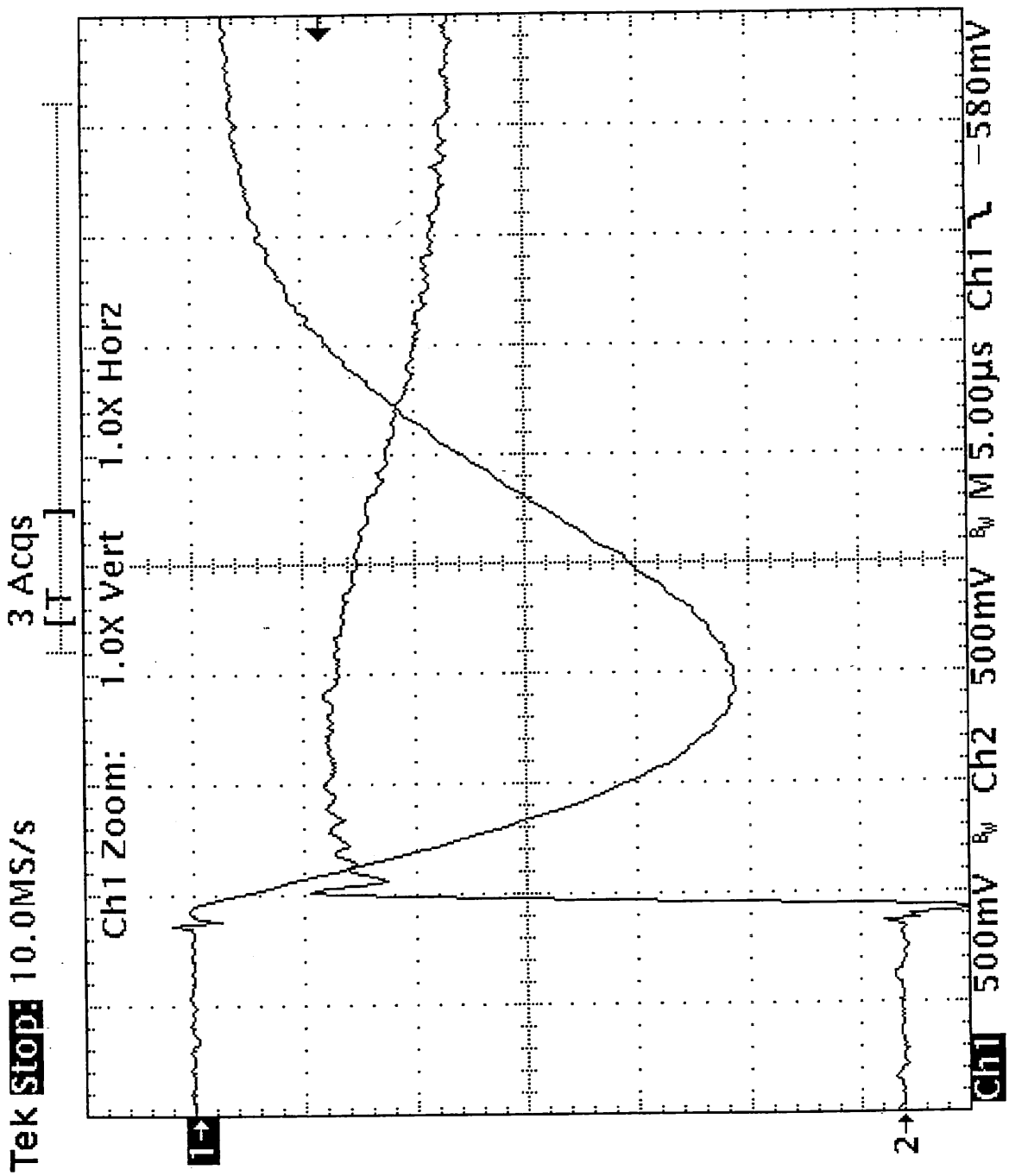


P	- calibrator CESI; CESI No. 346
C_k	- coupling capacitor 0,3 nF
Z_m	- coupling impedance
RS	- partial discharge detector HAEFELY TRENCH type TE 571; CESI No. 13281
OSC	- (not used)

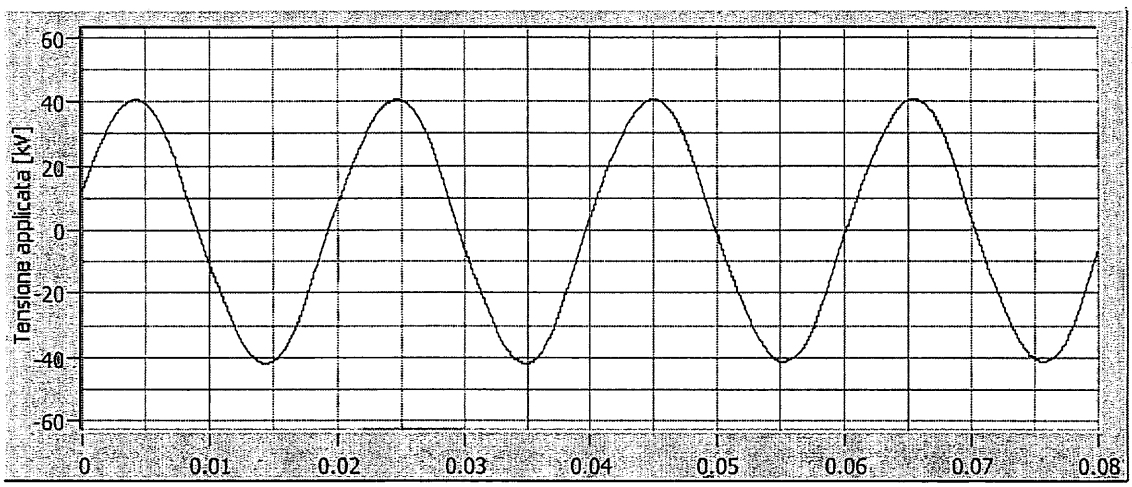


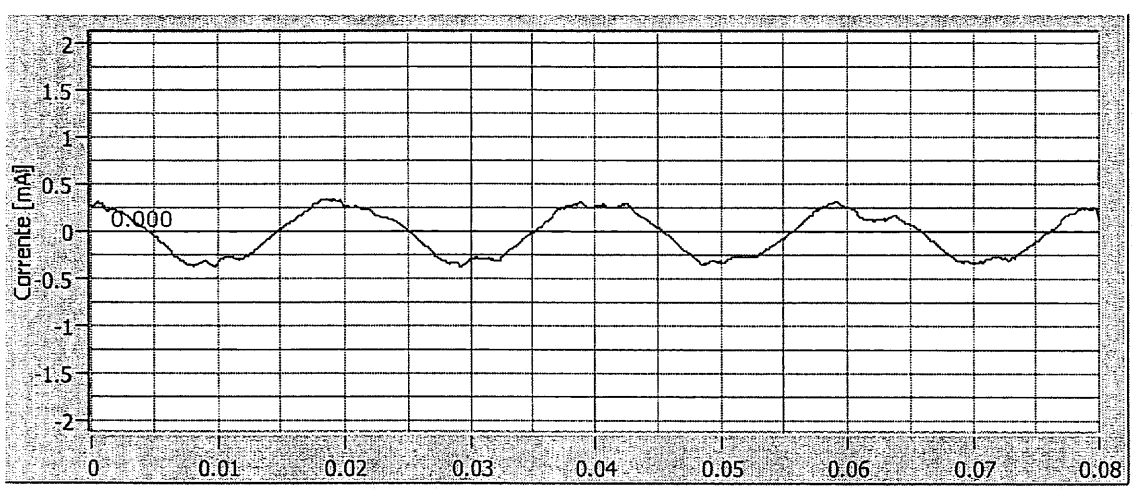
M I

CESI PeC A4523159 oscillogram n. 1



CESI PeC A4523159 oscillogram n. 2





MI

CESI PeC A4523159 oscillogram n. 3

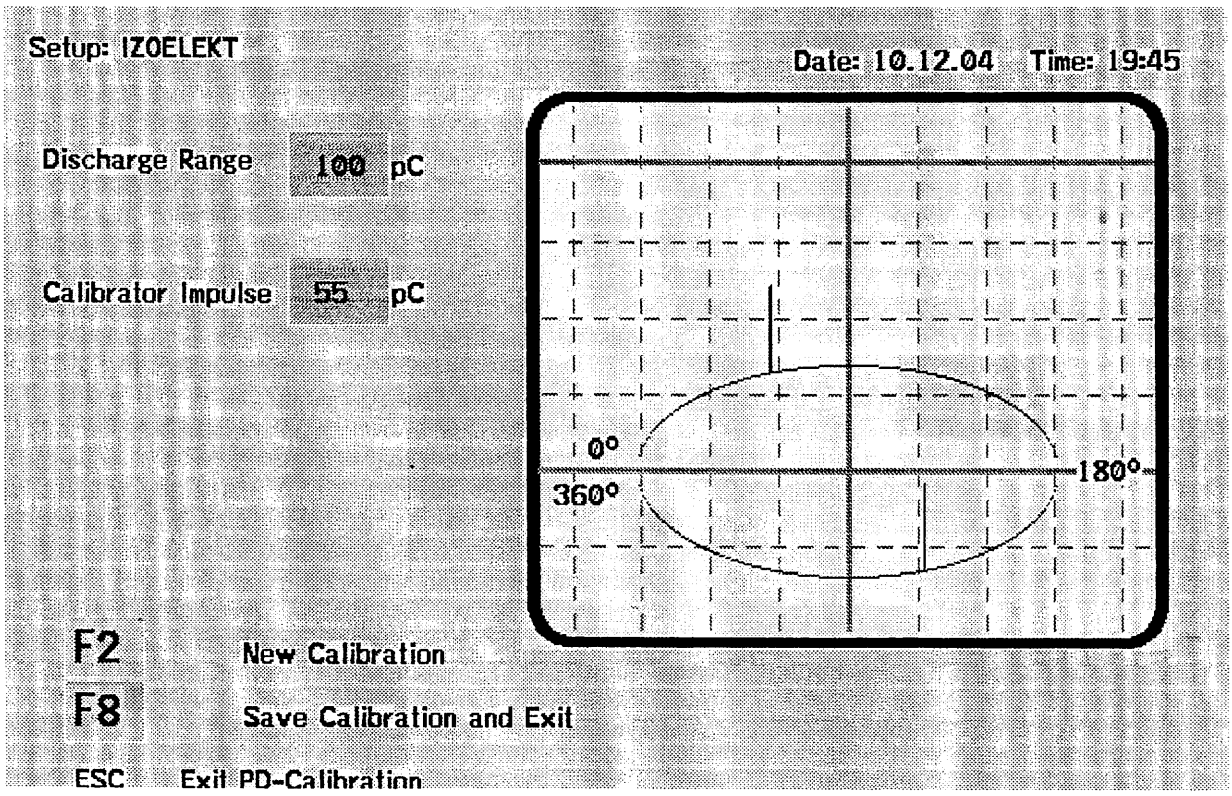
HAEFELY TRENCH TETTEX PD-DETECTOR

Info: 1
Measurement name:
Comment:
1st PD Range: 100 pC
Noise Suppression: 5 %
Test Measuring Time: 15 s

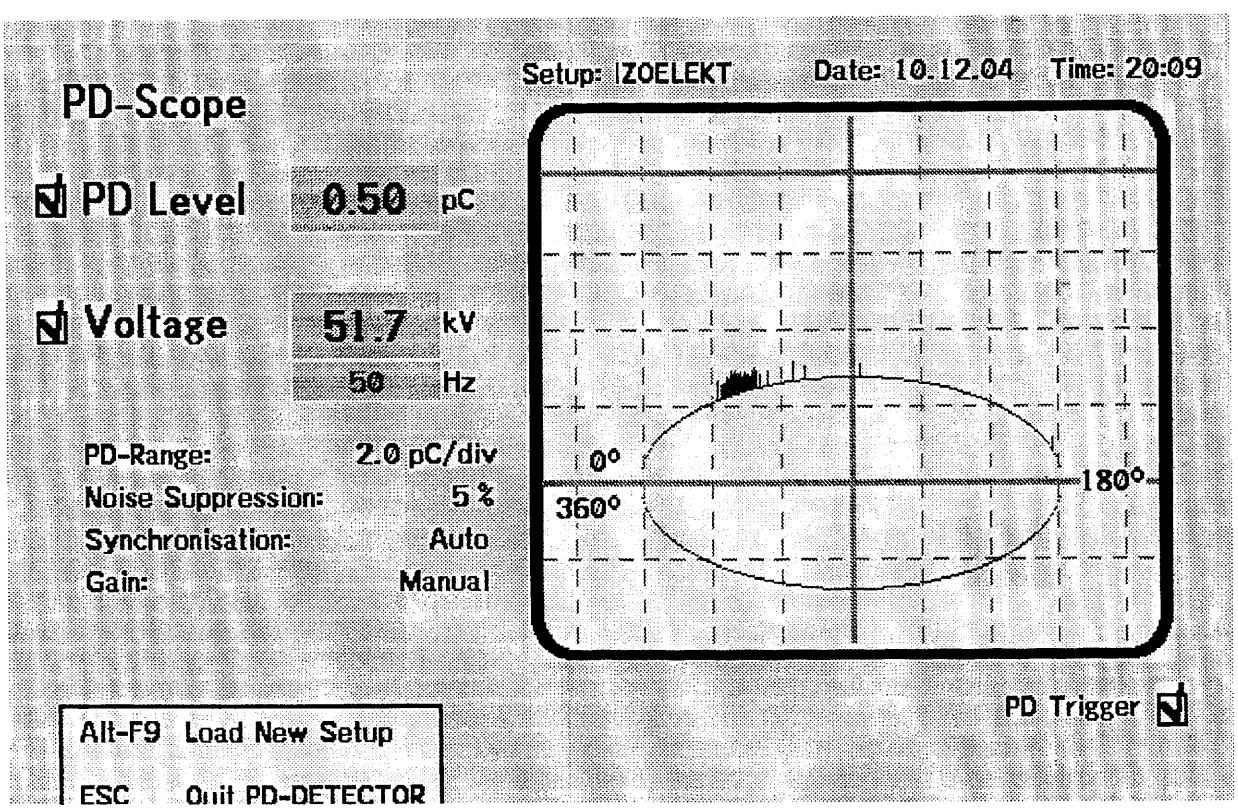
Start date: 00.00.00
Start time: 00:00

2nd PD Range: Not applied
Lockout Time: 7.3 usec
Voltage Range: 50 kV

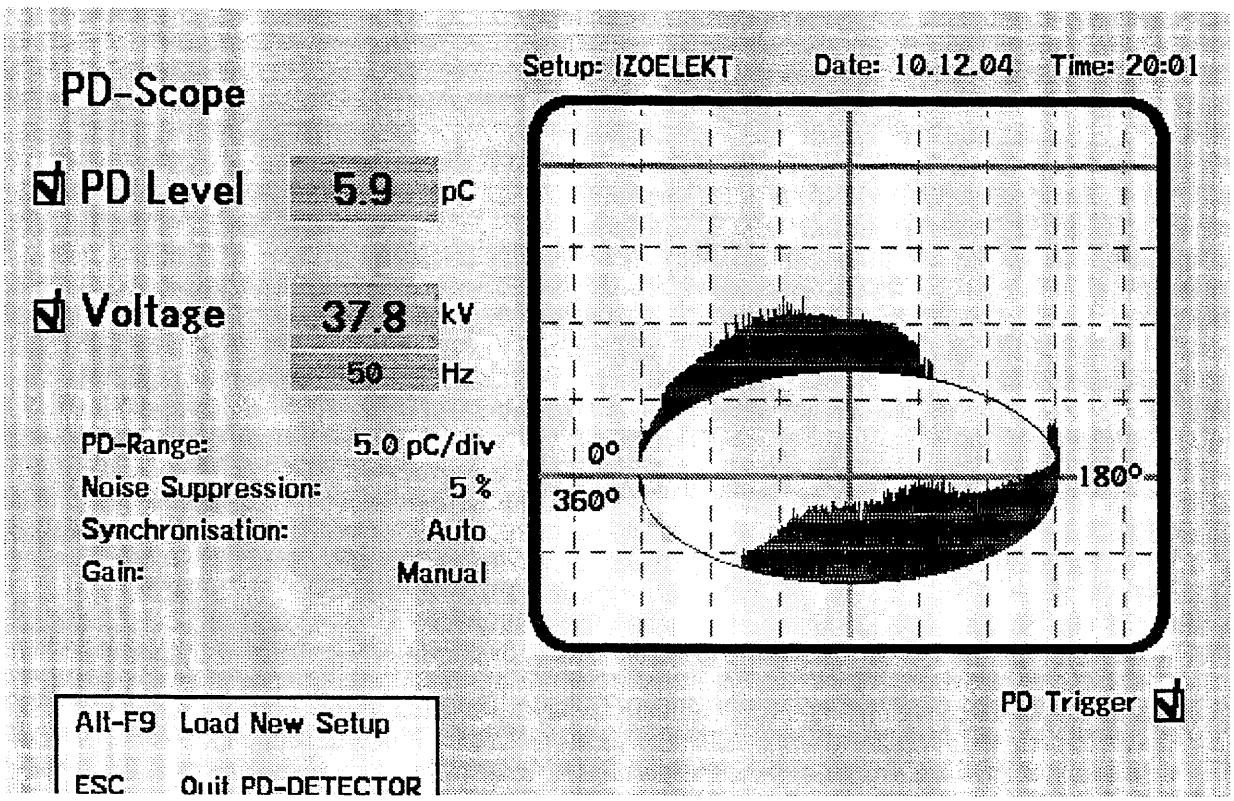
Remarks:



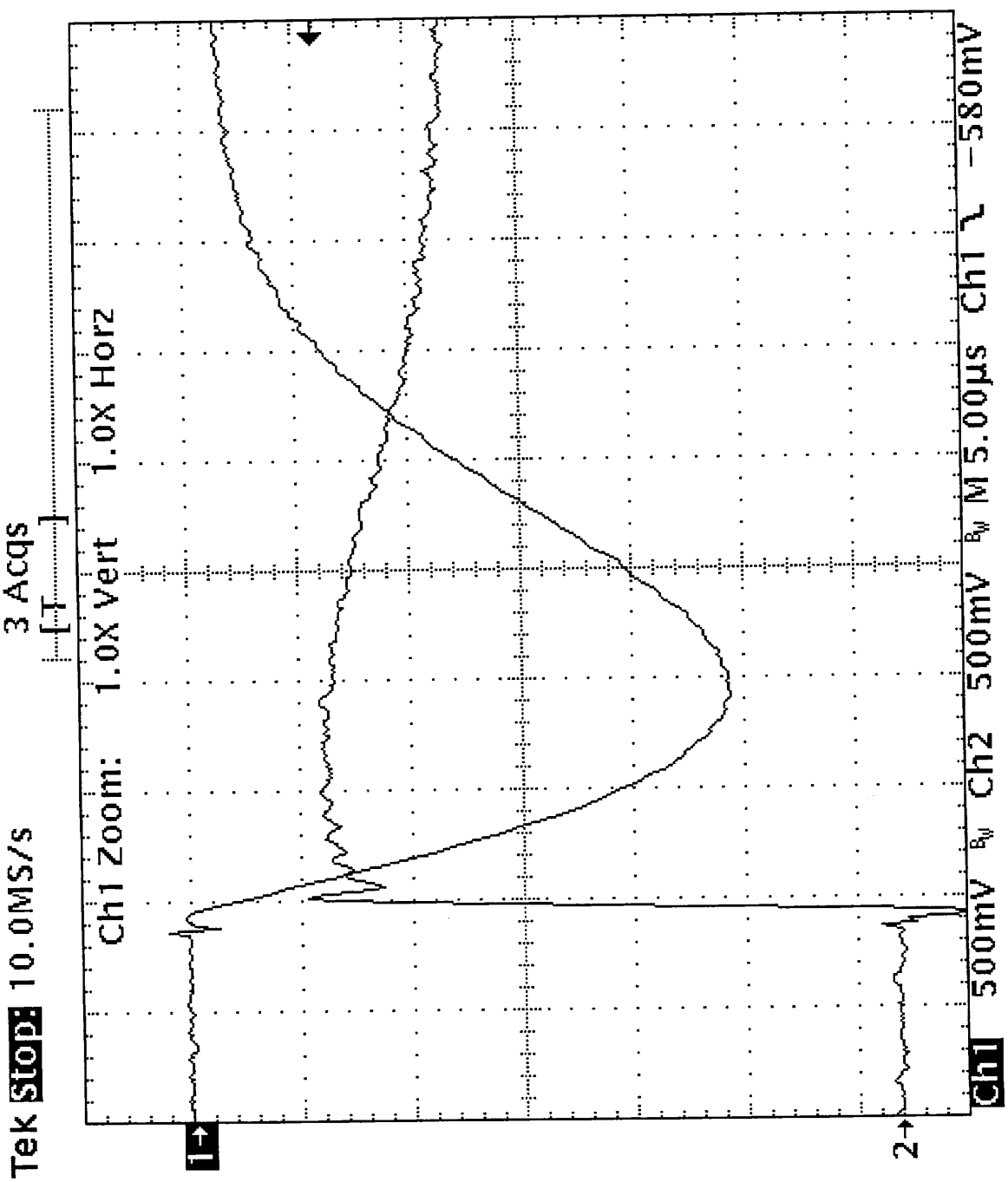
CESI PeC A4523159 oscillogram n. 4



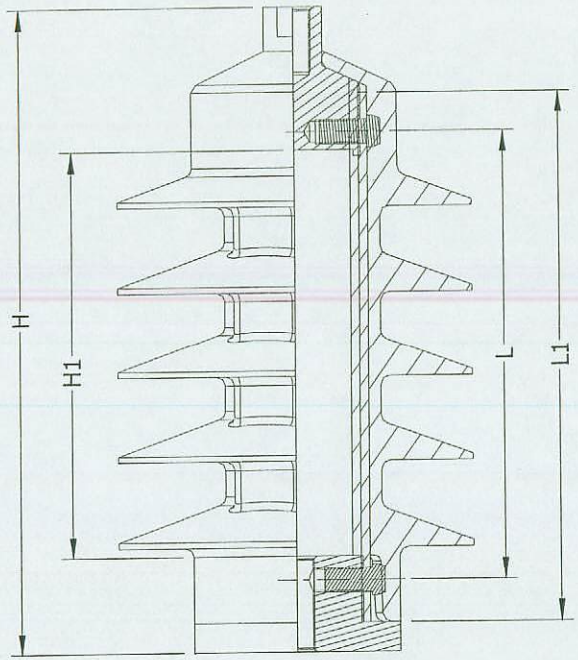
CESI PeC A4523159 oscillogram n. 5



CESI PeC A4523159 oscillogram n. 6



CESI PeC A4523159 oscillogram n. 7



Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks Hl (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
21-48-01	3,75	147	3	67	107	81
21-48-02	5	147	3	67	107	81
21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
21-48-06	15	193	5	113	153	127
21-48-07	17,5	243	6	163	203	177
21-48-08	20	243	6	163	203	177
21-48-09	22,5	243	6	163	203	177
21-48-10	25	270	7	190	230	204
21-48-11	26,25	270	7	190	230	204
21-48-12	27,5	270	7	190	230	204
21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

CESI
PROTOCOLLO DATA
A 5/ 0 C 07 07 n.1 23 FEB. 2005
Firma Marco Gaspari

ELEKTRO...	ISO2768 -			Measure: 7:10	Weight:
				Material:	
	Date:	Name:	Signature:	Type: SURGE ARRESTER 2SS15N	
Izdelal:	27.8.03	R. Kurnik			
Pregledal:	1.9.03	P. Pungercar			
Odobril:	1.9.03	P. Pungercar			
Opombe:				Code: 21-48-00	Sheet: 1/1
				Izdelek:	Prip.:

Test Report

CESI

Client	IZOELEKTRO d.o.o. – Pri Mariboru (Slovenia)
Tested equipment	Polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	Test of the bending moment
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	**from** November 26, 2004 **to** December 10, 2004

The results reported in this document relate only to the tested equipment.

No. of pages	20	**No. of pages annexed**	10
Issue date	February 23, 2005		
Prepared	BU PeC - M. Gregori		
Verified	BU PeC - A. Sironi		
Approved	BU PeC - M. de Nigris		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

Tests witnessed by:-----

Identification of the object: The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5006707 No. 1, is annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 26, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L. Podavitte – F. Mazzarella
Test laboratory	P177
Activity code	19774B

Rated characteristics of the tested object assigned by the Client

Metal-oxide surge arrester	
Manufacturer	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia).
Year of manufacture	2004
Electrical and mechanical characteristics	
Nominal discharge current (I_r)	10 kA
Line discharge class	1
Rated voltage (U_r)	45 kV
Continuous operating voltage (U_c)	36 kV
dynamic cantilever (Nxm)	**250**
Rated frequency	50-60 Hz
Geometrical characteristics	
Total height	405 mm
Number of sheds	12
Shed diameter	116 mm
Shed spacing	29 mm
Other characteristics	
Housing material	silicone
Housing color	grey

Name and signature of Client's witness:

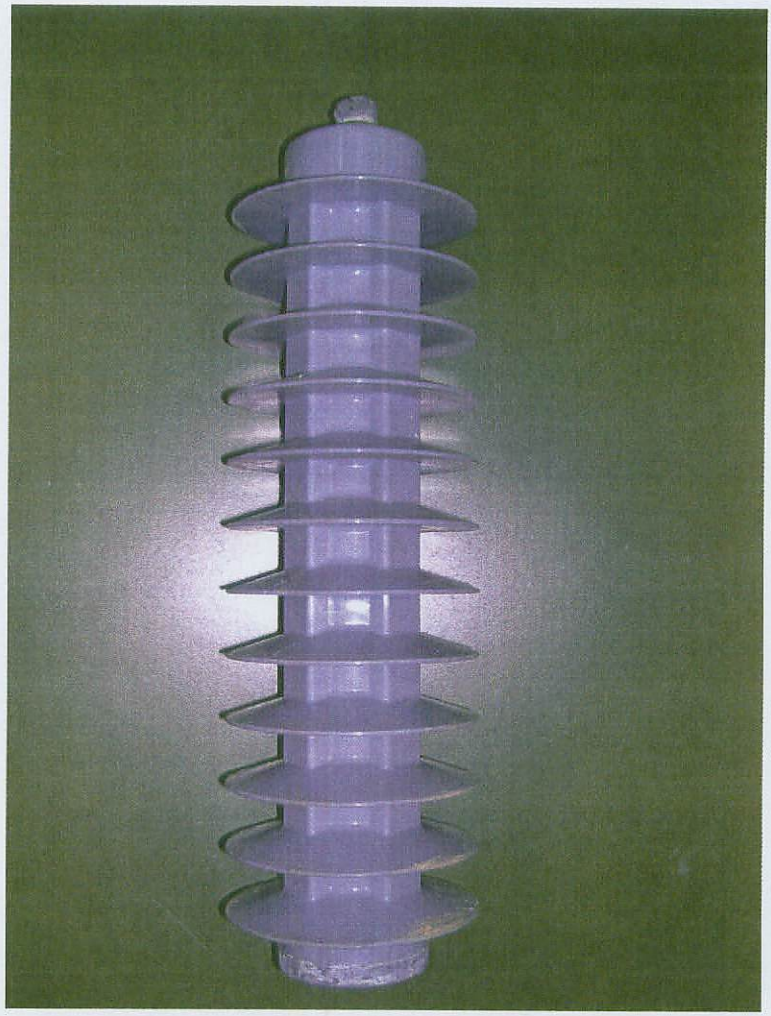


Photo no. 1
Photograph of the test object

Reference Standard

IEC 60099-4 (2004-05): "Metal-oxide surge arrester without gaps for a.c. system", clause 10.8.9,

Test carried out and identification of the test objects

Test carried out	Number of test objects	Test object identification
Initial measurement	1	BM
Bending application		
Water immersion test		
Test evaluation		

Test procedure

The test consisted of the following steps:

Initial measurements

- Watt losses have been measured at $0,8 \times U_c$
- Internal partial discharges have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 s. Then the voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.

The lightning impulse residual voltage has been measured at the discharge current $0,5 \times I_N$

Bending application

The test samples have been mounted in upright position. The specified load of 250 N×m (corresponding to 617 N on the sample having 405 mm height) was applied perpendicular to the axis to the free end of the surge arrester. The load was increased at constant speed, maintained at the specified value for about 60 to 90 seconds and then decreased to zero.

Water immersion

The samples have been immersed in a vessel, in boiling deionized water with 1 kg/m^3 of NaCl, for 42 hours. At the end the samples remained in the vessel until the water cooled to 50 °C

Verification test at ambient temperature

- The visual inspection was carried out
- Watt losses measurement at $0,8 \times U_c$ has been repeated
- Partial discharges measurement has been repeated at $1,05 \times U_c$
- The lightning impulse residual voltage test has been repeated at nominal discharge current $0,5 \times I_N$

Summary of test results

Visual inspection

The visual inspection of the polymer housed metal oxide surge arrester after test has revealed no sign of physical damage.

Bending application

The force-deflection curve does not show significant discontinuity.
The permanent deflection is not significant.

Electrical measurement

- Variation of watt losses at $0,8 \times U_c$

sample	before test		after test		variation
	voltage	power	voltage	power	
	kV	W	kV	W	%
BM1	28,93	0,619	28,82	0,653	5,50

The variation of the watt losses for sample BM before and after the test was less than 20% (maximum allowed variation according to reference standard is 20%).

- Variation of lighting impulse residual voltage at $0,5 \times I_N$

sample	before test		after test		variation
	discharge current	residual voltage	discharge current	residual voltage	
	kA	kV	kA	kV	%
BM1	4,95	106,32	4,95	107,2	0,83

The variation of the lighting impulse residual voltage before and after the test was less than 5% (maximum allowed variation according to reference standard is 5%).

- Partial discharges

The measured partial discharge value was below the specified limit of 10 pC before and after the test.

Conclusion:

The test result is positive.

Power frequency voltage-current characteristics before the test.

Test circuit: A019

Date: November 26, 2004

Sample No. BM						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	μA
01	28,93	0,356	0,356	0,253	0,619	----

Measurement of partial discharges before the test

Test circuit: A012
Measurement circuit: A022 "direct" calibration:55 pC/mV
Arrangement:

Atmospheric conditions and correction factor			
b	t_d/t_w	h	Relative umidity
kPa	°C	g / m^3	%
99,83	18/13	8,60	56,1

Date: November 26, 2004

Test sample	Applied voltage	Duration of voltage application	Temperature of the test object	Partial discharge measurement		Oscillogram	Notes
				voltage increase Q max	voltage decrease Q max		
	kV_{rms}	s	°C	pC	pC	No.	
MI	45,0	2-10	18	---	----		
MI	37,8	60	18		≤ 1	---	

continued

Lightning impulse residual voltage measurement before the test

Test circuit: A0120

Date: November 26, 2004

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	µs	kA	kV
BM	0,5 x I_N	59,3 x 2	02	7,9/21,4	4,95	106,32

	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	5	0,5	50:5
Voltage	5	1,0	50:5

Notes: Due to limitation of the test circuit, the residual voltage has been measured at the reduced current equal to 0,5 x I_N

Photo no. 2
Test setting for bending application

Bending application

Test date: December 01, 2004

The test sample was mounted in upright position. The specified load (corresponding to the maximum bending moment at 250 N×m) was applied perpendicular to the axis to the free end of the surge arrester. The load was increased at constant speed, maintained at the specified value for about 60 to 90 seconds and then decreased to zero.
A view of the test arrangement is shown in the photos pages no.12.
The curves of the load&deflection versus time are shown in the oscillogram no.3 . The curves of the load versus deflection are shown in the oscillogram no.4 .

Water immersion test

Test date: December 08÷10, 2004

The sample has been immersed in a vessel, in boiling deionized water with 1 kg/m^3 of NaCl, for 42 hours. At the end the sample remained in the vessel until the water cooled to 50 °C and maintained at this temperature in the vessel until verification tests.

Power frequency voltage-current characteristics after the test.

Test circuit: A019

Date: December 10, 2004

Sample No BM						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
5	28,82	0,362	0,353	0,258	0,653	----

Measurement of partial discharges after the test

Test circuit: A012
Measurement circuit: A022 "direct" calibration:55 pC/mV, oscillogram No. 6 - background noise ≤ 1 oscillogram No. 7
Arrangement:

Atmospheric conditions and correction factor			
b	t_d/t_w	h	Relative umidity
kPa	°C	g / m³	%
100,1	18/12	7,38	48,2

Date: December 10, 2004

Test sample	Applied voltage	Duration of voltage application	Temperature of the test object	Partial discharge measurement		Oscillogram	Notes
				voltage increase Q max	voltage decrease Q max		
	kV_{rms}	s	°C	pC	pC	No.	
BM	45,0	2-10	18	---	---		
	37,8	60	18		≤ 8	8	

continued

Lightning impulse residual voltage measurement after the test

Lightning impulse residual voltage measurement after the test

Test circuit: A0120

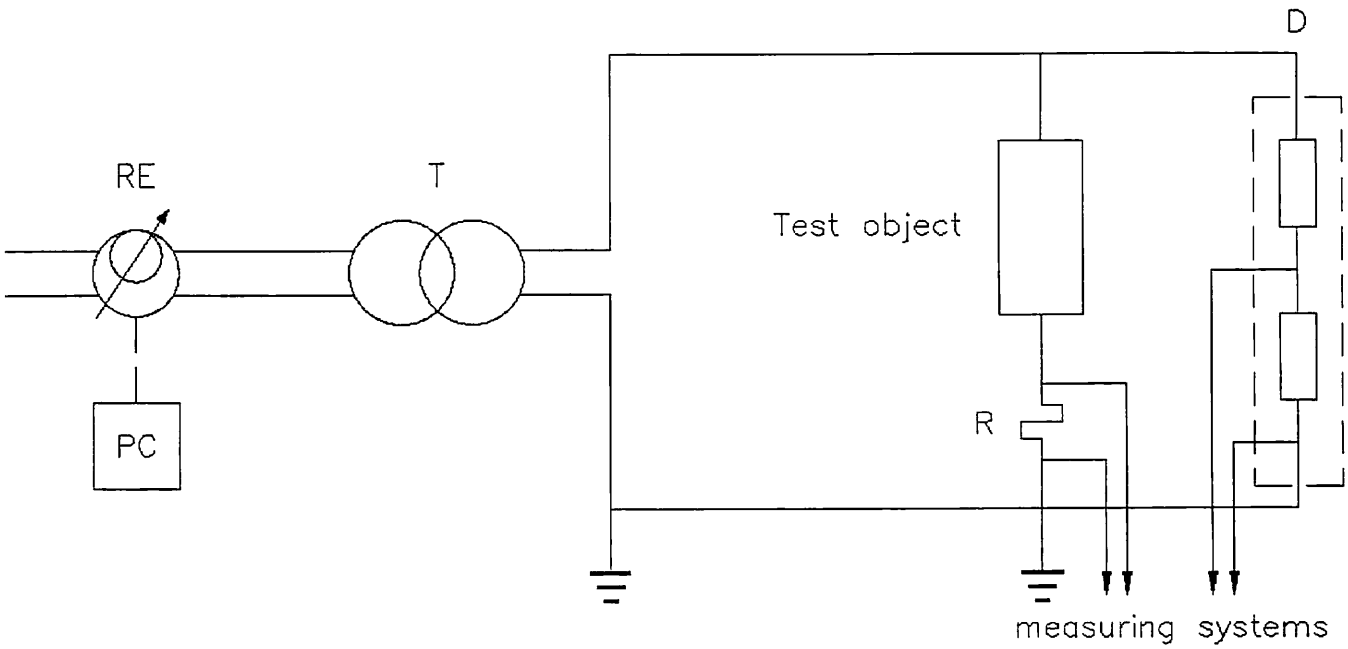
Date: December 10, 2004

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage
No.		kV	No.	μs	kA	kV
MI	0,5 x I_N	59,3 x 2	9	7,9/21,4	4,95	107,20

	Oscilloscope settings		
	sampling division	input	attenuation
	μs	V_{div}	
Current	5	0,5	50:5
Voltage	5	1,0	50:5

Notes: Due to limitation of the test circuit, the residual voltage has been measured at the reduced current equal to 0,5 x I_N

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

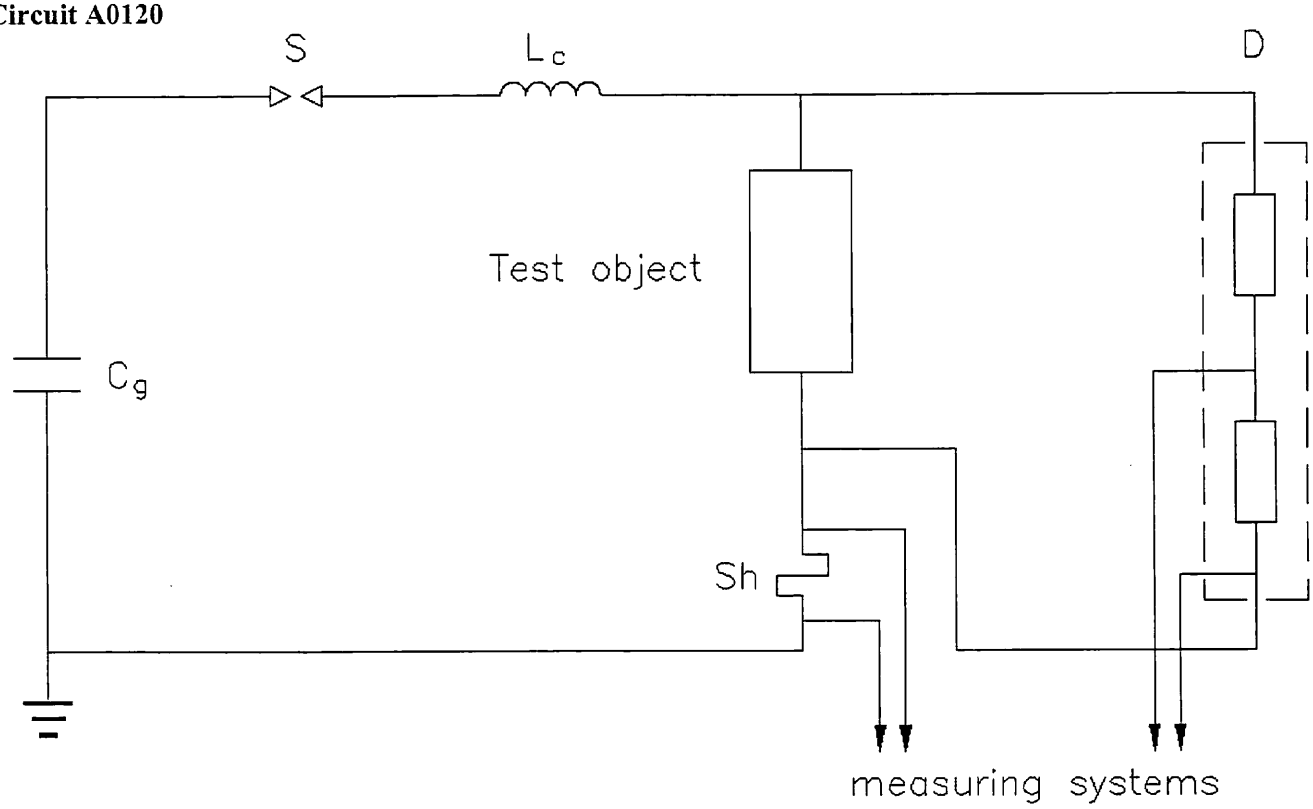
Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system CESI No.11521/522; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11517/518; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Circuit A0120



Impulse generator

No. of stages	2
Cg	4,98 µF
Lc	18 µH
S	- Spark-gap

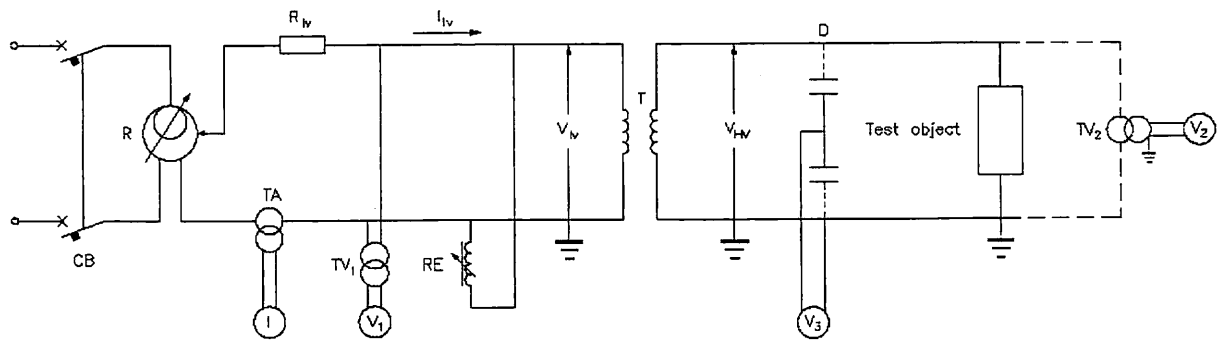
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.13027
	- Electro optical system CESI No.11521/522
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
	- Electro optical system CESI No11517/518
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0012

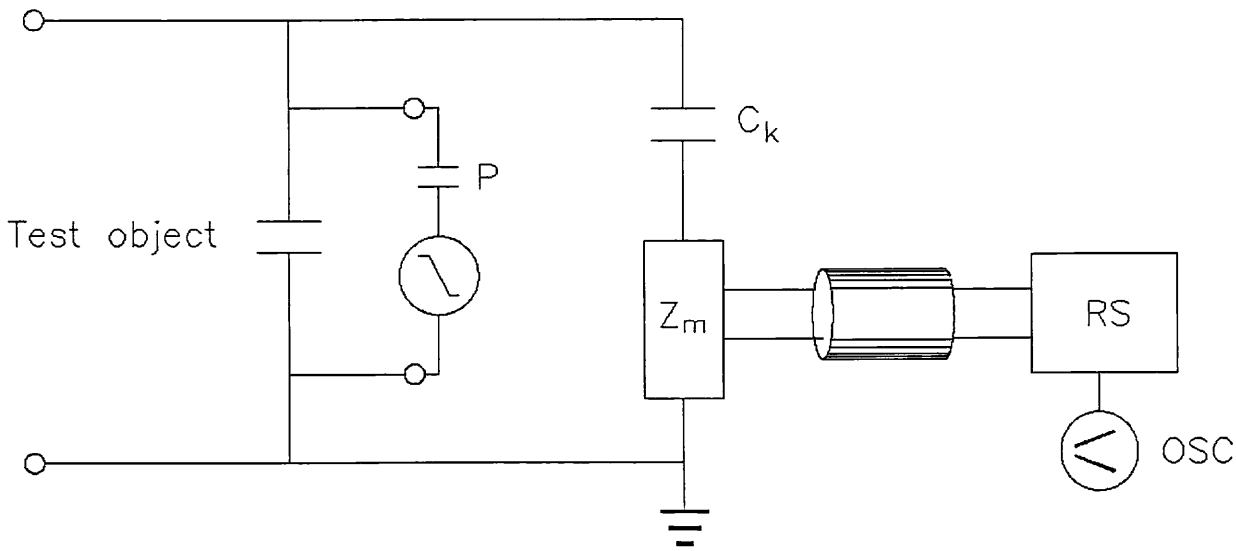


Power frequency test circuit

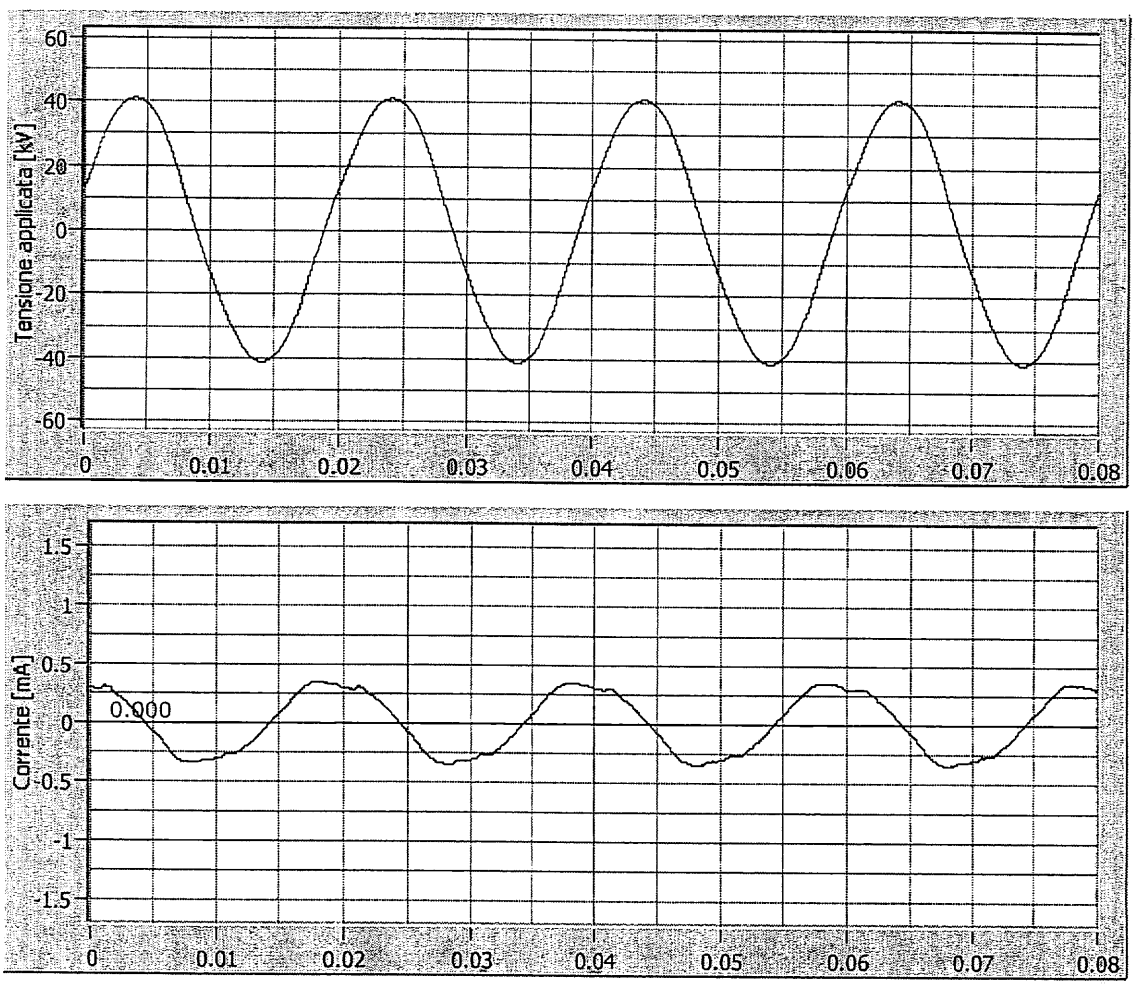
R	- regulator type CORMES; power 66 kVA; voltage 380 V/0-0,22 kV
TA	- current transformer CGS; ratio 150/5 A/300/5 A
I	- amperemeter
TV_1	- voltage transformer CGS; ratio 220-440 V/100 V
V_1	- voltmeter direct reading TSE
RE	- (not used)
T	- booster transformer PIVI; power 250 kVA; voltage 200-400V/250 kV
D	- (not used)
V_3	- (not used)
TV_2	- voltage transformer type PIVI; ratio 25000 V/100 V
V_2	- voltmeter CESI No.6393

Circuit A0022

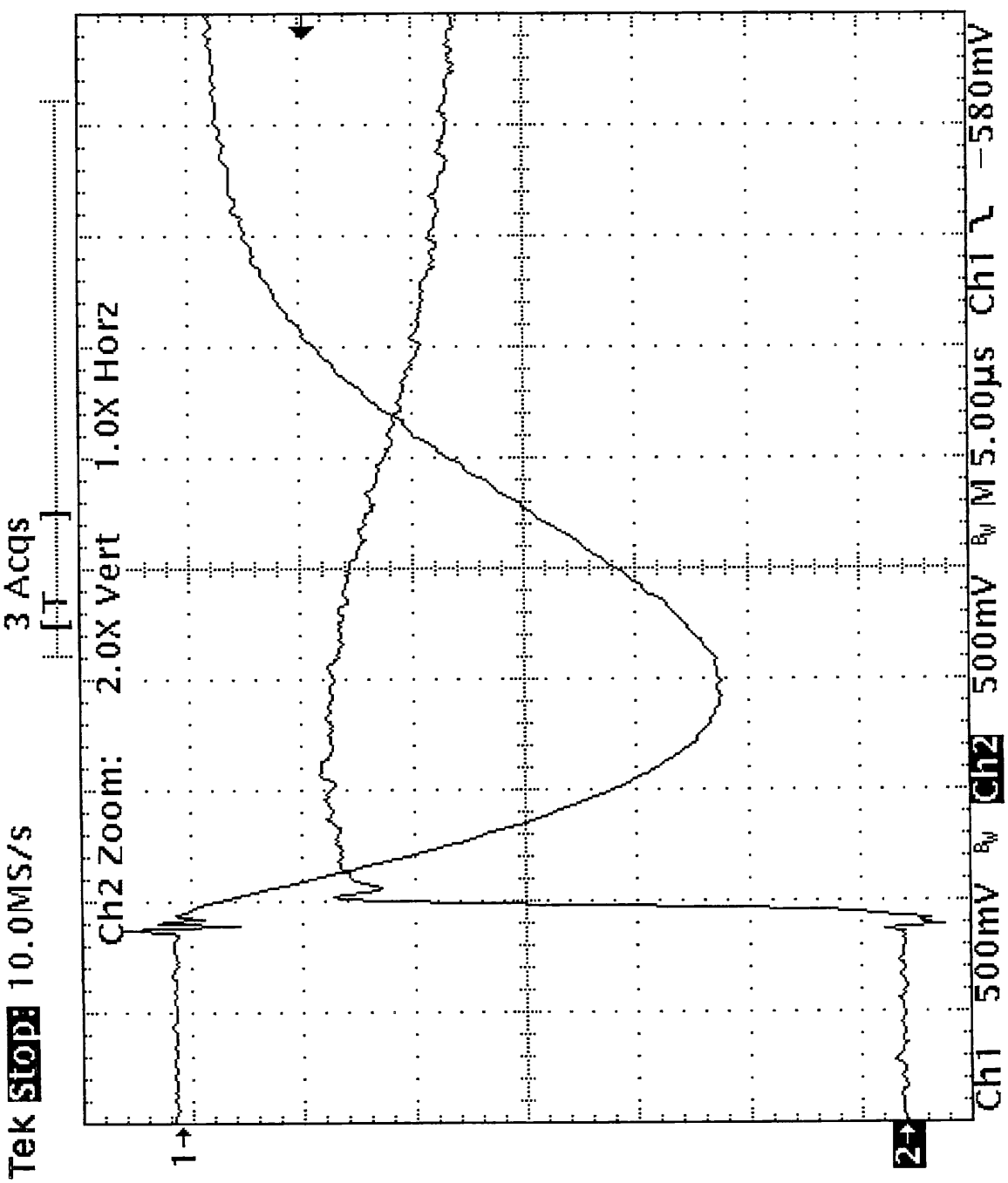
Partial discharges measurement
Direct circuit - Scheme 1a



P	- calibrator CESI; CESI No. 346
C_k	- coupling capacitor 0,3 nF
Z_m	- coupling impedance
RS	- partial discharge detector HAEFELY TRENCH type TE 571; CESI No. 13281
OSC	- (not used)

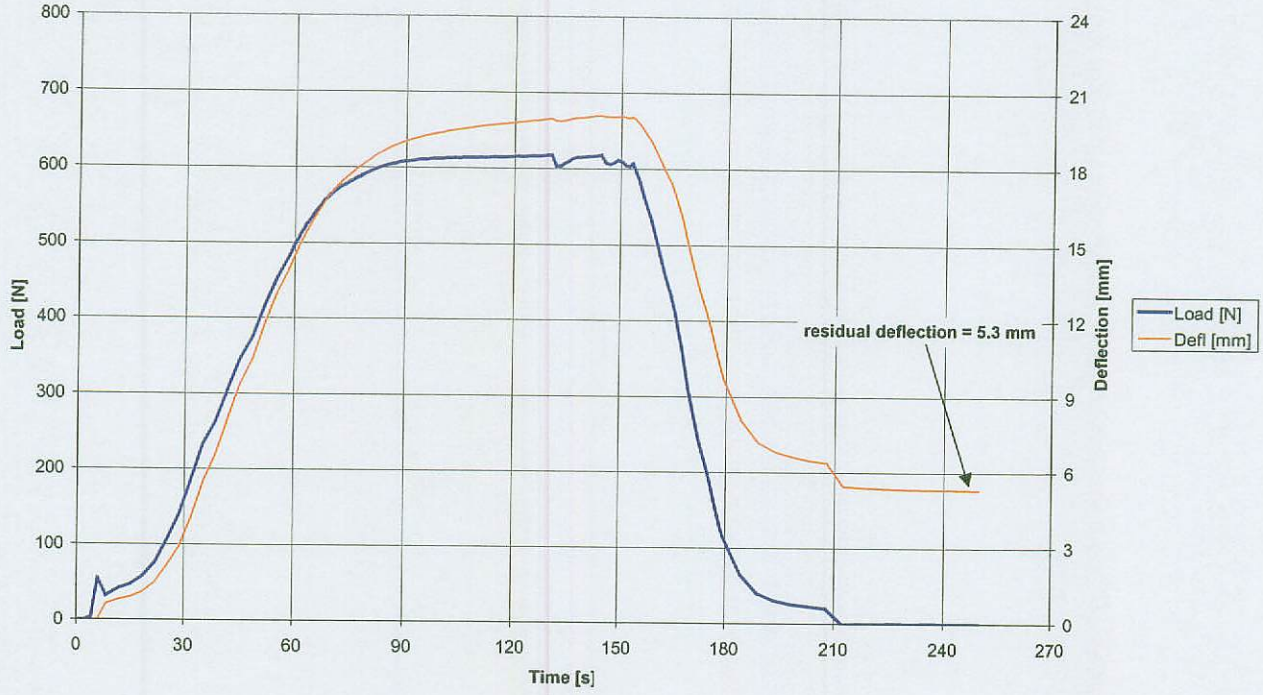


CESI PeC A4523280 oscillogram n. 1



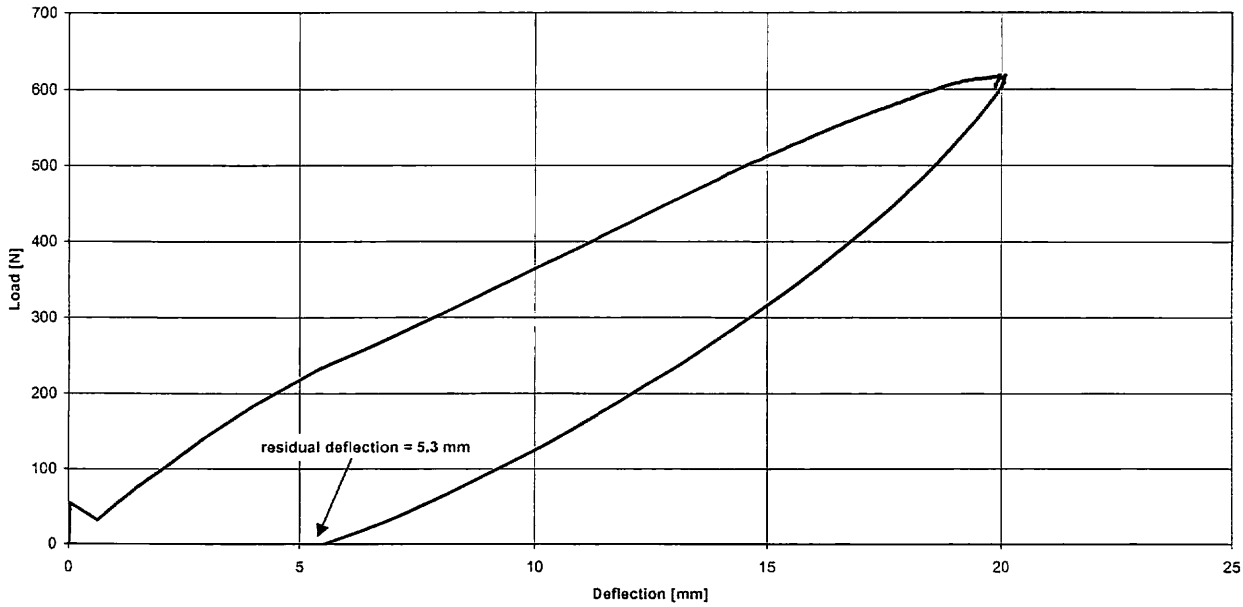
CESI PeC A4523280 oscillogram n. 2

Surge arrester type 2SS15N - rated torque 250 Nm - h=405 mm; F=617 N

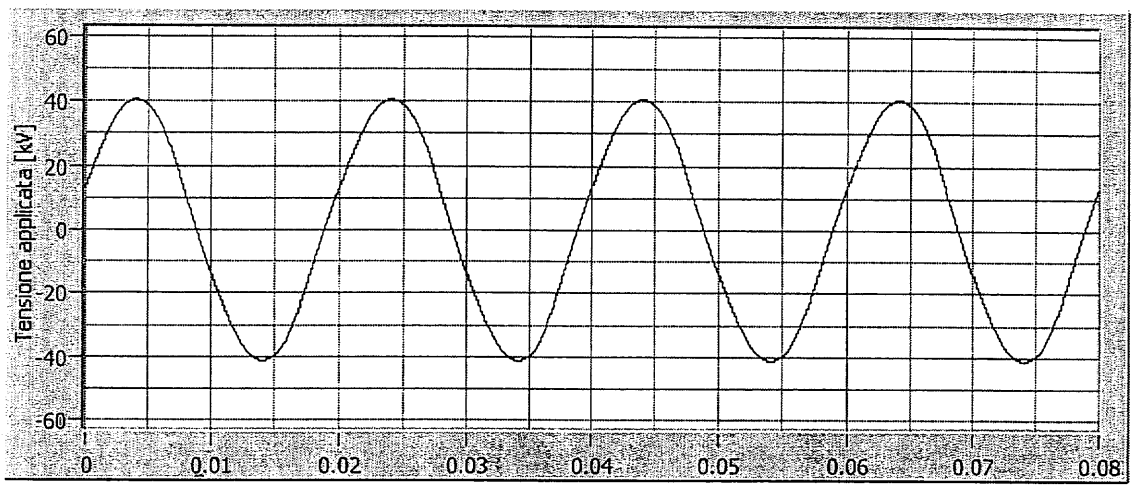


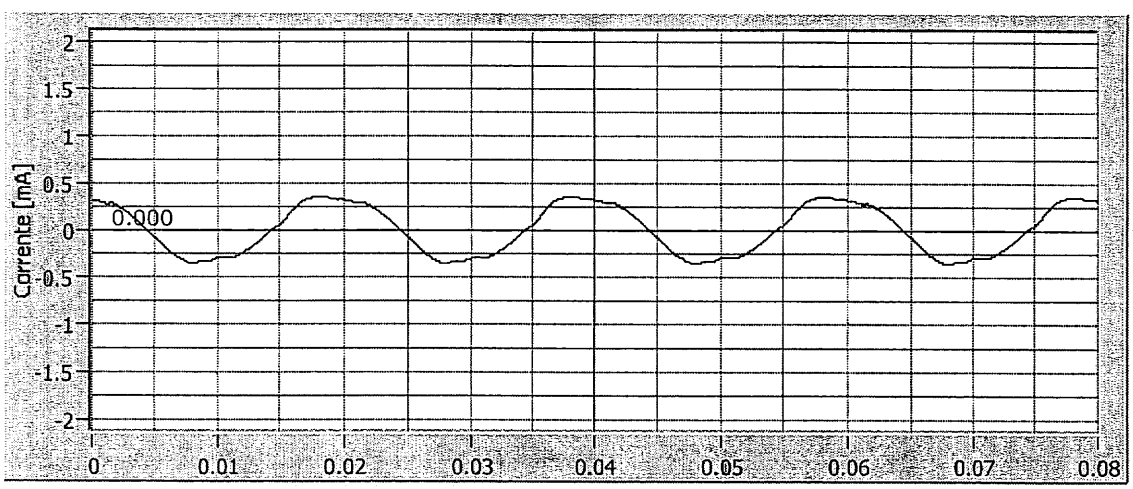
CESI PeC A4523280 oscillogram n. 3

Surge arrester type 2SS15N - rated torque 250 Nm - h=405 mm; F=617 N



CESI PeC A4523280 oscillogram n. 4





BM

CESI PeC A4523280 oscillogram n. 5

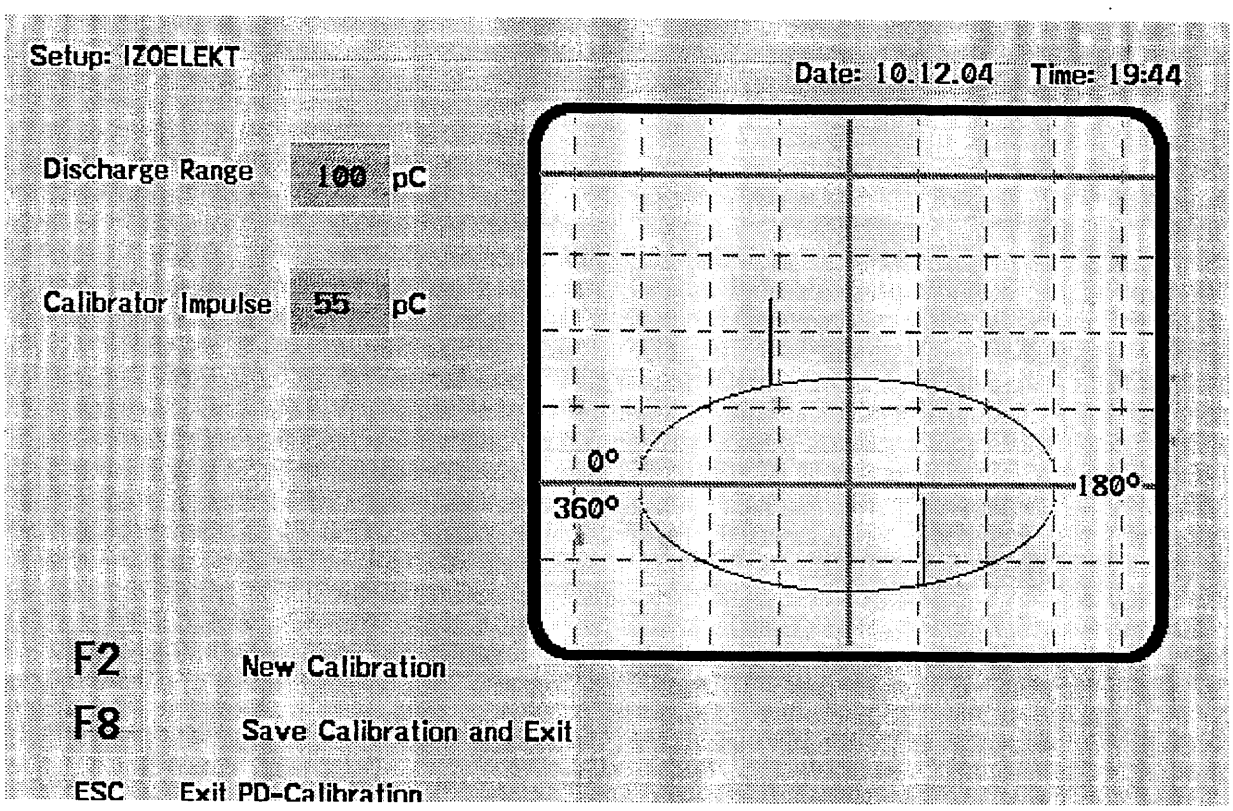
HAEFELY TRENCH TETTEX PD-DETECTOR

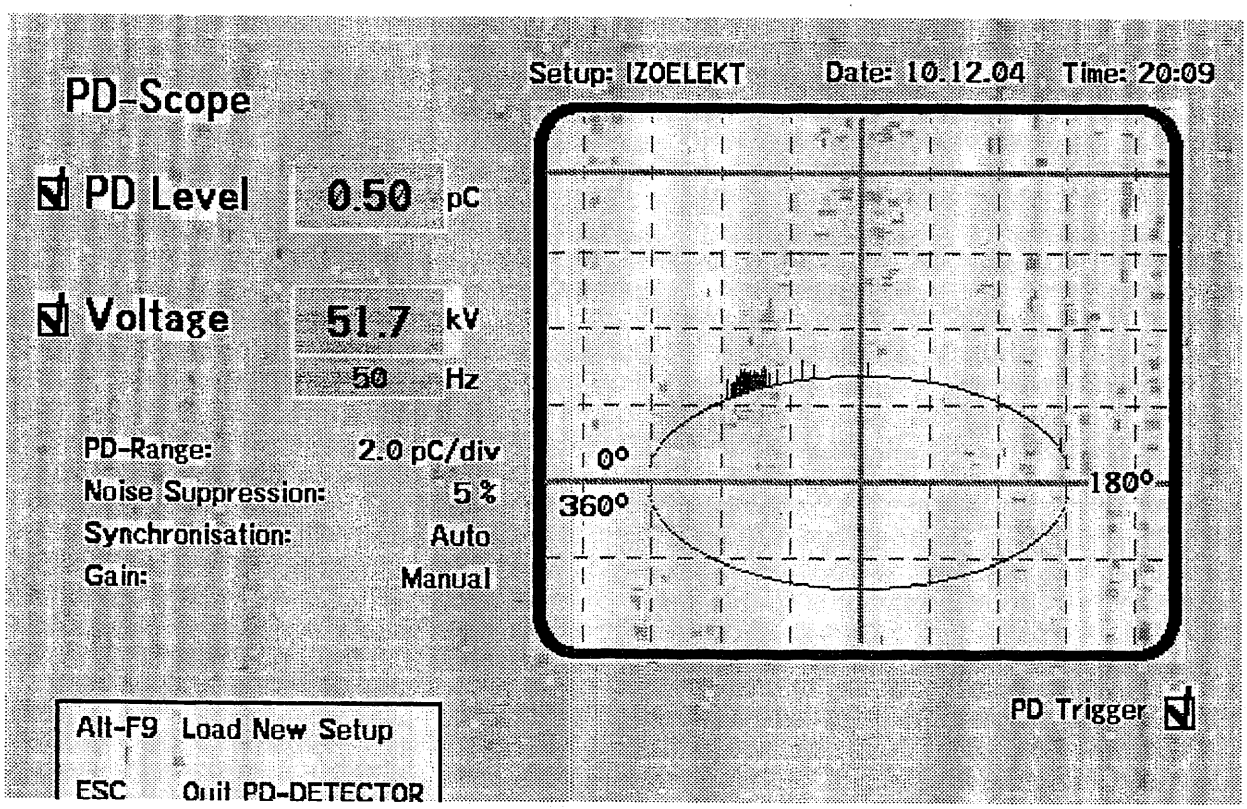
Info: 1
Measurement name:
Comment:
1st PD Range: 100 pC
Noise Suppression: 5 %
Test Measuring Time: 15 s

Start date: 00.00.00
Start time: 00:00

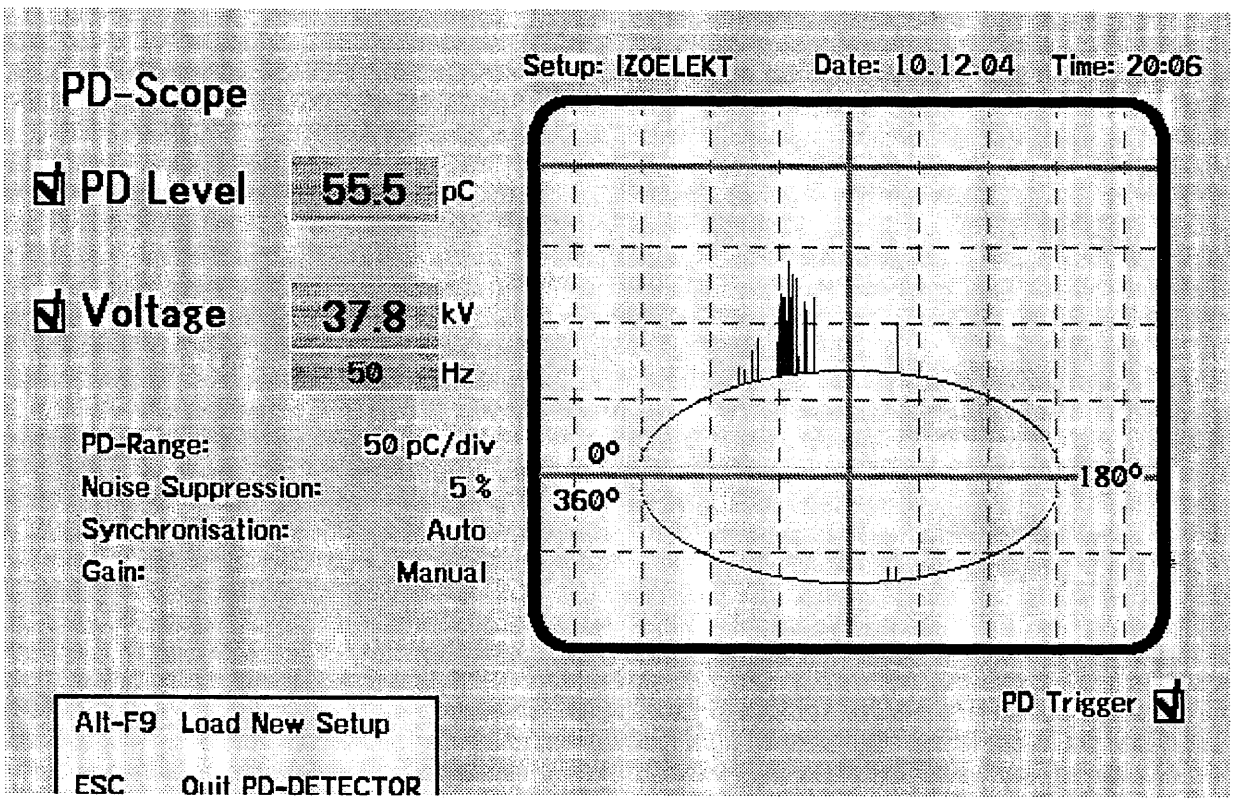
2nd PD Range: Not applied
Lockout Time: 7.3 usec
Voltage Range: 50 kV

Remarks:

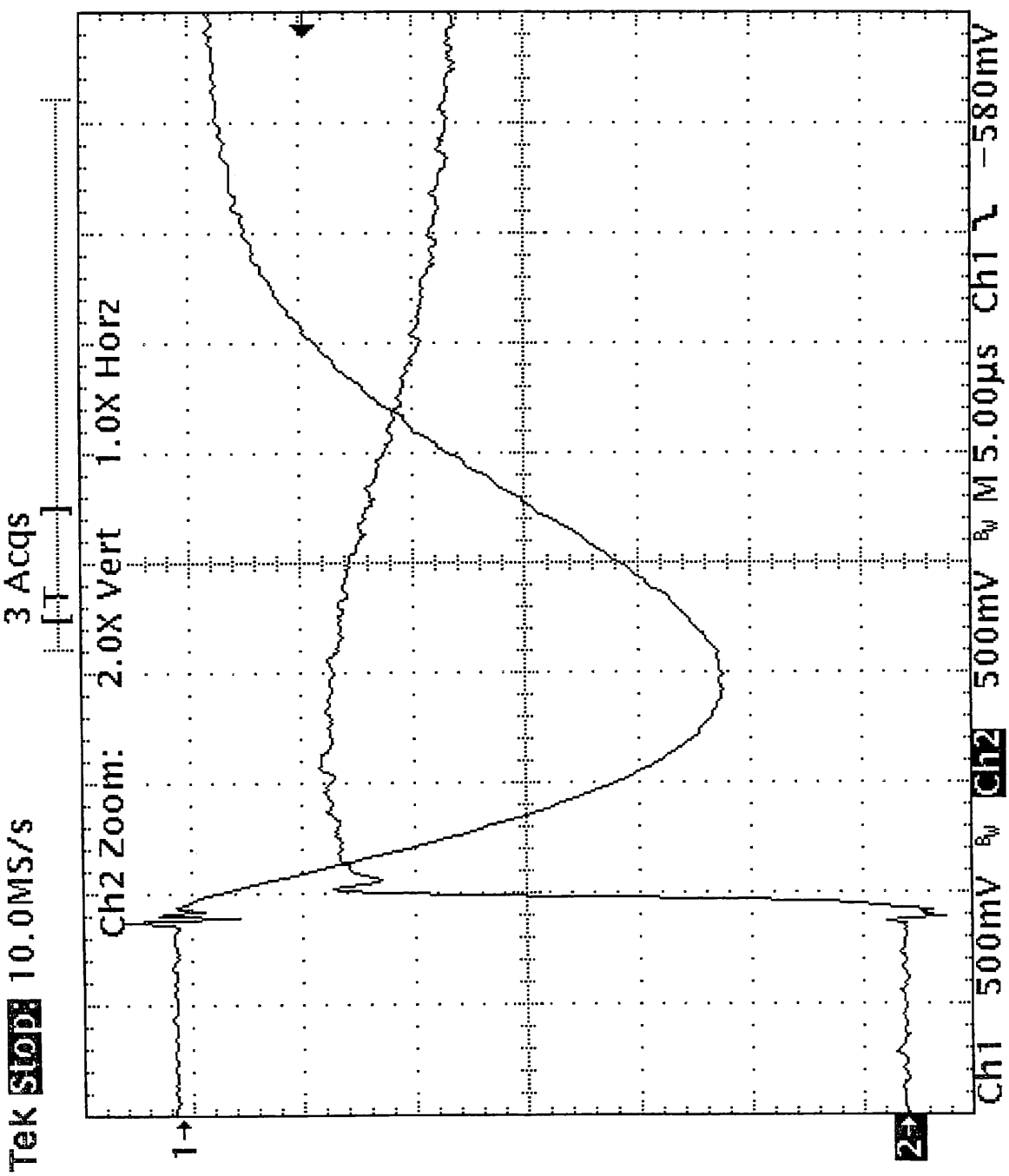




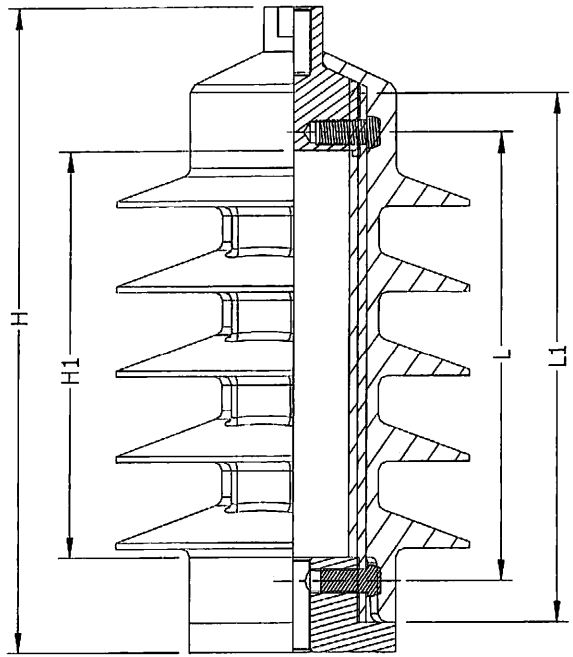
CESI PeC A4523280 oscillogram n. 7



CESI PeC A4523280 oscillogram n. 8



CESI PeC A4523280 oscillogram n. 9



Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks Hl (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
21-48-01	3,75	147	3	67	107	81
21-48-02	5	147	3	67	107	81
21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
21-48-06	15	193	5	113	153	127
21-48-07	17,5	243	6	163	203	177
21-48-08	20	243	6	163	203	177
21-48-09	22,5	243	6	163	203	177
21-48-10	25	270	7	190	230	204
21-48-11	26,25	270	7	190	230	204
21-48-12	27,5	270	7	190	230	204
21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

CESI
PROTOCOLLO A 5/0 0 6 7 07 n.1
DATA 23 FEB. 2005
Firma Marco Gegon

IZO ELEKTRO...	ISO2768 -	Measure: 1:10	Weight:
		Material:	

	Date:	Name:	Signature:
Izdelal:	27.8.03	R. Kuernik	
Pregledal:	1.9.03	P. Pungercar	
Odobril:	1.9.03	P. Pungercar	

Opombe:

Type: SURGE ARRESTER 2SS15N

Code: 21-48-00

Sheet: 1/1

Izdelek: Pripr.

Test Report

CESI Sinal n° 0030 Approved

Client	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Tested equipment	Polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	Residual voltage tests
Standards/Specifications	IEC 60099-4 (2004-05)
Test date	**from** December 10, 2004 **to** December 14, 2004

No. of pages	16	**No. of pages annexed**	20
Issue date	February 23, 2005		
Prepared	BU PeC - M. Gregori		
Verified	BU PeC - A. Sironi		
Approved	BU PeC - M. de Nigris		

CESI
CENTRO ELETTROTECNICO SPERIMENTALE ITALIANO
Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

Tests witnessed by: —

Identification of the object:

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5006707 No. 1, is annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 28, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L. Podavitte – Mr I. Guacci
Test laboratory	P177
Activity code	19774B

Test object characteristics

type: Polymer housed metal-oxide surge arrester section

electrical characteristics (assigned by the client)

Manufacturer's name	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Nominal discharge current - I_N [kA]	10,0
Rated voltage - U_n [kV]	0,9912 x Uref.
Continuous operating voltage - U_c [kV]	0,7930 x Uref.
Reference current - $I_{ref.}$ [mA]	1,4
Line discharge class	1
Rated frequency - [Hz]	50 – 60
year of manufacture	2004

geometrical characteristics (measured on the test sample)

Height [mm]	215
Number of sheds	5
Shed diameter [mm]	117

other characteristics

Housing material	silicone
Housing color	grey

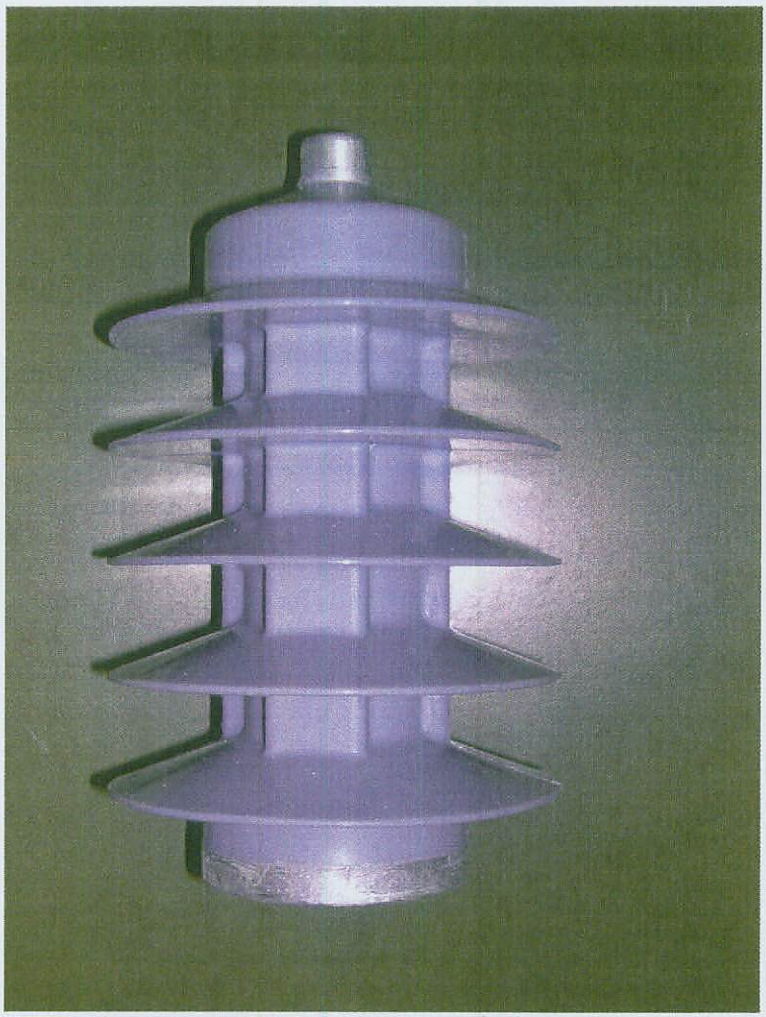


Photo no. 1
Panoramic view of the test object

Reference Standard

IEC 60099-4 (2004-05) Clause 10.8.3
"Metal-oxide surge arrester without gaps for a.c. system"

Test carried out	Number of sample tested
Lightning impulse residual voltage test	3
Switching impulse residual voltage test	
Steep current impulse residual voltage test	

Test object identification

Test object name	Identification of test sample (given by Cesi)
polymer housed metal-oxide surge arresters section	RV1-RV2-RV3

Test procedure

- The lightning impulse residual voltage with current waveshape having front time equal to 8 μs and time to half value equal to 20 μs at the following values has been measured at following current levels:

  I_N = 10 kA
  0,5 I_N = 5 kA
  2 I_N = 20 kA

- The switching impulse residual voltage with current waveshape having front time greater then to 30 μs but less than 100 μs and time to half value roughly twice has been measured according to table 3 of the reference standard at following current levels:

  I = 125 A
  I = 500 A

- The steep current residual voltage at I_N with current waveshape having front time equal to 1 μs and time to half value not longer than 20 μs has been measured.
  The inductive error was measured replacing the surge arrester section with a metal blocks having the same dimensions. The inductive correction was applied by substracting the impulse shape measured on the surge arrester and the impulse shape on the metal block.

Lightning impulse residual voltage test. IEC 60099-4 Standard

Test circuit: A0120

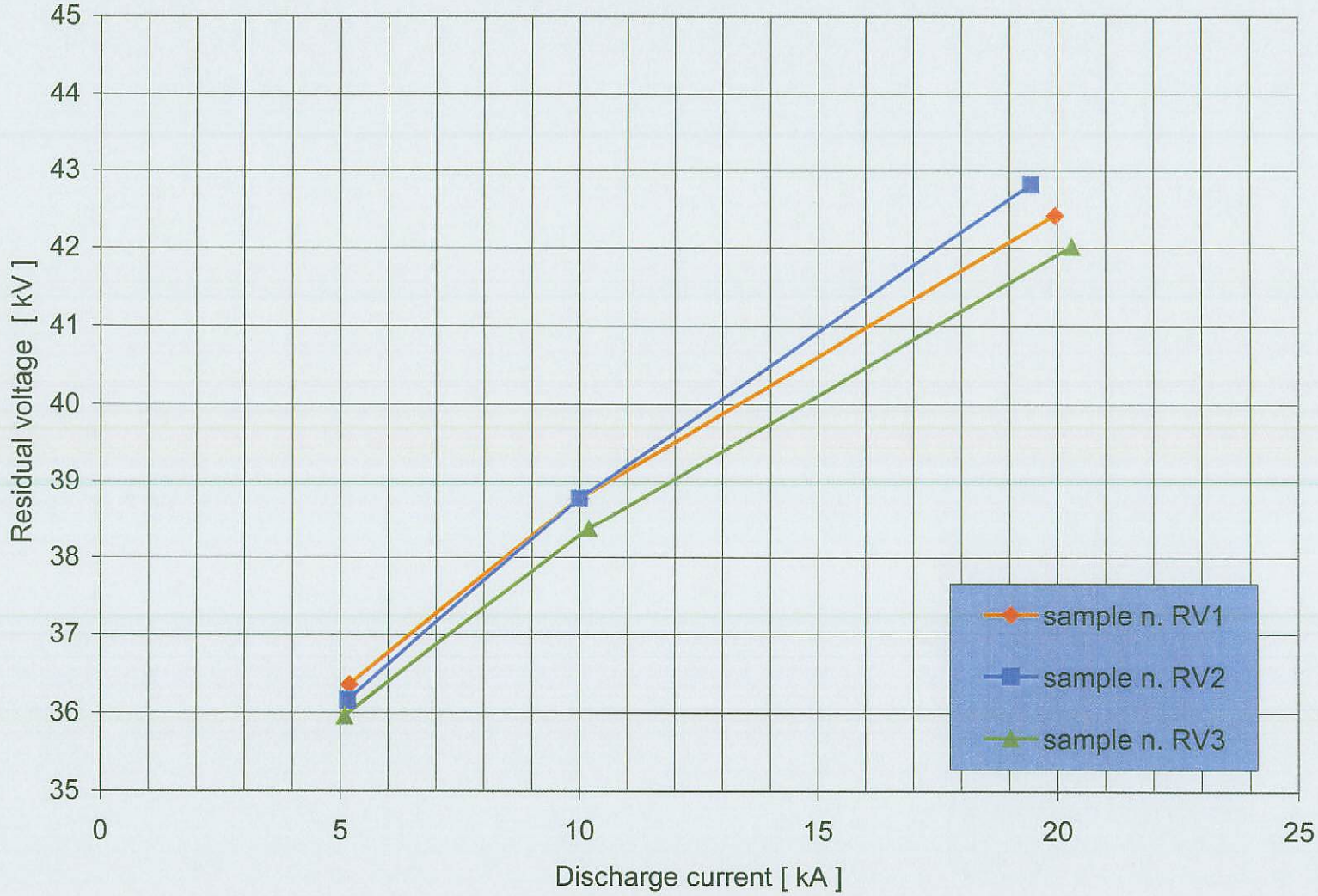
Date: December 13, 2004

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage	Lightning impulse protection level
No.		kV	No.	µs	kA	kV	kV
RV1	0,5 × I_N	43,0	10	7,9/20,0	5,20	36,36	see relevant curve in the following page 9
	I_N	52,0	4	8,0/19,4	10,00	38,78	
	2,0 × I_N	68,8	7	8,4/19,1	19,95	42,42	
RV2	0,5 × I_N	43,0	11	7,9/20,0	5,16	36,16	
	I_N	52,0	5	8,0/19,4	10,00	38,78	
	2,0 × I_N	68,8	8	8,4/19,1	19,45	42,82	
RV3	0,5 × I_N	43,0	12	7,9/20,0	5,10	35,96	
	I_N	52,0	6	8,0/19,4	10,20	38,38	
	2,0 × I_N	69,0	9	8,4/19,1	20,30	42,02	

		Oscilloscope settings		
		sampling division	input	attenuation
		µs	V_{div}	
Current	0,5 I_N	5	0,5	20:5
	I_N		0,5	50:5
	2 I_N		1,0	50:5
Voltage	0,5 I_N	5	1,0	50:5
	I_N		1,0	50:5
	2 I_N		1,0	50:5

Notes:

Lightning impulse protection level



Switching impulse residual voltage test. IEC 60099-4 Standard

Test circuit: A0122

Date: December 14, 2004

Sample	Requested current	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage	Switching impulse protection level
No.	A	kV	No.	µs	A	kV	kV
RV1	125	29,1	13	31/86	130	28,89	30,50
	500	35,2	16	32/73	504	30,50	
RV2	125	29,3	14	31/86	130	28,08	
	500	35,2	17	32/73	500	29,90	
RV3	125	29,3	15	31/86	131	28,08	
	500	35,2	18	32/73	518	30,10	

	Oscilloscope settings		
	sampling division	input	attenuation
	µs	V_{div}	
Current	20	0,5	5:5
Voltage	20	1,0	50:5

Notes:

Steep current impulse residual voltage test. IEC 60099-4 Standard

Measurement of the inductive error

Test circuit: A0121B

Date: December 14, 2004

Sample	Charging voltage	Oscillogram	Current waveshape	Discharge current	Peak voltage	Inductive error
No.	kV	No.	μs	kA	kV	%
aluminium block	59,0	19	0,95/2,2	10,2	1,2	2÷20 (1)

	Oscilloscope settings		
	sampling division	input	attenuation
	ns	V_{div}	
Current	500	2	x 10
Voltage		0,5	---

Notes: (1) correction is required

Steep current impulse residual voltage test. IEC 60099-4 Standard

Test circuit: A0121B

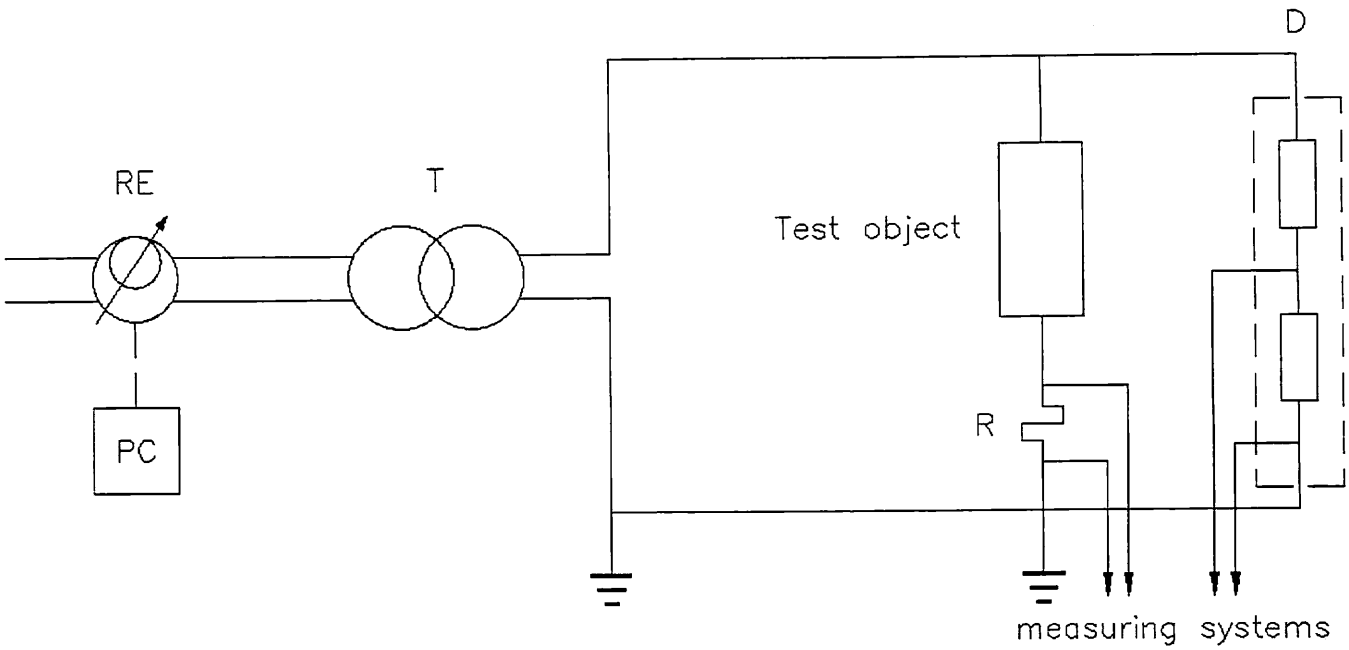
Date: December 14, 2004

Sample	Charging voltage	Oscillogram	Current waveshape	Discharge current	Residual voltage	Steep current impulse protection level
No.	kV	No.	µs	kA	kV	kV
RV1	59,0	20	0,95/2,2	10,1	42,1	42,6
RV2	59,1	21		9,95	42,6	
RV3	59,2	22		10,1	42,0	

	Oscilloscope settings		
	sampling division	input	attenuation
	ns	V_{div}	
Current	500	2	x10
Voltage		10	---

Notes: wave channel 1 : discharge current
wave channel 2 : residual voltage
wave channel M1 : corrected residual voltage

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
PC - personal computer
T - voltage transformer type SPECIALTRASFO; power 30 kVA; voltage 200 V/15-30 kV

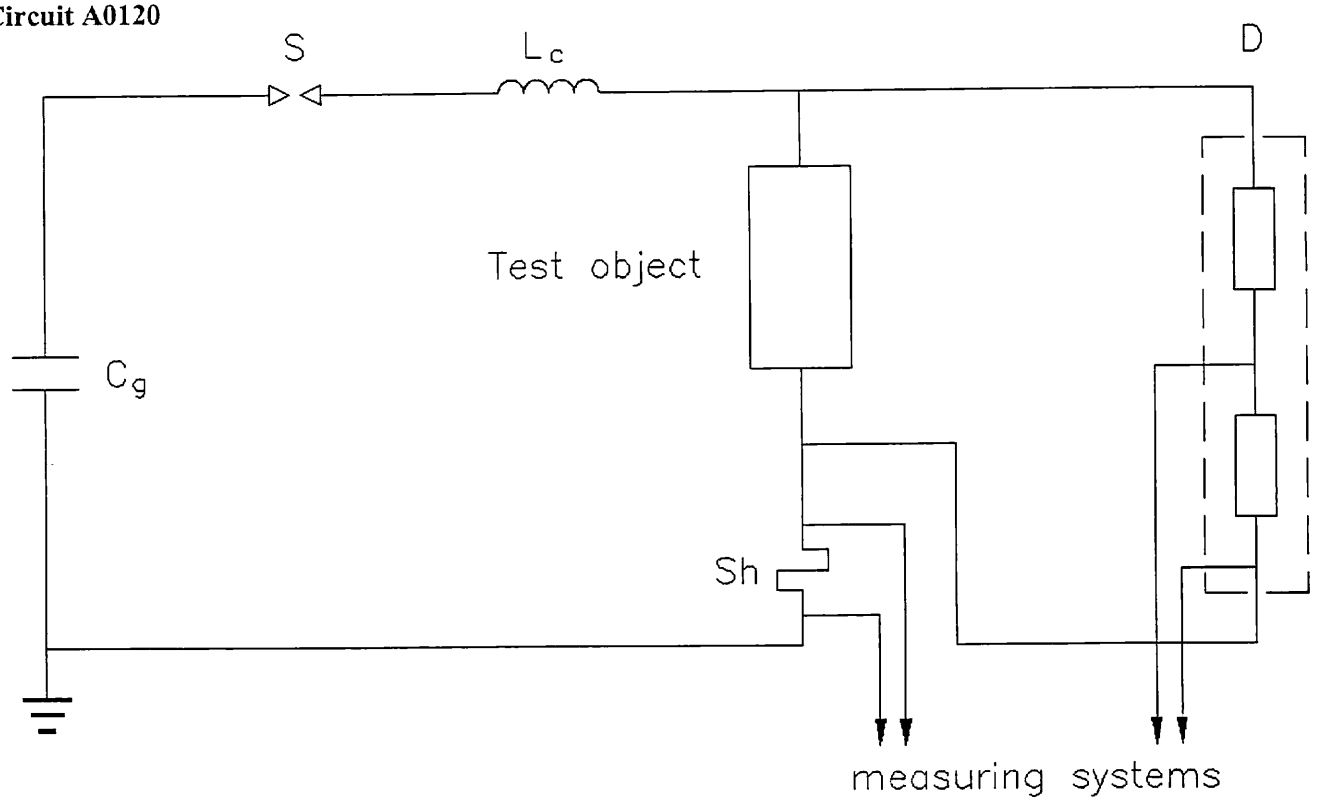
Current measuring system

R - Current shunt CESI No.31120; R= 941,4 Ω
- Electro optical system CESI No.11517/518; attenuation 5:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11521/522; attenuation 50:5
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Circuit A0120



Impulse generator

No. of stages	2
Cg	4,98 µF
Lc	10 µH
S	- Spark-gap

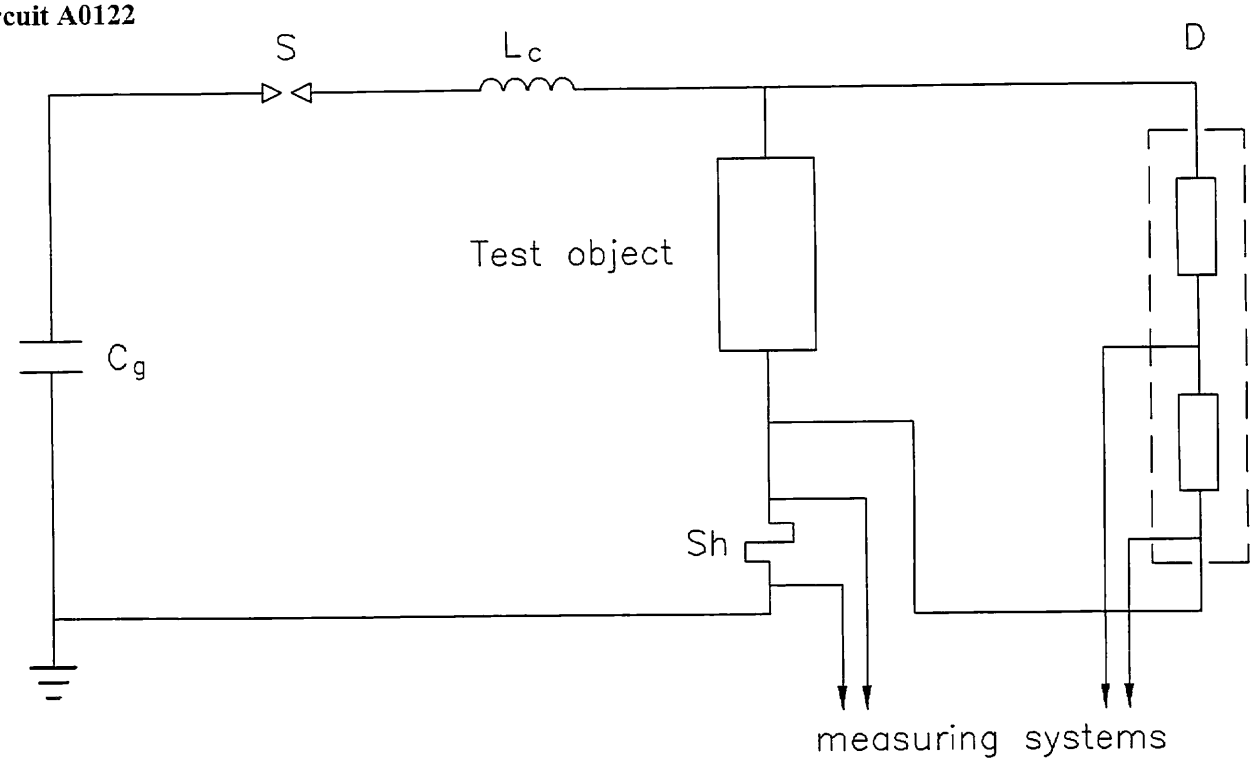
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.11120
	- Electro optical system CESI No.11521/522;
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6042; R= 2 mΩ; peak current= 250 kA
	- Electro optical system CESI No.11517/518;
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0122



Impulse generator

No. of stages	1
Cg	2,49 µF
Lc	150 µH
S	- Spark-gap

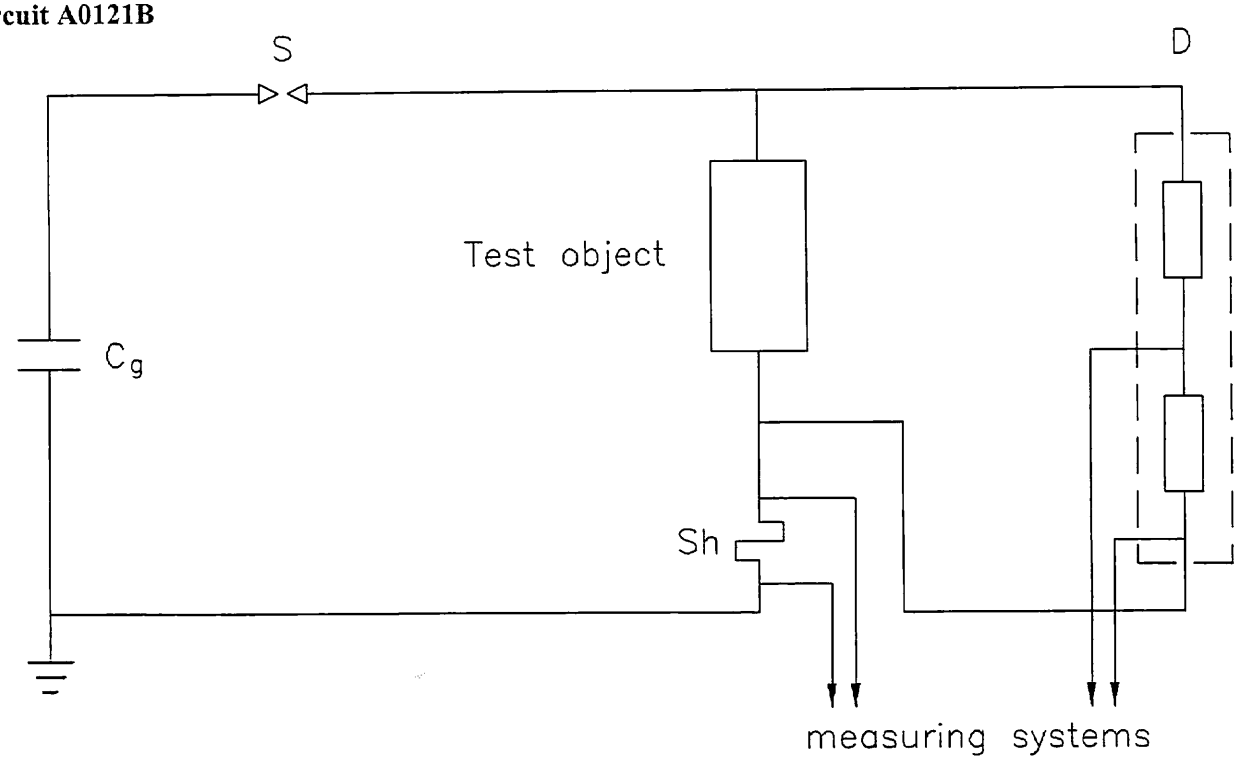
Voltage measuring system.

D	- Voltage divider SAGI; CESI No.11120
	- Electro optical system CESI No 11521/522
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

Sh	- Current shunt CESI No.6037; R= 20 mΩ ; peak current= 250 kA
	- Electro optical system CESI No11517/518
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)

Circuit A0121B



Impulse generator

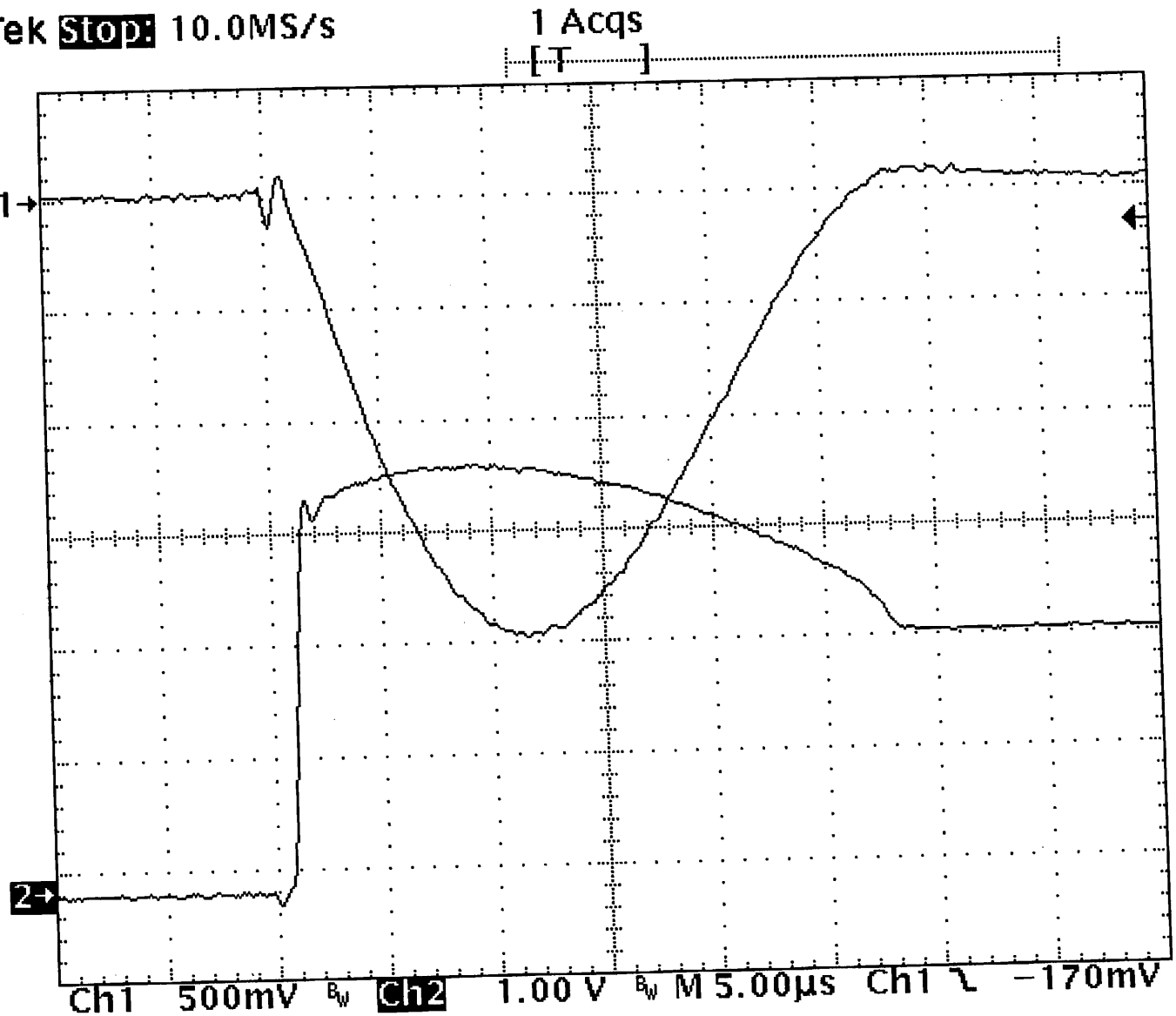
No. of stages	1
Cg	0,25 µF
S	- Spark-gap

Voltage measuring system.

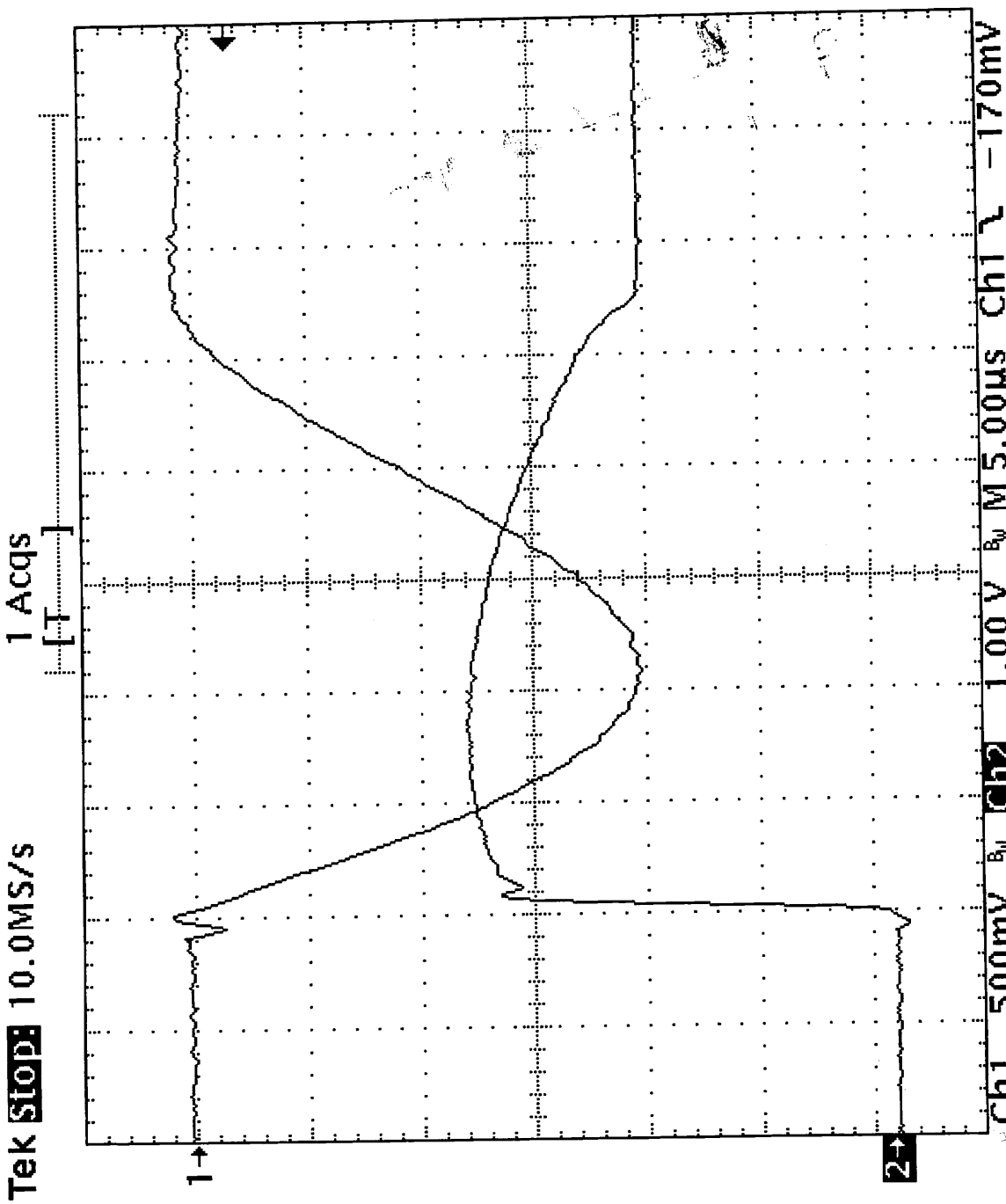
D	- Voltage divider SAGI; CESI No.11120
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.2)

Current measuring system

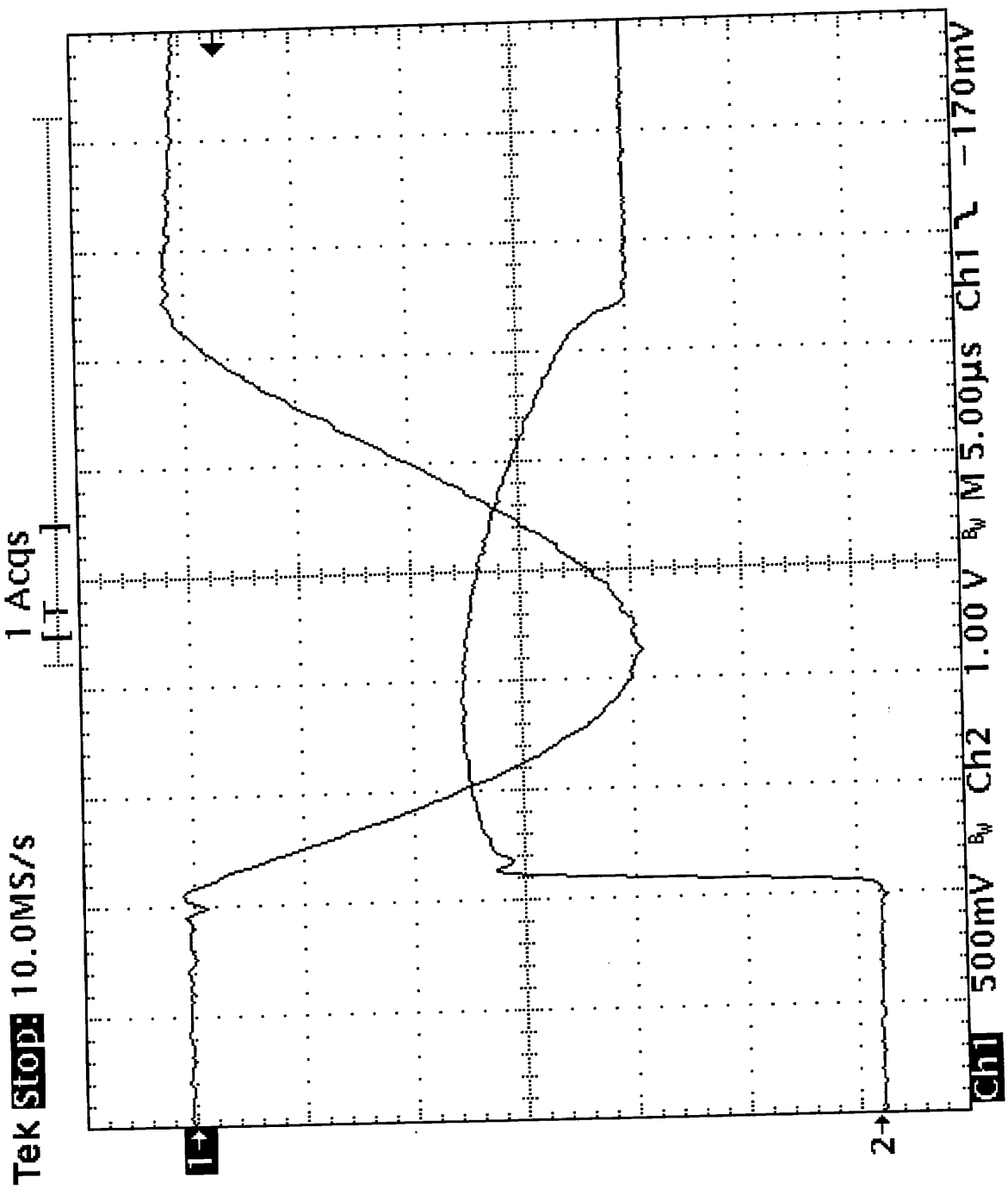
Sh	- Current Pearson CESI No.6042; o,o1 V xA
OSC	- Oscilloscope type TEKTRONIX TDS 540A; CESI No.13217 (on channel No.1)



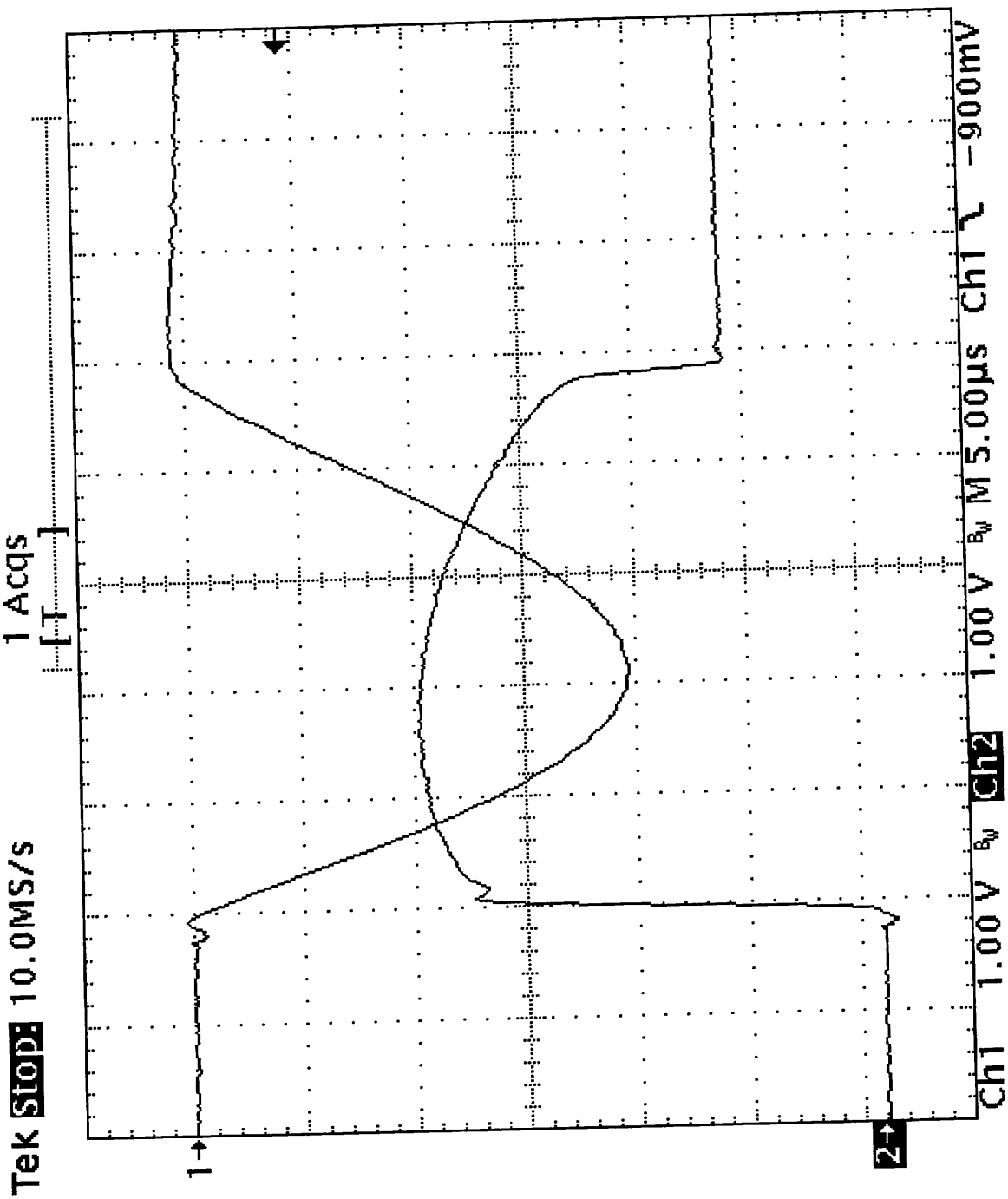
CESI PeC A4522503 oscillogram n. 4



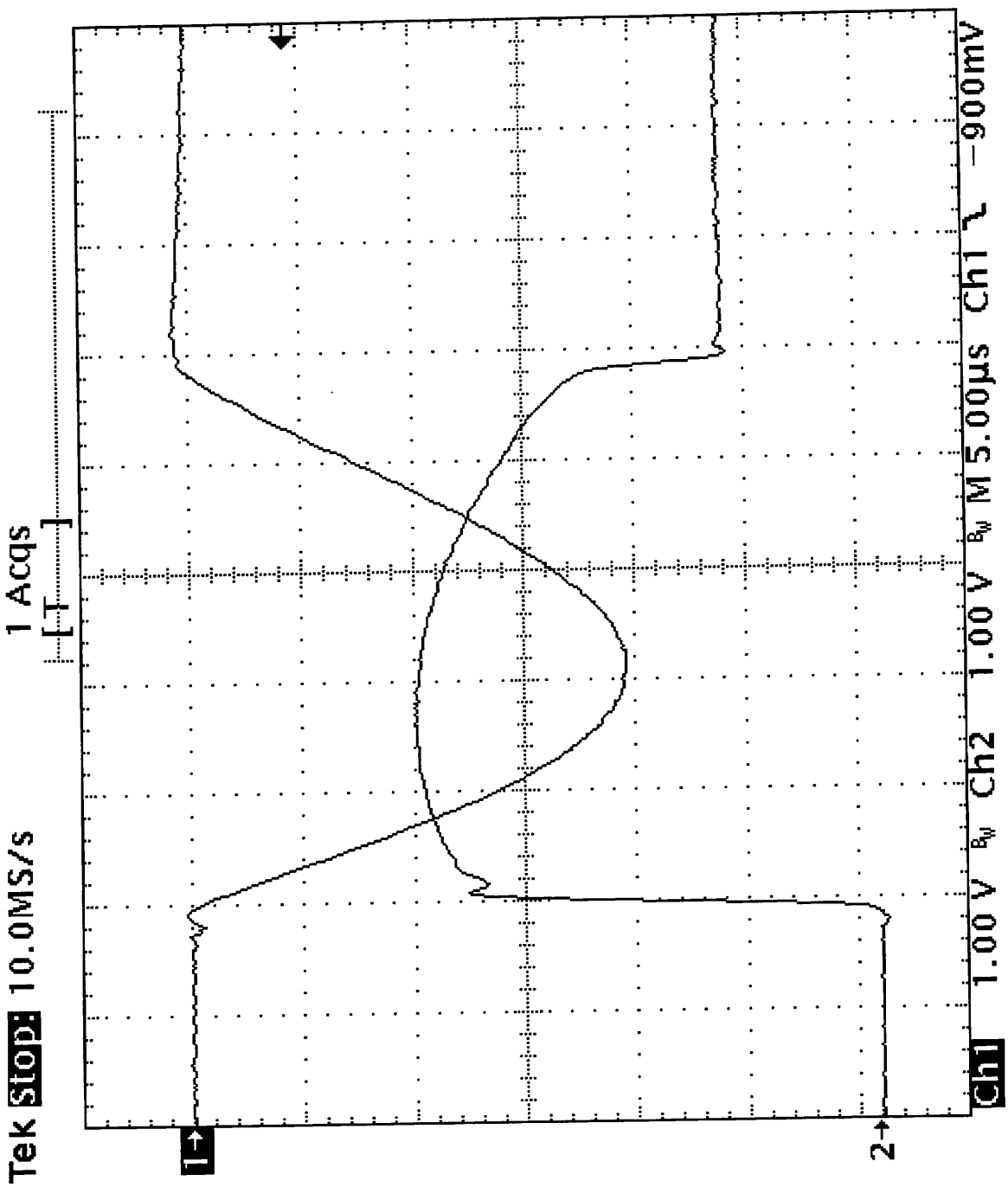
CESI PeC A4522503 oscillogram n. 5



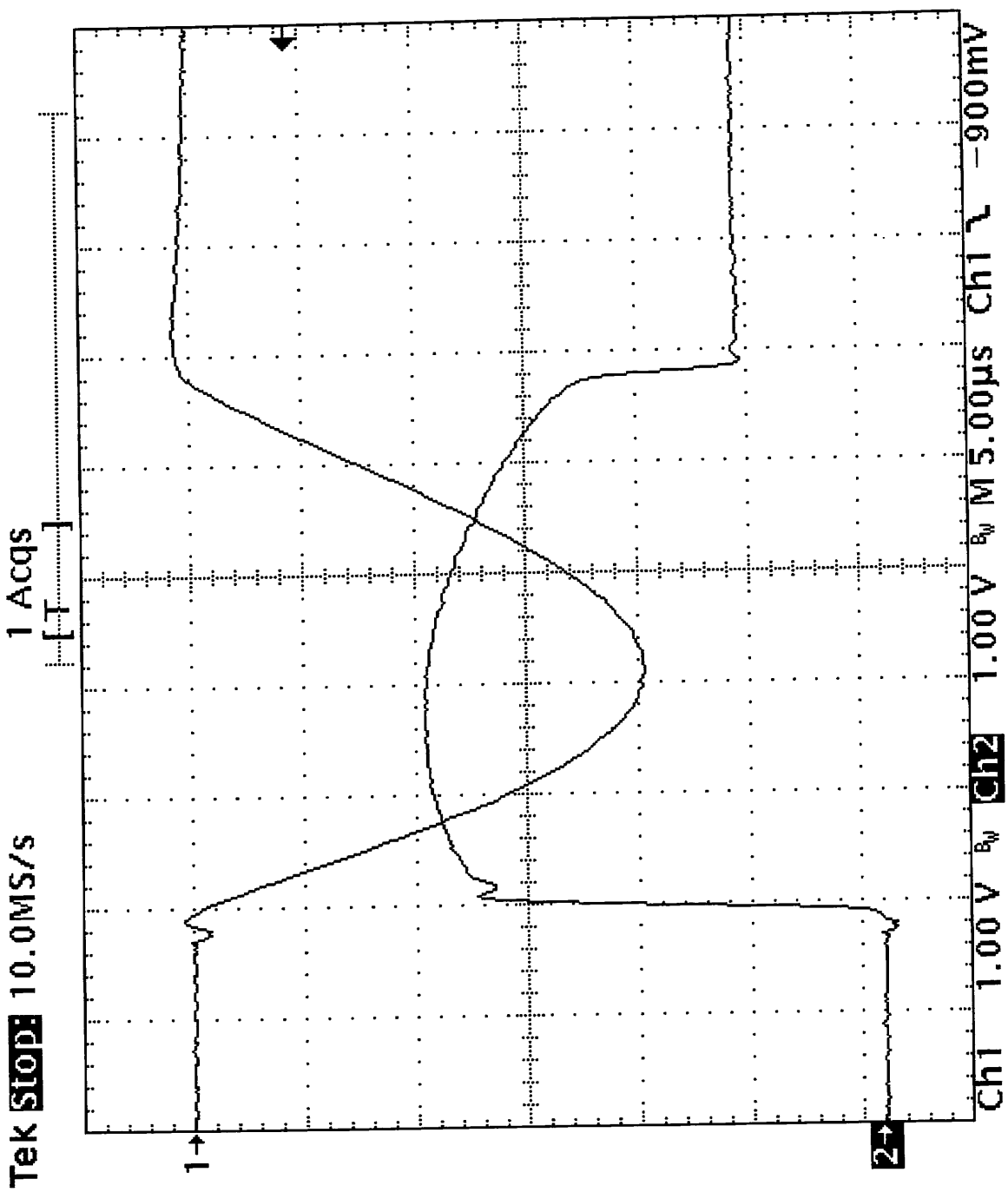
CESI PeC A4522503 oscillogram n. 6



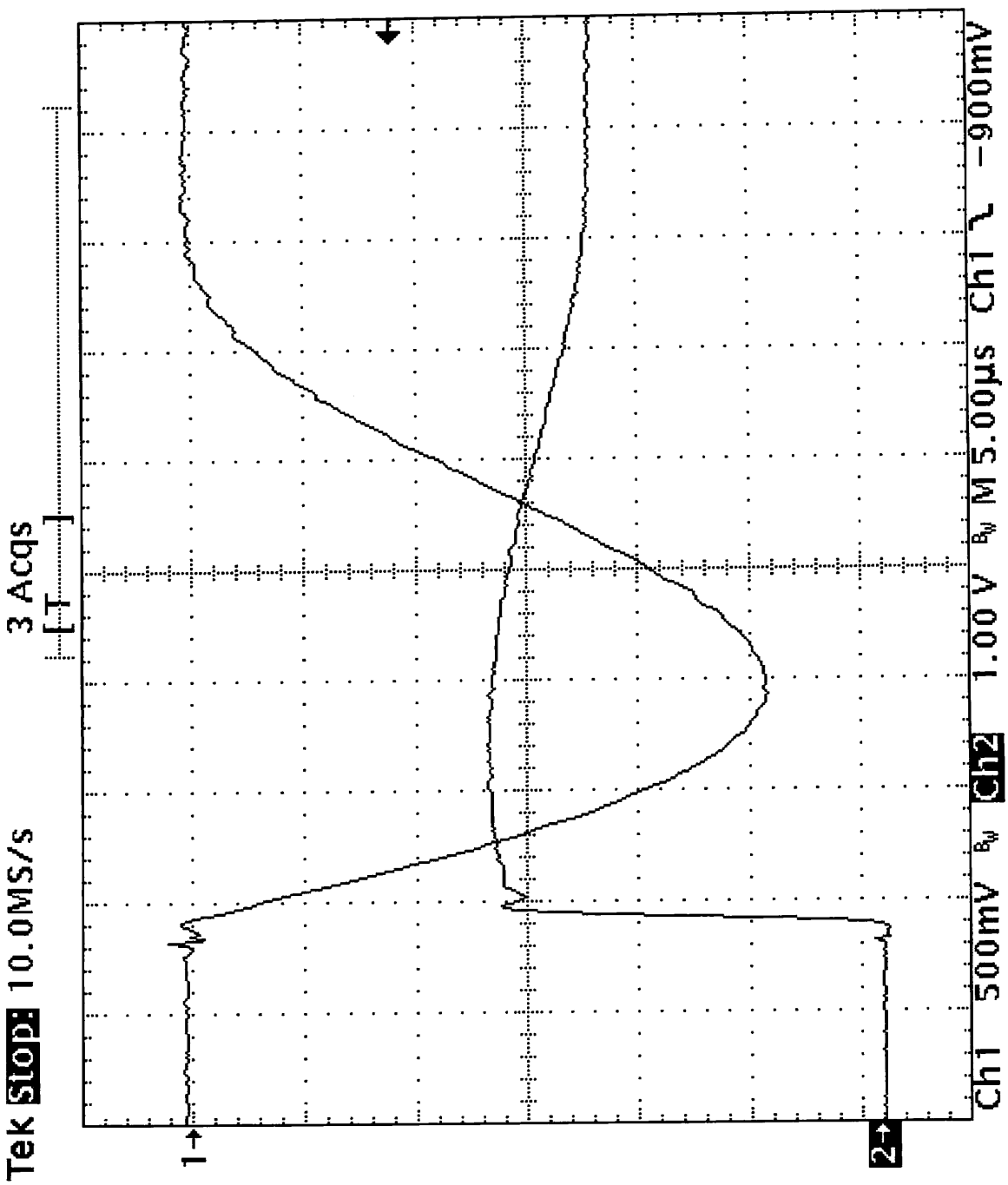
CESI PeC A4522503 oscillogram n. 7



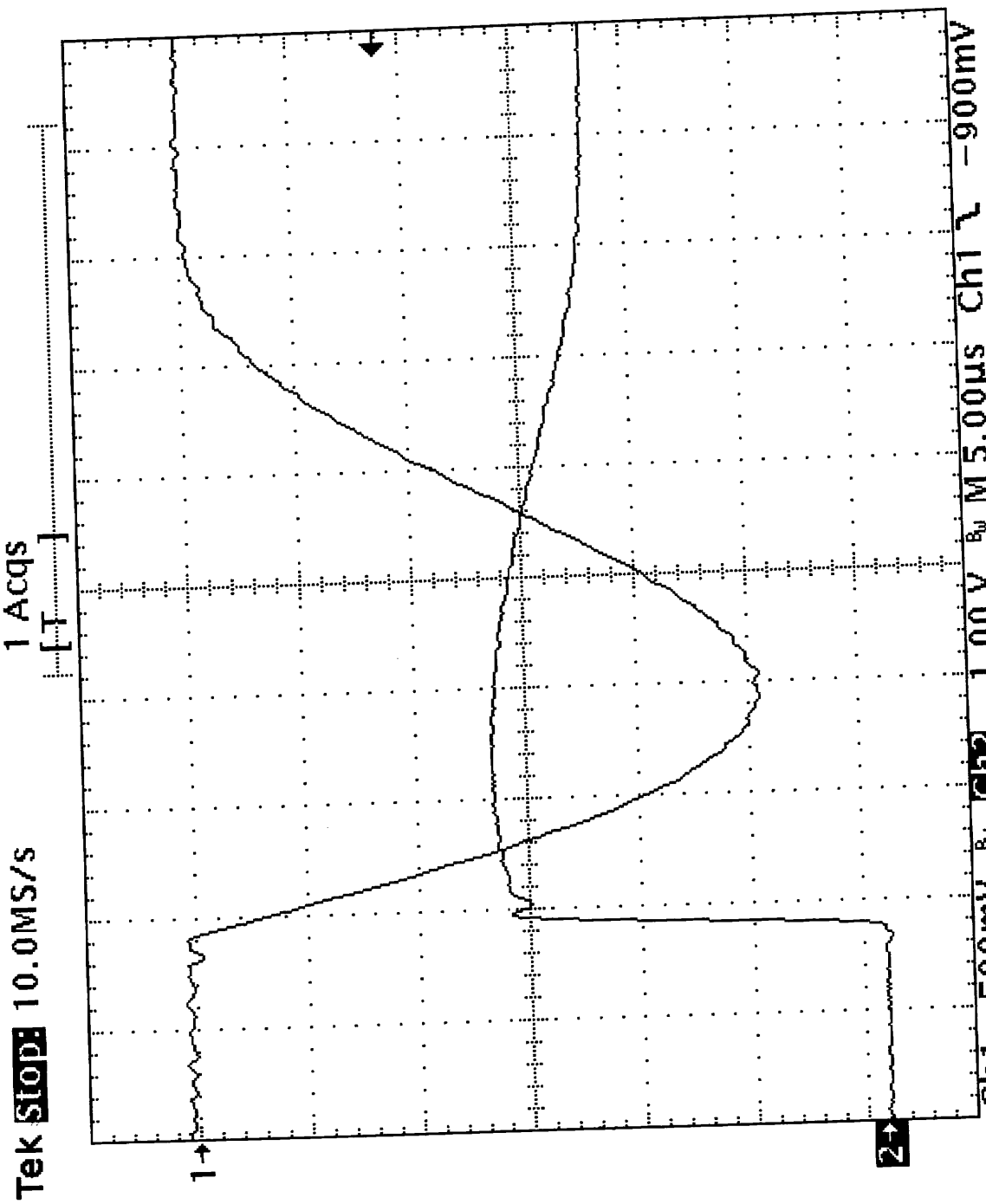
CESI PeC A4522503 oscillogram n. 8



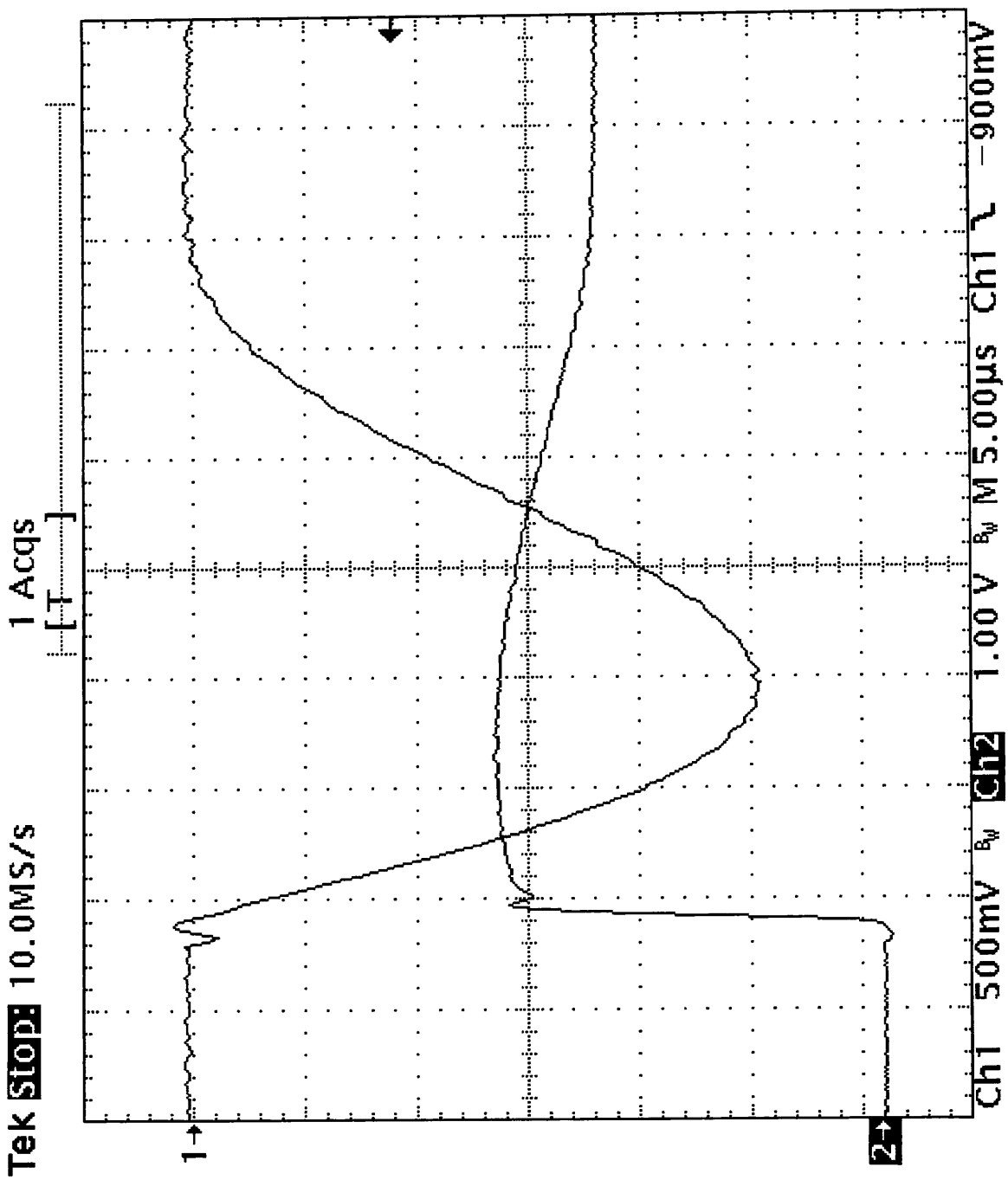
CESI PeC A4522503 oscillogram n. 9



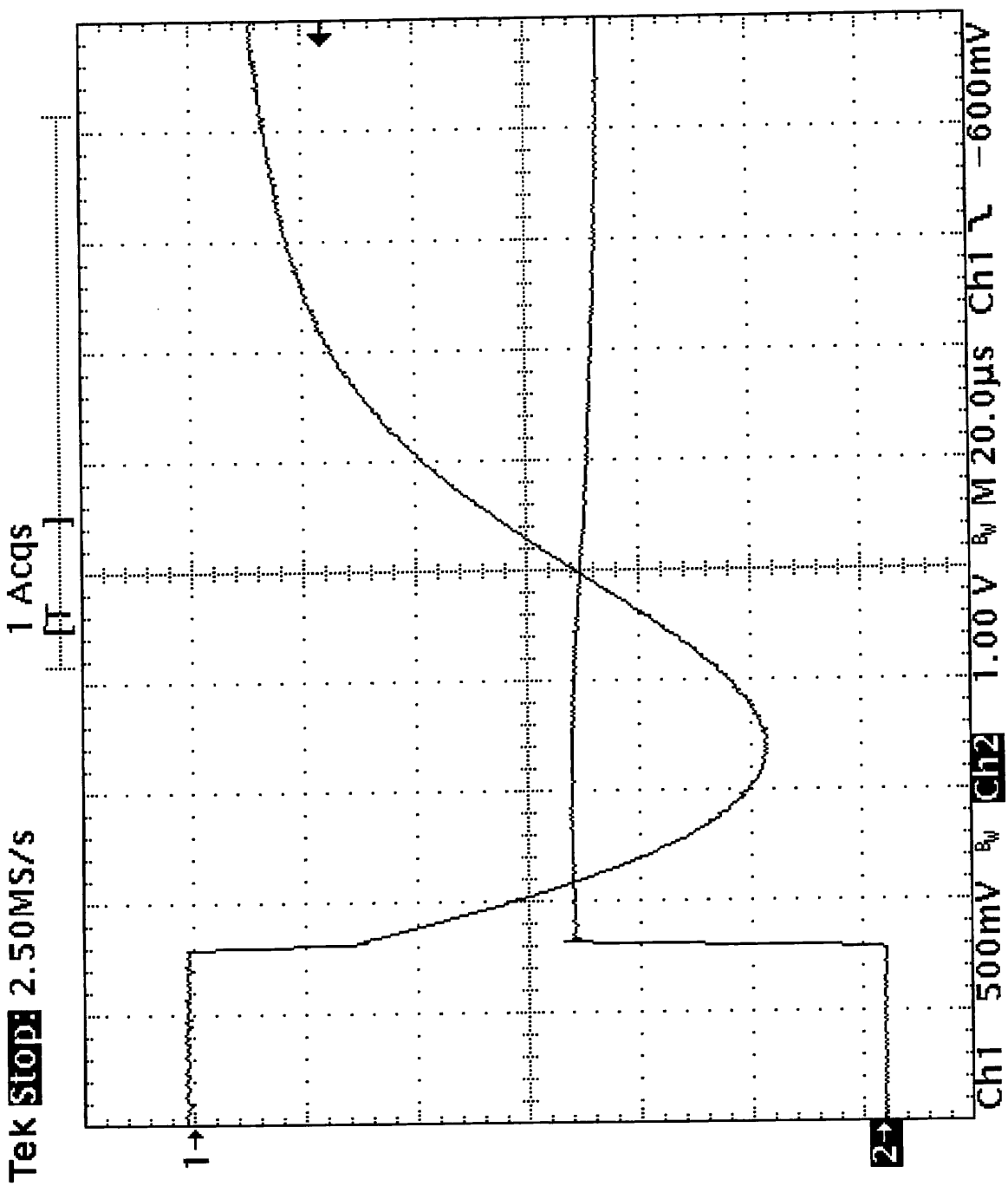
CESI PeC A4522503 oscillogram n. 10



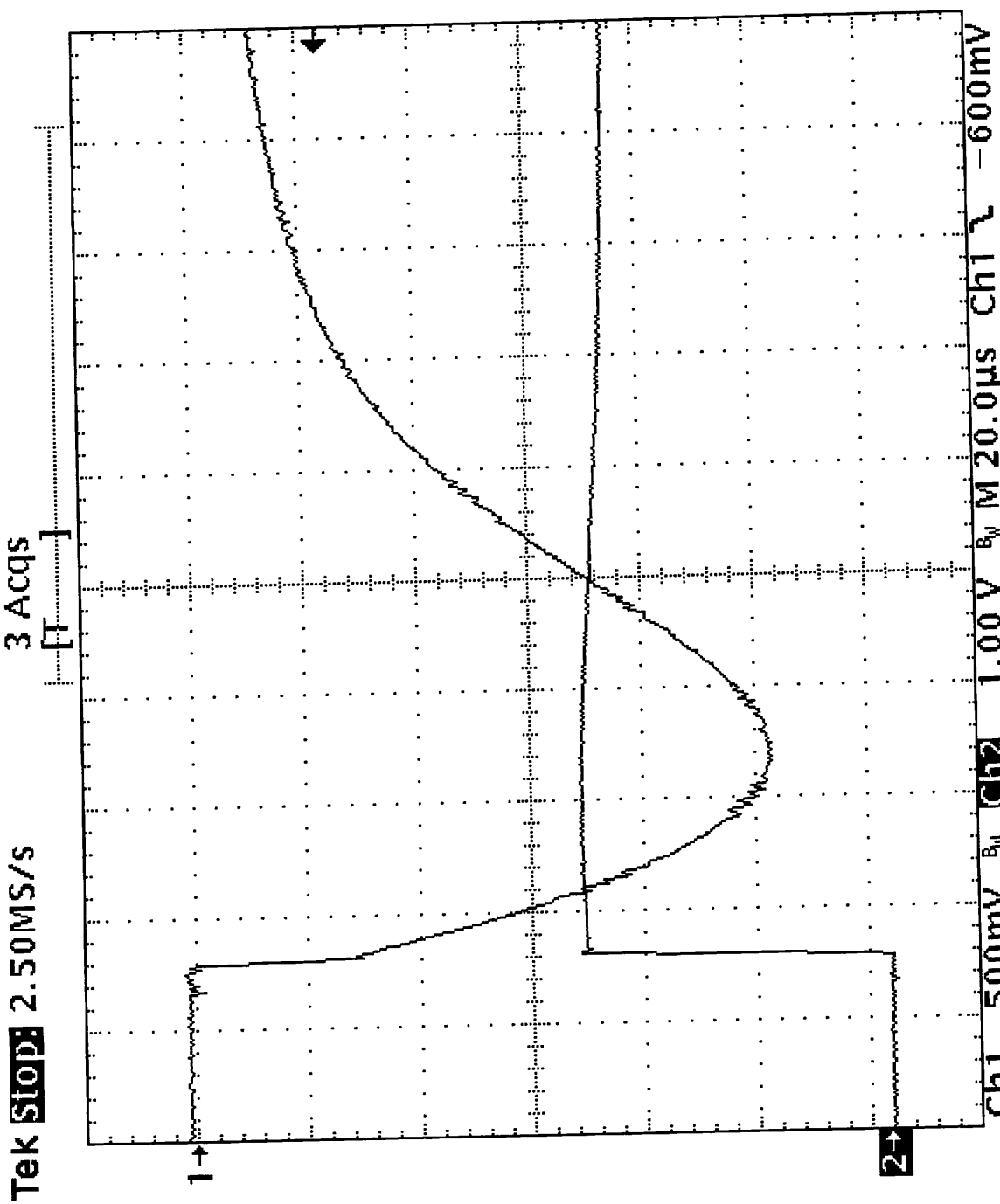
CESI PeC A4522503 oscillogram n. 11



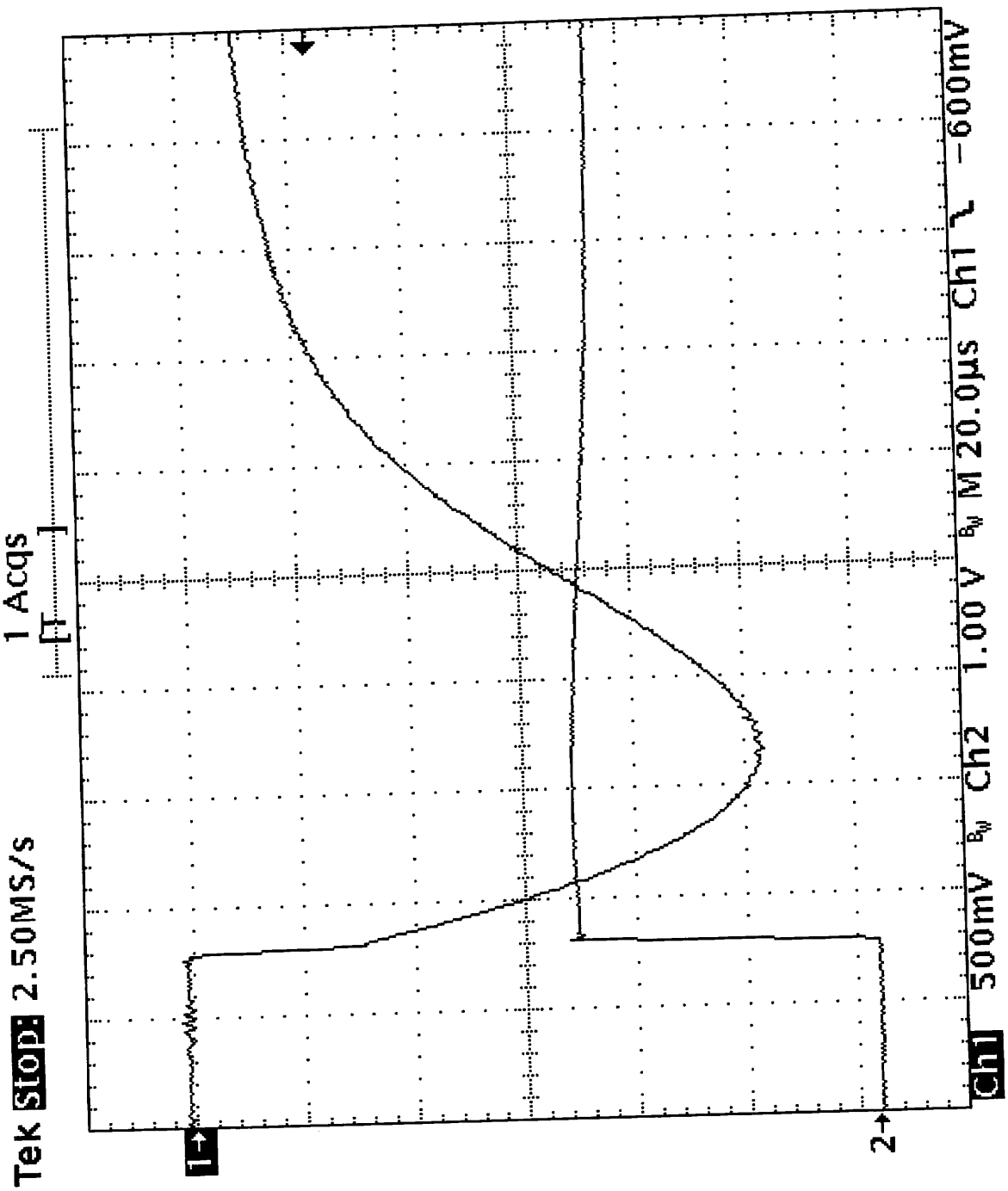
CESI PeC A4522503 oscillogram n. 12



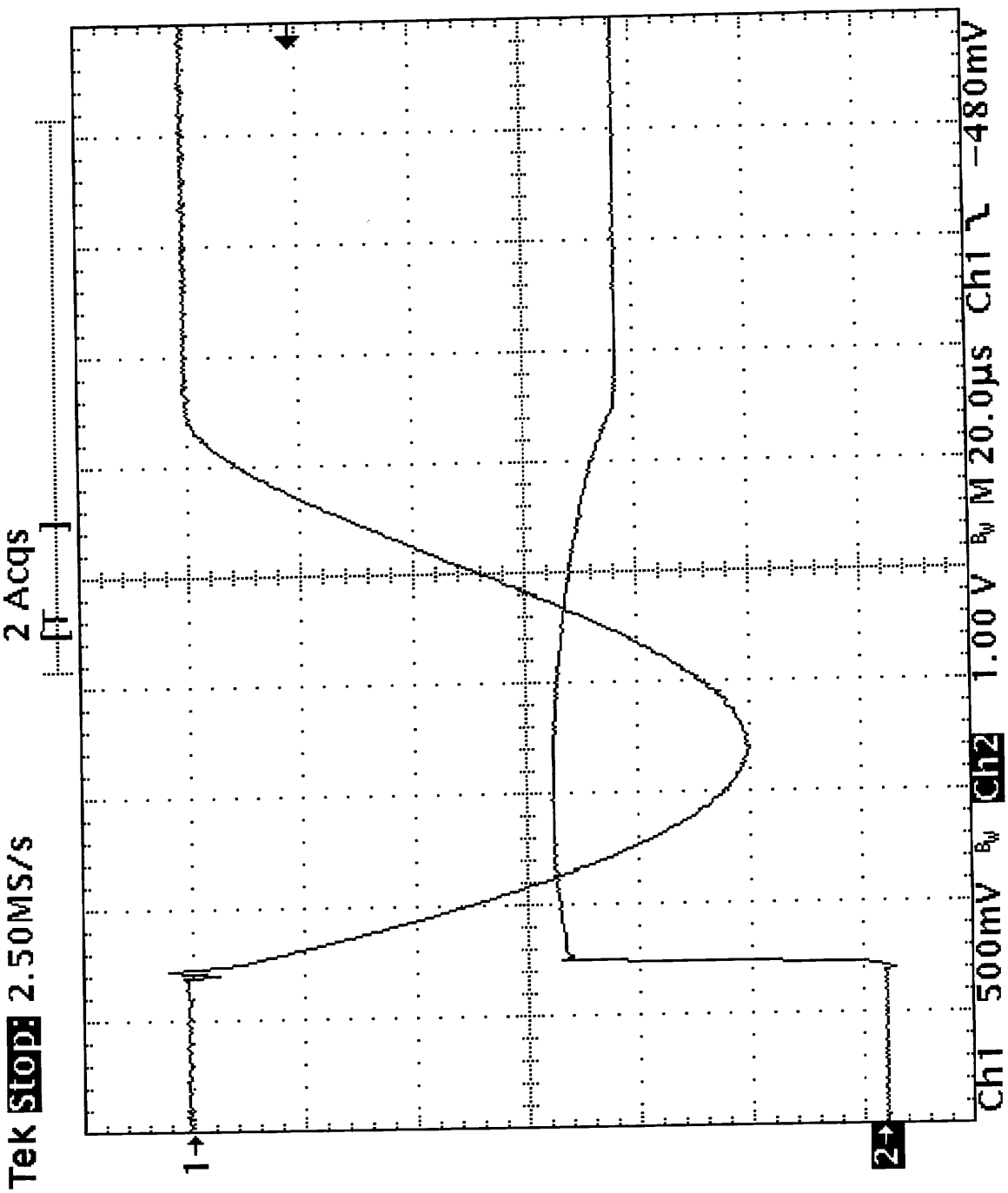
CESI PeC A4522503 oscillogram n. 13



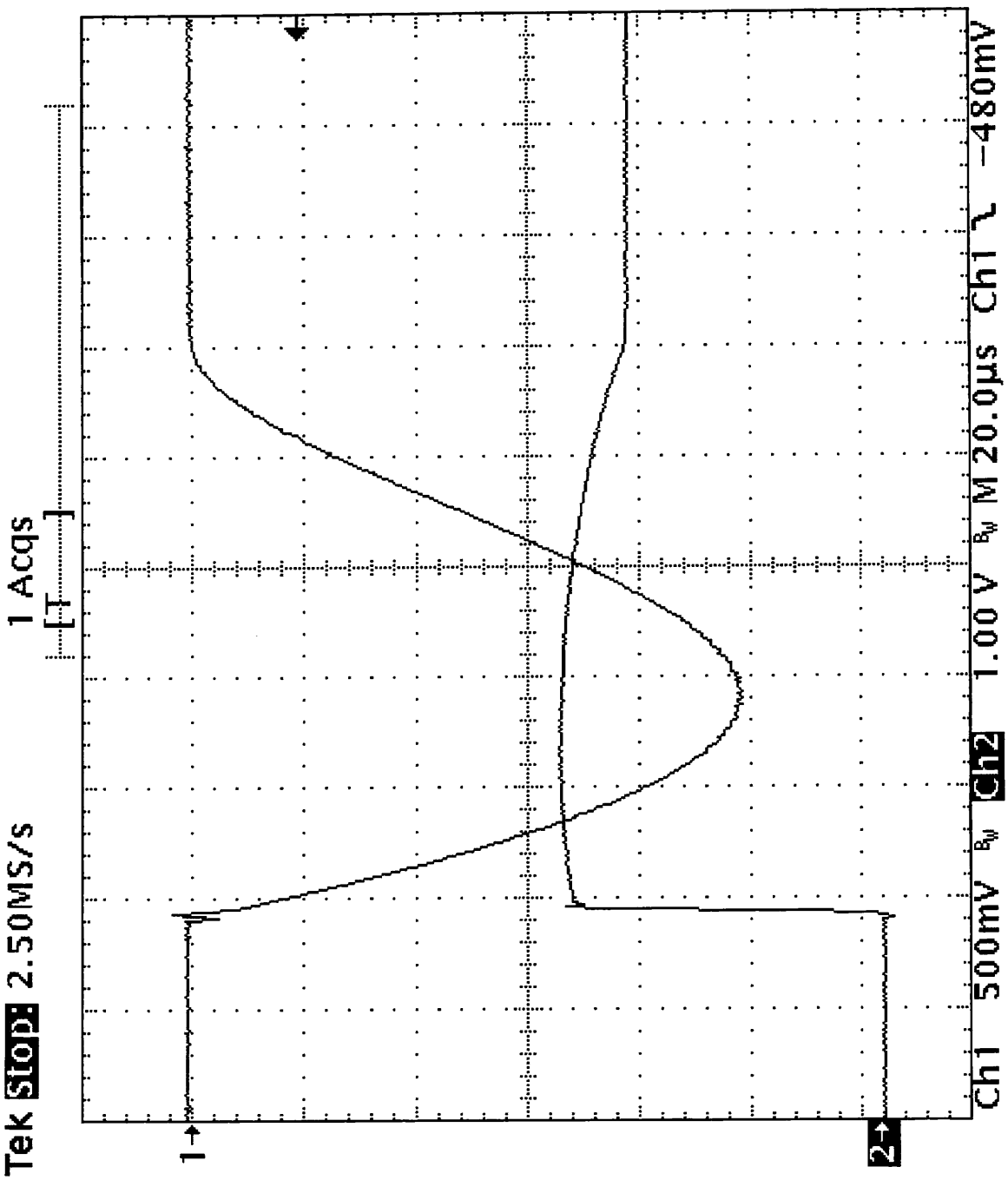
CESI PeC A4522503 oscillogram n. 14



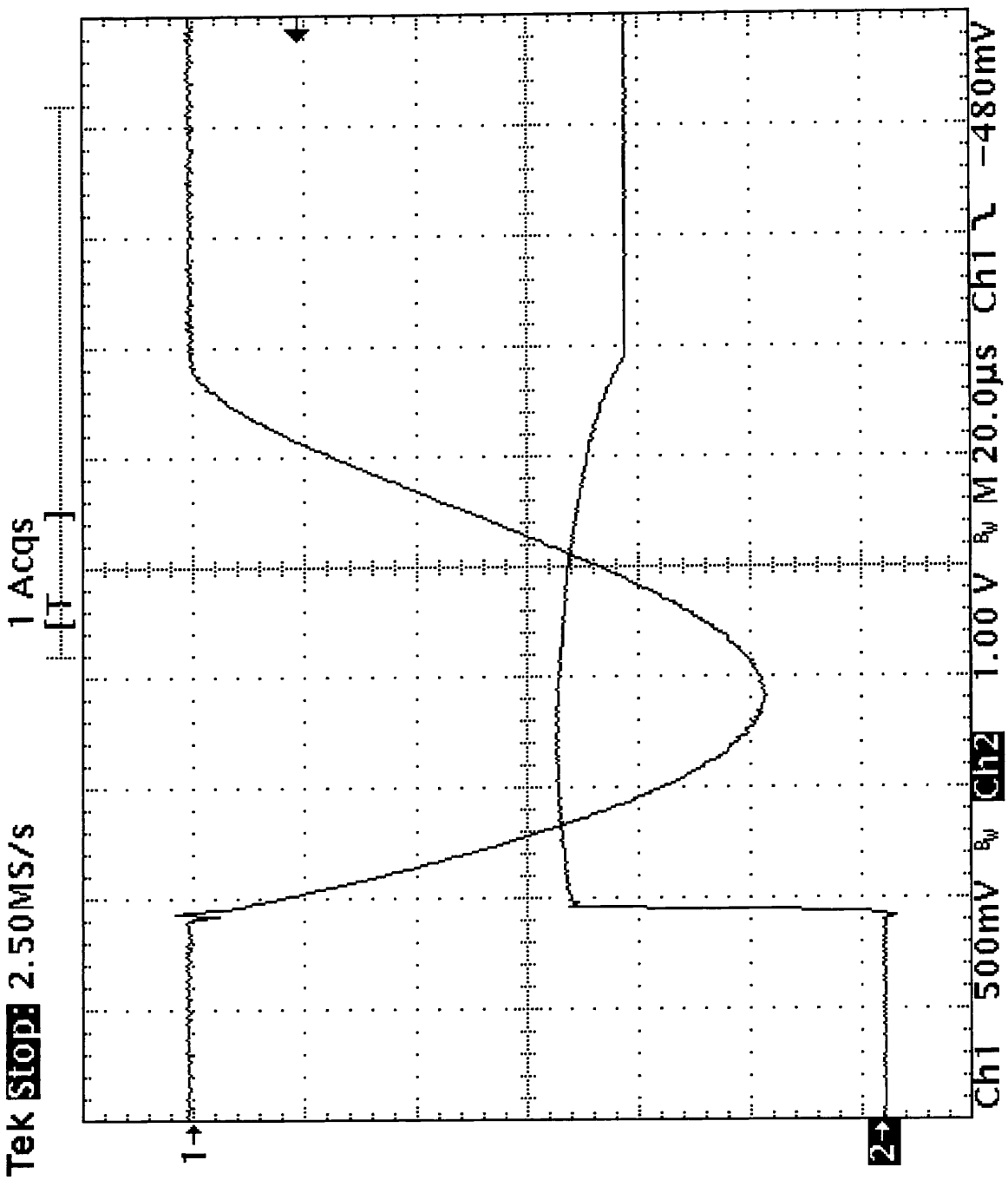
CESI PeC A4522503 oscillogram n. 15



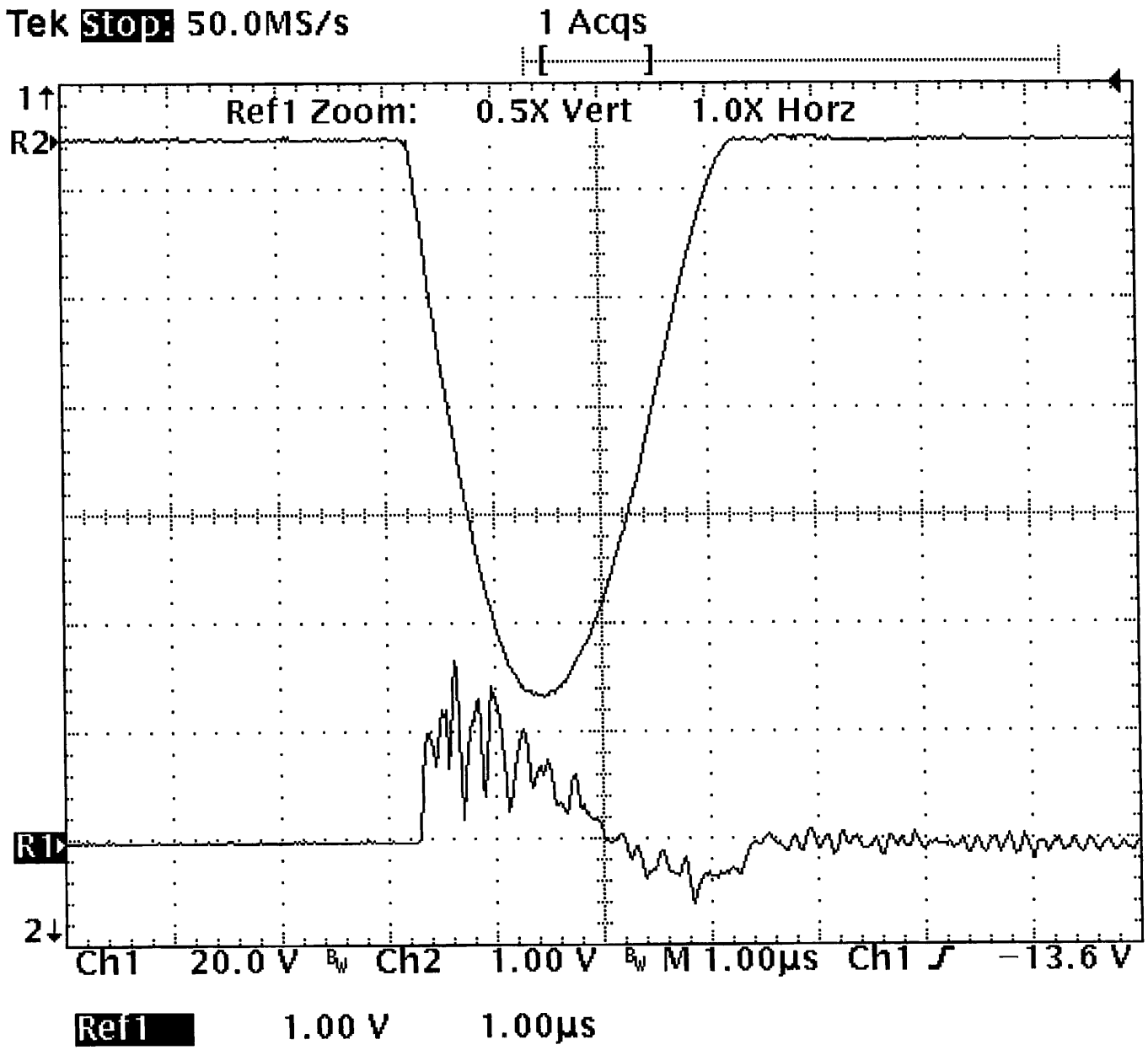
CESI PeC A4522503 oscillogram n. 16



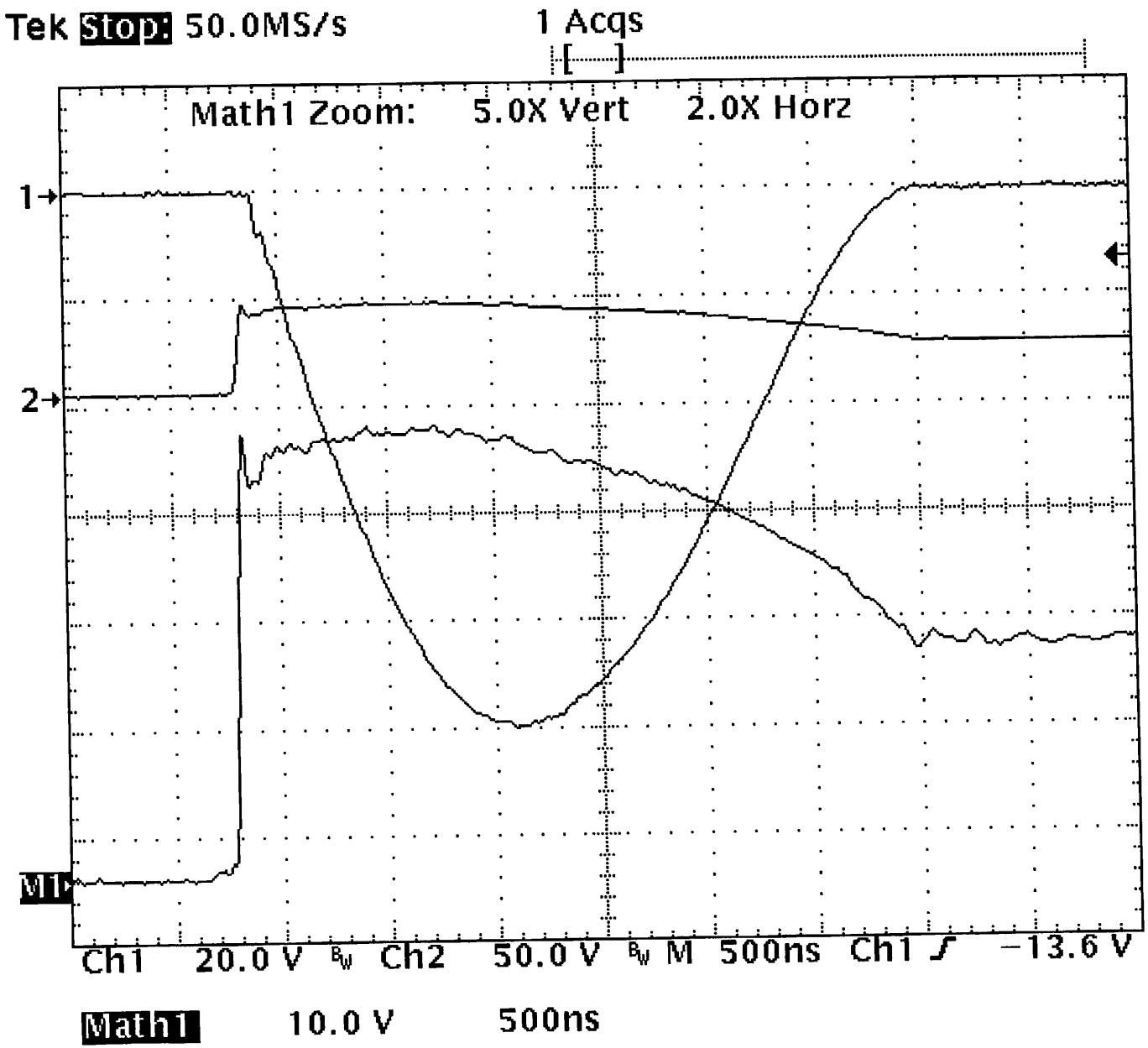
CESI PeC A4522503 oscillogram n. 17



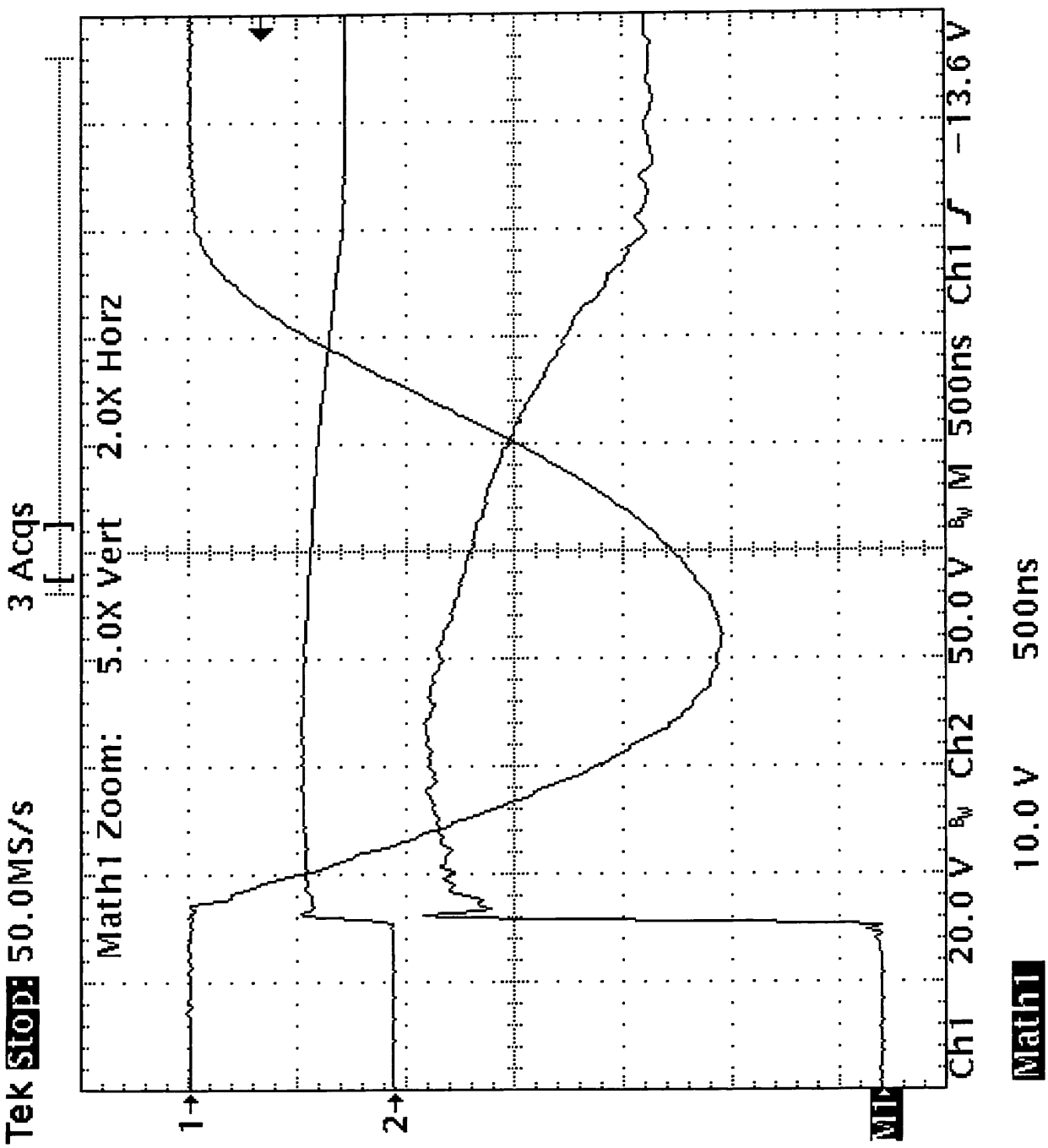
CESI PeC A4522503 oscillogram n. 18



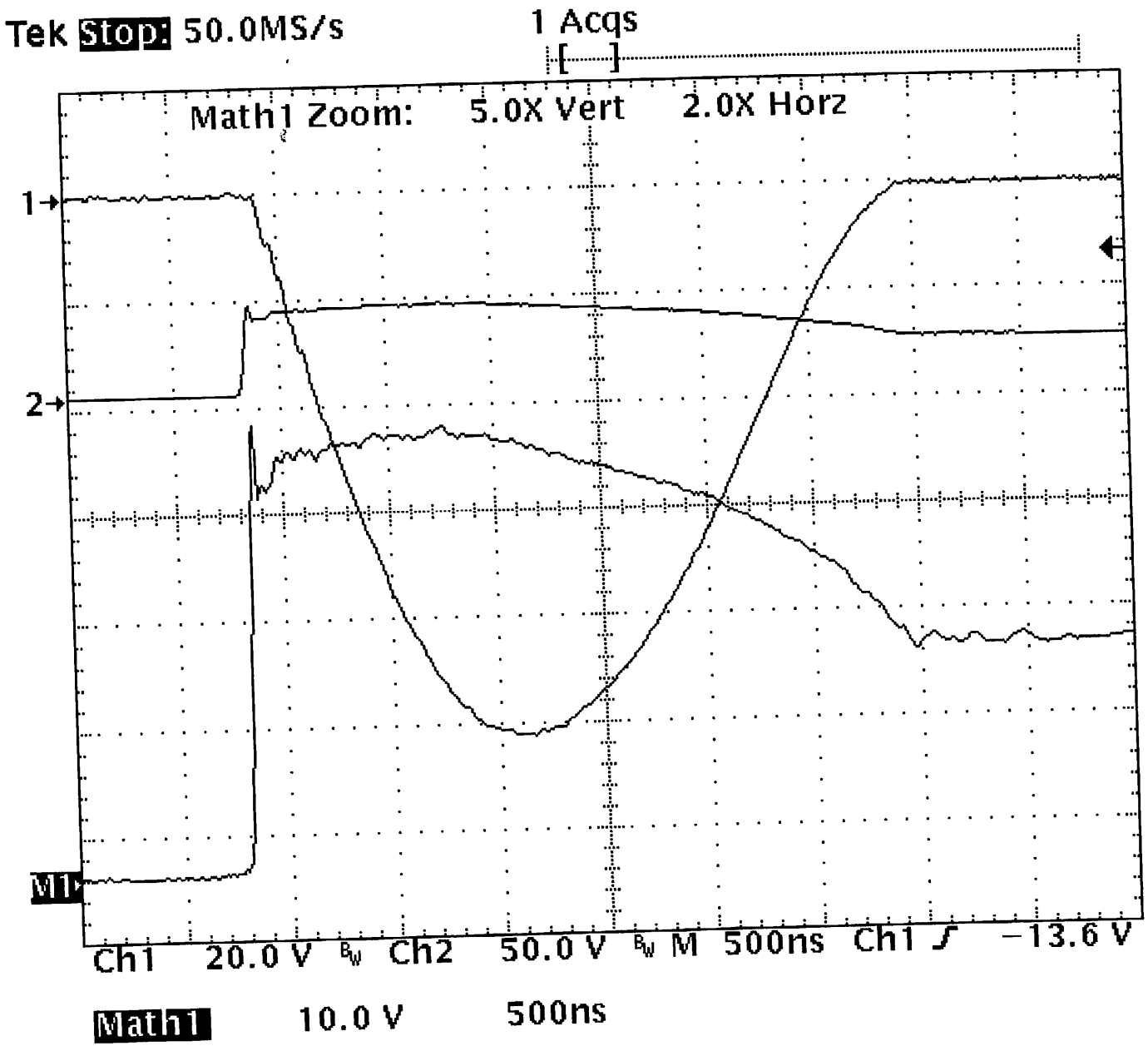
CESI PeC A4522503 oscillogram n. 19



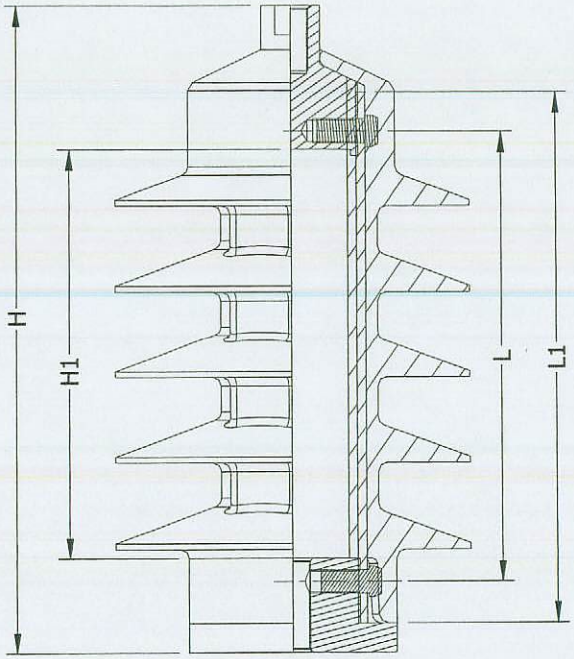
CESI PeC A4522503 oscillogram n. 20



CESI PeC A4522503 oscillogram n. 21



CESI PeC A4522503 oscillogram n. 22



Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks H1 (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
21-48-01	3,75	147	3	67	107	81
21-48-02	5	147	3	67	107	81
21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
21-48-06	15	193	5	113	153	127
21-48-07	17,5	243	6	163	203	177
21-48-08	20	243	6	163	203	177
21-48-09	22,5	243	6	163	203	177
21-48-10	25	270	7	190	230	204
21-48-11	26,25	270	7	190	230	204
21-48-12	27,5	270	7	190	230	204
21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

IZO ELEKTRO...	ISO2768 -		Measure: 7:10	Weight:
			Materiali:	
	Date:	Name:	Signature:	Type: SURGE ARRESTER 2SS15N
Izdelali:	27.8.03	R. Kurnik		
Pregledal:	1.9.03	P. Pungercar		
Odobril:	1.9.03	P. Pungercar		
Opombe:				Code: 21-48-00
				Sheet: 1/1
				Izdelek: Prip.:

Client	**Izoelektro d.o.o. - Pesnica (Slovenia)**
Tested equipment	Polymer housed metal-oxide surge arrester type 2SS15N
Tests carried out	Weather ageing test - Test series A: 1000 hours
Standards/Specifications	IEC Standard 60099-4 Edition 2.0 (2004-05)
Test date	**from** January 19, 2005 **to** March 17, 2005

No. of pages	18	**No. of pages annexed**	6
Issue date	March 18, 2005		
Prepared	BU PeC - G. Fedeli		
Verified	BU PeC - A. Sironi		
Approved	BU PeC - M. de Nigris		

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Tests witnessed by:
/

Identification of the object: Performed

The Manufacturer guarantees that the tested object is manufactured according to the submitted drawing.
CESI checked that this drawing adequately represents in shape and dimensions the essential details and the parts of the tested object.
This drawing, identified by CESI and numbered A5/011512, is annexed to this document.

The data necessary to permit repetition of the tests are contained in the document marked: ----

Measurement uncertainties:

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %;**	**time parameters: ± 10 %**	
- dielectric tests with impulse current	: **peak value: ± 3 %;**	**time parameters: ± 10 %**	
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**		
- dielectric tests with direct voltage	: **voltage: ± 3 %**		
- atmospheric conditions	: **temperature: ± 2 °C;**	**pressure: ± 0,133 kPa;**	**humidity: ± 10 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values.

Laboratory information

Receipt date of the sample	November 26, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	G. Fedeli
Test laboratory	P188
Activity code	19774B

Test object

One polymer housed metal-oxide surge arrester manufactured by Izoelektro has been tested; The sample is type 2SS15N. The sample has been identified by CESI as sample W1.

Rated characteristics of the tested object assigned by the Client

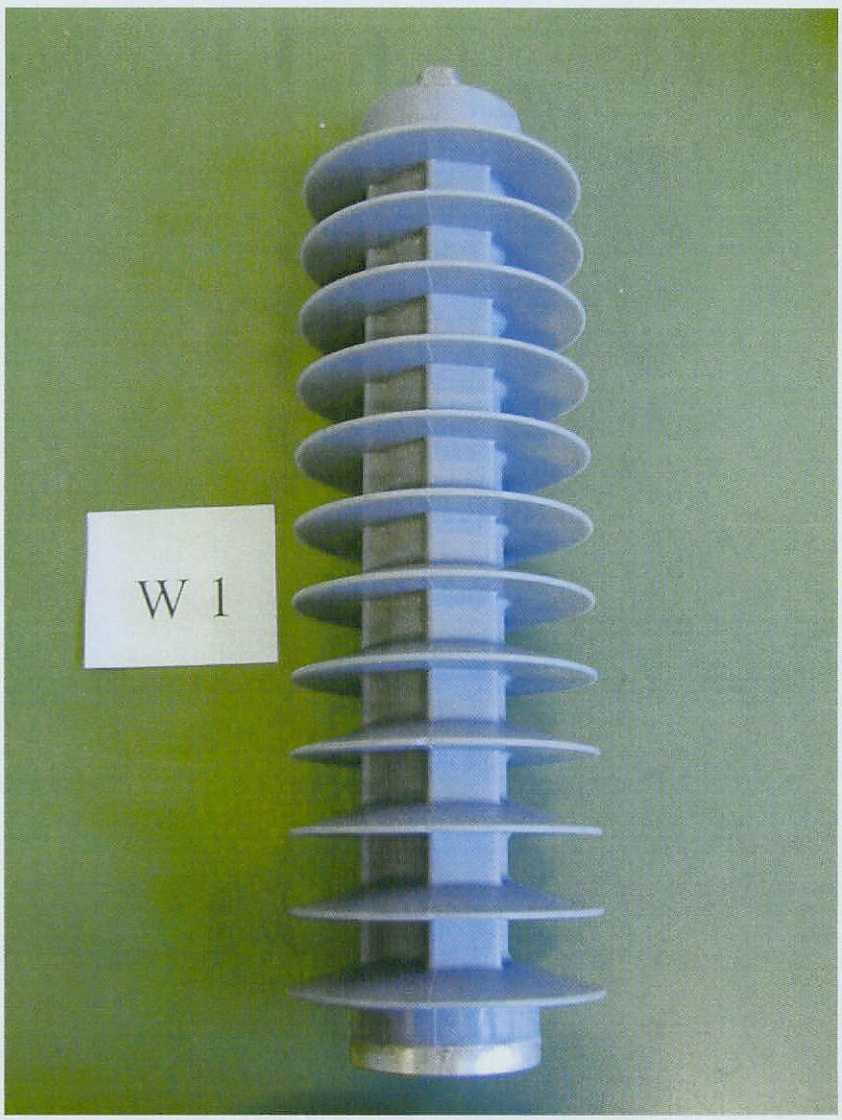
Metal oxide surge arrester	
Manufacturer	**Izoelektro**
Type	2SS15N
Drawing No.	21-48-00
Rated voltage (Ur)	45 kV
Maximum continuous operating voltage (Uc)	36 kV
Rated frequency	50 Hz
Nominal discharge current (8/20 μs impulse shape)	10 kA
Line discharge class	1

Name and signature of Client's witness: /

Dimensional characteristics of the test object measured by CESI

Total height	405 mm
Maximum creepage distance	1080 mm
Sheds number	12
Sheds diameter	116 mm
Sheds spacing	30 mm

Picture of the test object



Test carried out and test procedure

The tests have been carried out according to IEC Standard 60099-4 Edition 2.0 (2004-05) "Metal-oxide surge arrester without gaps for a.c. system", at clause 10.8.14.

Initial measurements

- The reference voltage has been measured at reference current equal to 1,4 mA_{pk}.

- Internal partial discharges have been measured.
  The application voltage has been increased up to rated voltage (U_r) and maintained for 10 sec.
  The voltage has been decreased to 1,05 times the continuous operating voltage (U_c) and the partial discharge level has been measured according to the reference standard.

Weather ageing test. Test series A: 1000 hours

The test sample has been assembled in the test room in vertical position spaced from the chamber walls in order to avoid electrical field disturbance.
The test object has been cleaned with deionized water before starting the test.

The surge arrester has been energised at U_c= 36 kV_{rms} and kept for a total duration of 1000 hours in the test room filled with salt fog in the following condition:
- initial salinity of the water solution: 10 Kg/m^3 (see note 1)
- water flow rate: 0,4 ± 0,1 $l/h*m^3$

The salt fog was not directly sprayed against the specimen.

Note 1: Due to repeated flashover the salinity had to be reduced several times during the test as detailed in the table at page 8

A scheme and a view of the test configuration are shown at pages 13 and 14.

The test sample has been visually inspected after about 500 hours and at test completion.
Photos were taken at the end of the test.

Final measurements

The initial measurements were repeated.

Summary of test result

Test series A: 1000 hours

The external flashovers occurred during the test and the salinity change are noted in the table below.

Flashovers	Test salinity [g/l]	Salinity change
After 66 hours	10	/
After 185 hours	10	From 10 g/l to 7 g/l
After 260 hours	7	/
After 265 hours	7	From 7 g/l to 5 g/l
After 343 hours	5	/
After 360 hours	5	From 5 g/l to 3,5 g/l
After 403 hours	3,5	/
After 523 hours	3,5	From 3,5 to 2,5 g/l
After 654 hours	2,5	/
After 690 hours	2,5	From 2,5 g/l to 1,7 g/l
After 971 hours	1,7	/

Visual inspection

Note: Sheds are numbered starting from the live side.

After 500 hours:

No tracking, shed puncture or significant erosions have been evidenced by the visual inspection carried out after 500 hours.

After 1000 hours:

No tracking, shed puncture or significant erosions have been evidenced by the visual inspection carried out after 1000 hours (see photos from page 15).

Three-like colour change was noted in particular above the sheds n. 2 and n. 3 (see photos at page 16)

Variation of the reference voltage

Test object	Before test	After test	Variation
	kV	kV	%
Sample W1	45,29	45,86	+ 1,26

Acceptance criteria: satisfied

Partial discharge level

Test object	Before test	After test
	PC	pC
Sample W1	≤ 1	≤ 1

Acceptance criteria: satisfied

Conclusion

The acceptance criteria specified by the standard are satisfied. The test result is positive

Measurement of the reference voltage - initial

Test circuit: /

Date: January 19, 2005

Sample No. W1						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
1	45,29	1,41	1,31	0,65	17,32	/

Measurement of partial discharges - initial

Test object: Polymer housed metal-oxide surge arrester
Test circuit: /
Measurement circuit: "direct" calibration:50 pC/mV, oscillogram n. / ; background noise ≤ 1 pC, see oscillogram n. /
Arrangement: /

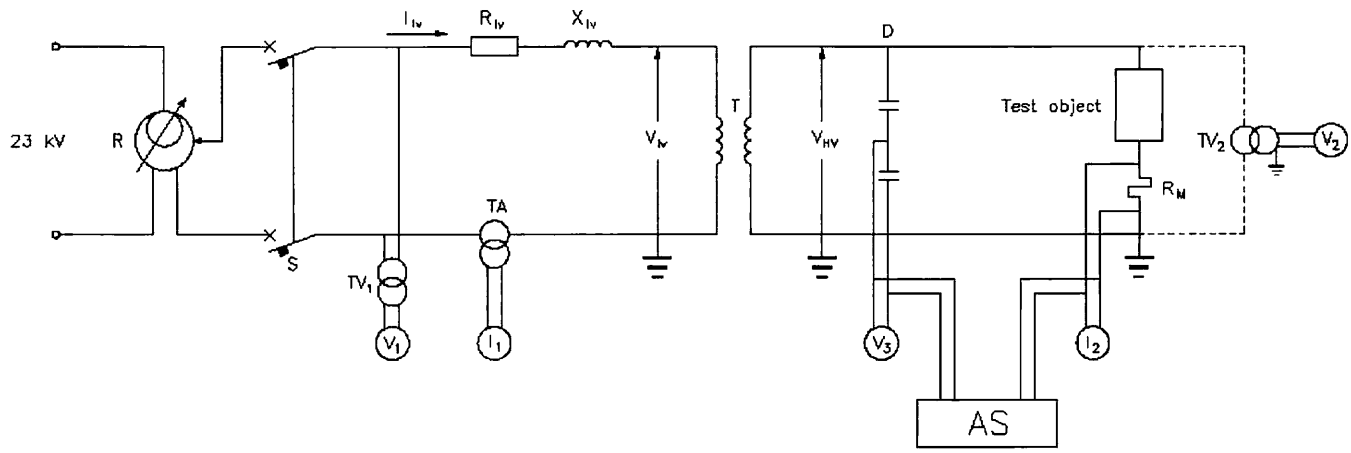
Atmospheric conditions and correction factor			
B	t_d/t_w	H	Relative humidity
kPa	°C	g / m^3	%
/	17/--	/	/

Date: January 19, 2005

Test condition	Applied voltage	Duration of voltage application	Temperature of the test object	Partial discharge measurement				Oscillogram	Notes
				voltage increase		Voltage decrease			
				CRO readout	Q max	CRO Readout	Q max		
No.	KV_{rms}	s	°C	mV	pC	MV	pC	No.	
Rated voltage	45	10	17	/	/	/	/	/	
36x1,05	37.8	/	17	/	/	/	≤ 1	/	

continued

Weather ageing test. Circuit A0060



Power frequency test circuit

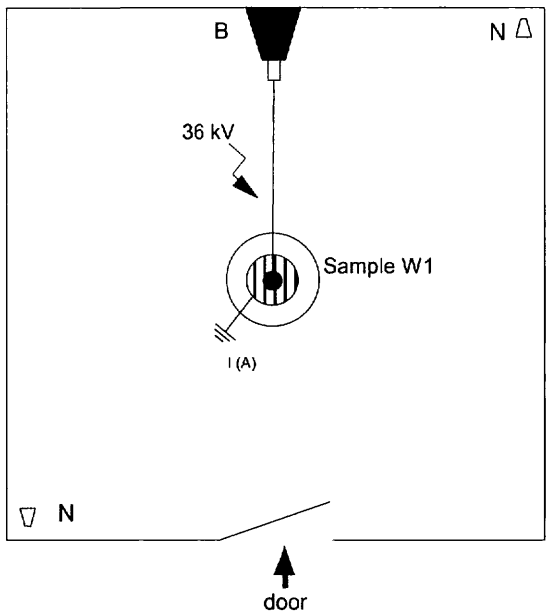
R - regulator type SPECIALTRASFO; power 50 kVA; secondary connection 400 V; CESI No. 37163
TV_1 - voltage reducer /
V_1 - voltmeter CESI No./
TA - current reducer ; ratio 100/1 A
I_1 - direct reading amperometer
R_{lv} - protection resistor / Ω
X_{lv} - protection reactor / Ω
T - booster transformer type SPECIALTRASFO; power 50 kVA; ratio 380 V/30 kV; unit No. 37168; CESI No. 37168
D - capacitive voltage divider type /; V= / kV; capacitance / nF; CESI No. /
V_3 - voltmeter CESI No. /
AS - acquiring system; board / ; optical decoupler CESI No. /; software type /
R_M - leakage current measuring resistor /
I_2 - leakage current measuring instrument type /; CESI No. /
TV_2 - voltage reducer type MAGRINI GALILEO; CESI No. 6276; ratio 42 kV/100 V
V_2 - voltmeter CESI No. 9625

Check of the test circuit

Date: 01/24/05

Low voltage				High voltage					k_t
				$k_2 = 420$		$k_3 = /$			
V_1	V_{lv}	I_1	I_{lv}	V_2	V_{HV}	V_3	V_{HV}	V_{HV}	V_{HV} / V_1
V	V	A	A	V	kV	V	kV	kV	
/	/	/	/	47,86	20,10	/	/	/	/
/	/	/	/	81,63	34,28	/	/	/	/

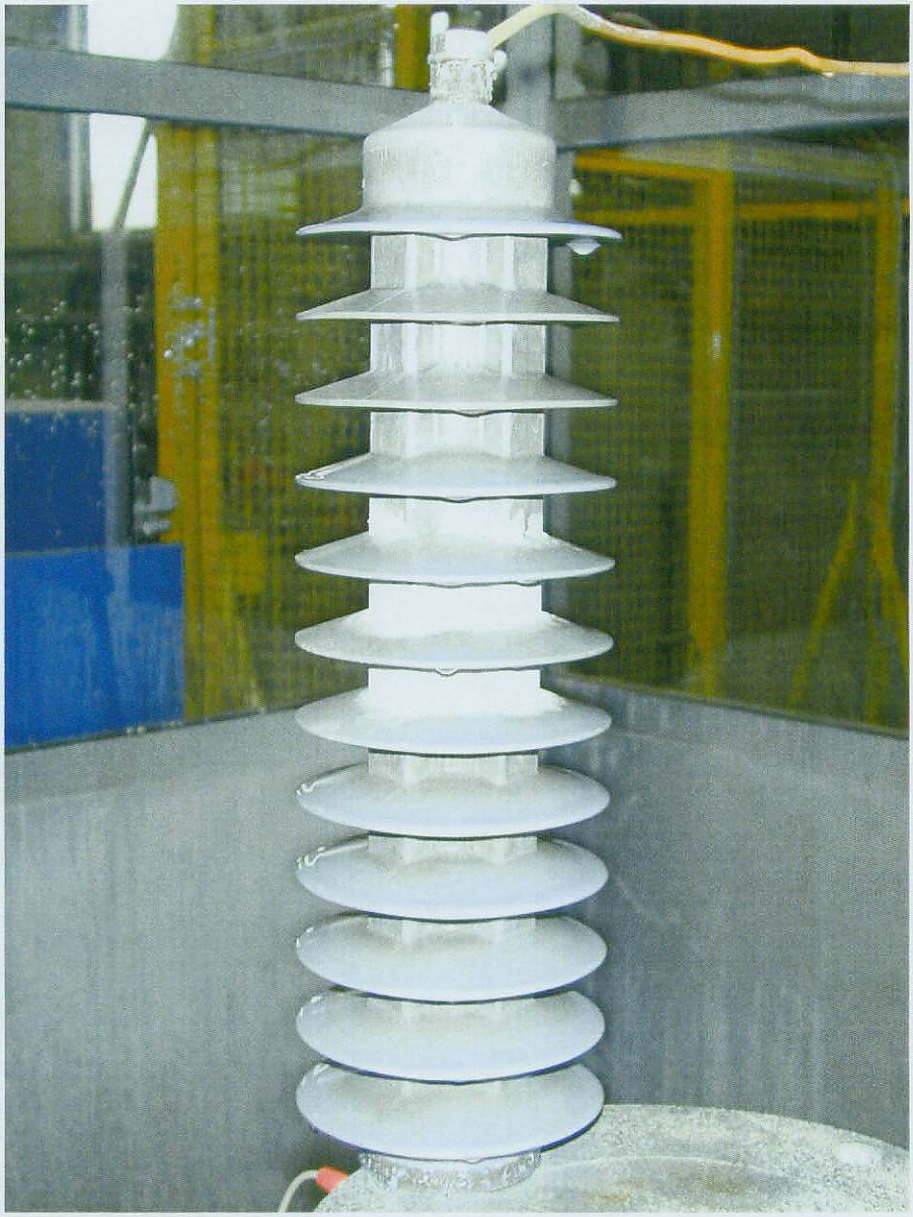
Weather ageing test. Test arrangement
Plant: pollution test room planimetry



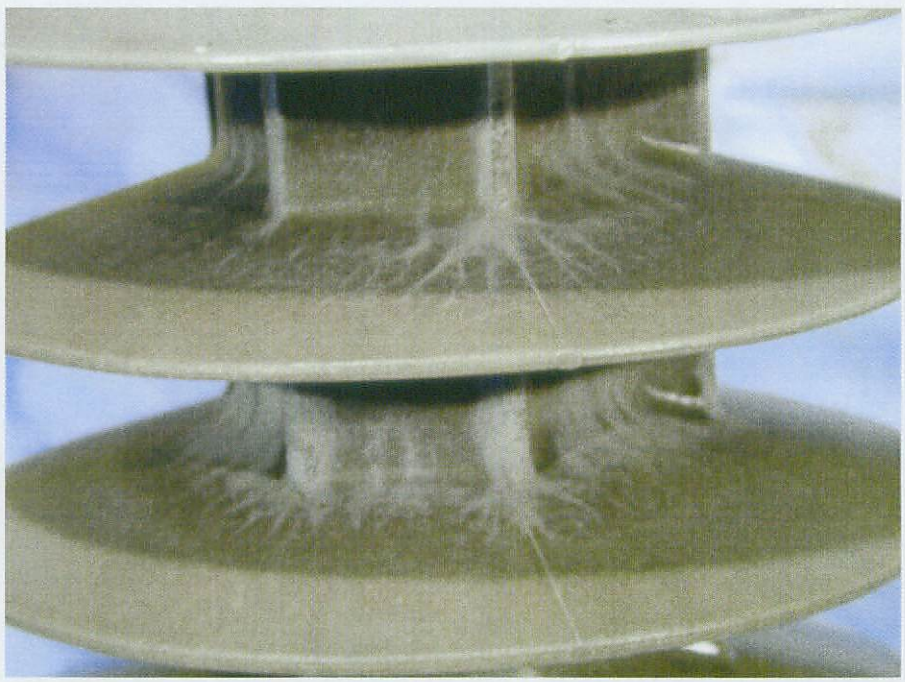
Test room volume: 24,3 m^3
B: bushing
N: spray nozzles. Number of spray nozzles: 2

View of the test arrangement

Overall view of the test sample after the weather ageing test



Details of the test object after the weather ageing test



Measurement of the reference voltage - final

Test circuit: /

Date: March 17, 2005

Sample No. W1						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
2	45,86	1,42	1,41	0,654	18,45	/

Measurement of partial discharges - final

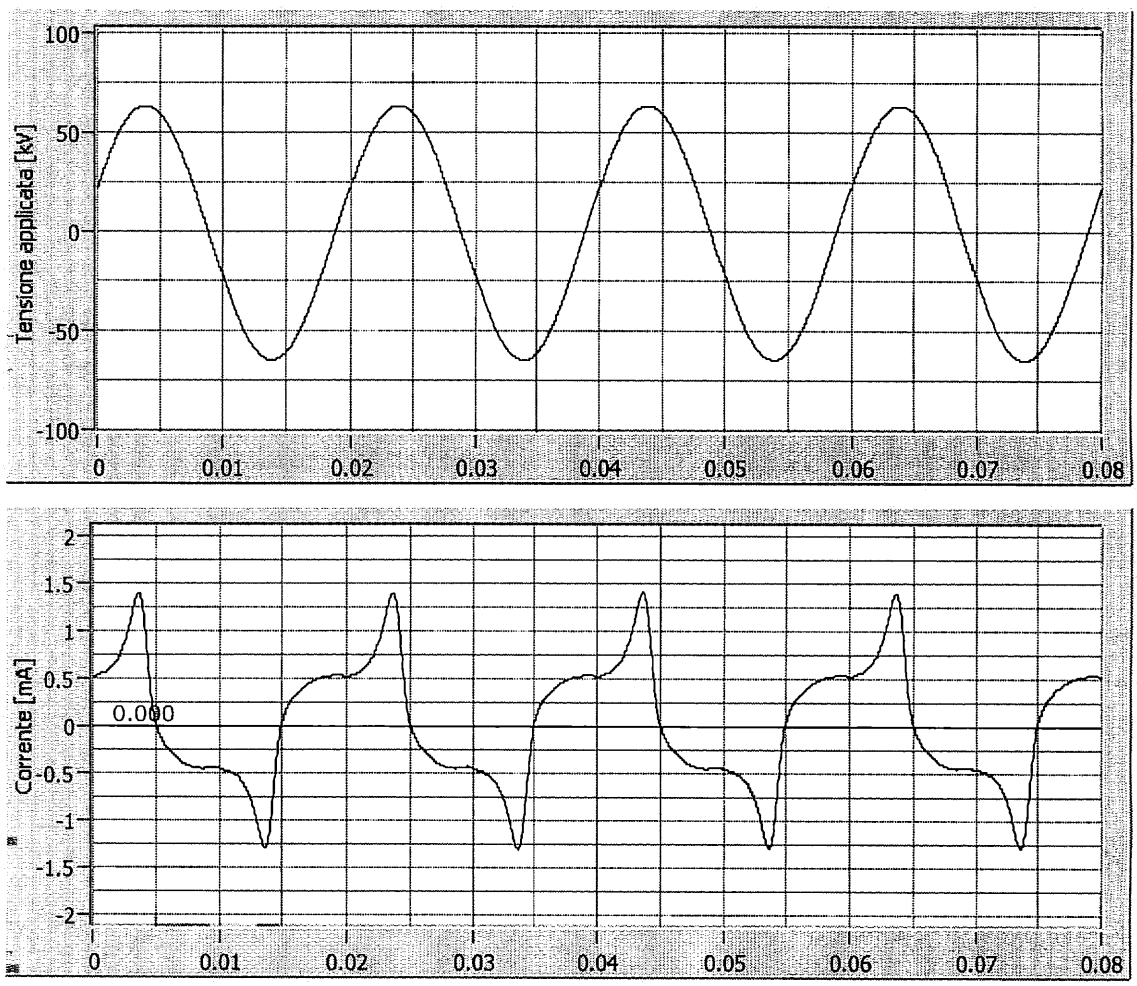
Test object: Polymer housed metal-oxide surge arrester
Test circuit: /
Measurement circuit: / "direct" calibration:49 pC/mV, oscillogram No. 3; background noise ≤ pC, see oscillogram No. 4
Arrangement: /

Atmospheric conditions and correction factor			
b	t_d/t_w	h	Relative humidity
kPa	°C	g / m³	%
/	19/-	/	/

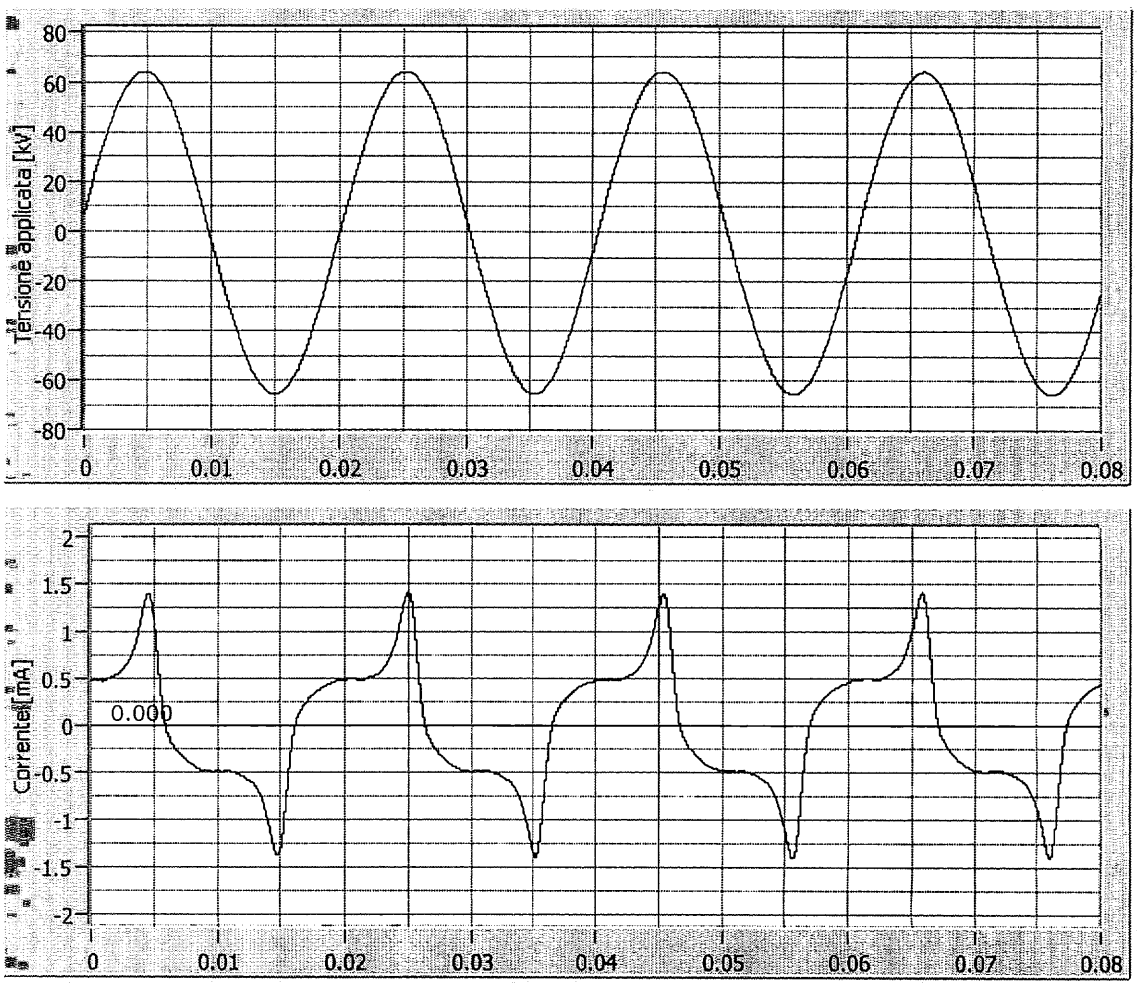
Date:

Test condition	Applied voltage	Duration of voltage application	Temperature of the test object	Partial discharge measurement				Oscillogram	Notes
				voltage increase		voltage decrease			
				CRO readout	Q max	CRO readout	Q max		
No.	kV_{rms}	s	°C	mV	pC	mV	pC	No.	
rated voltage	45	10	19	/	/	/	/	/	
36x1,05	37,8	/	19	/	/	/	≤ 1	5	

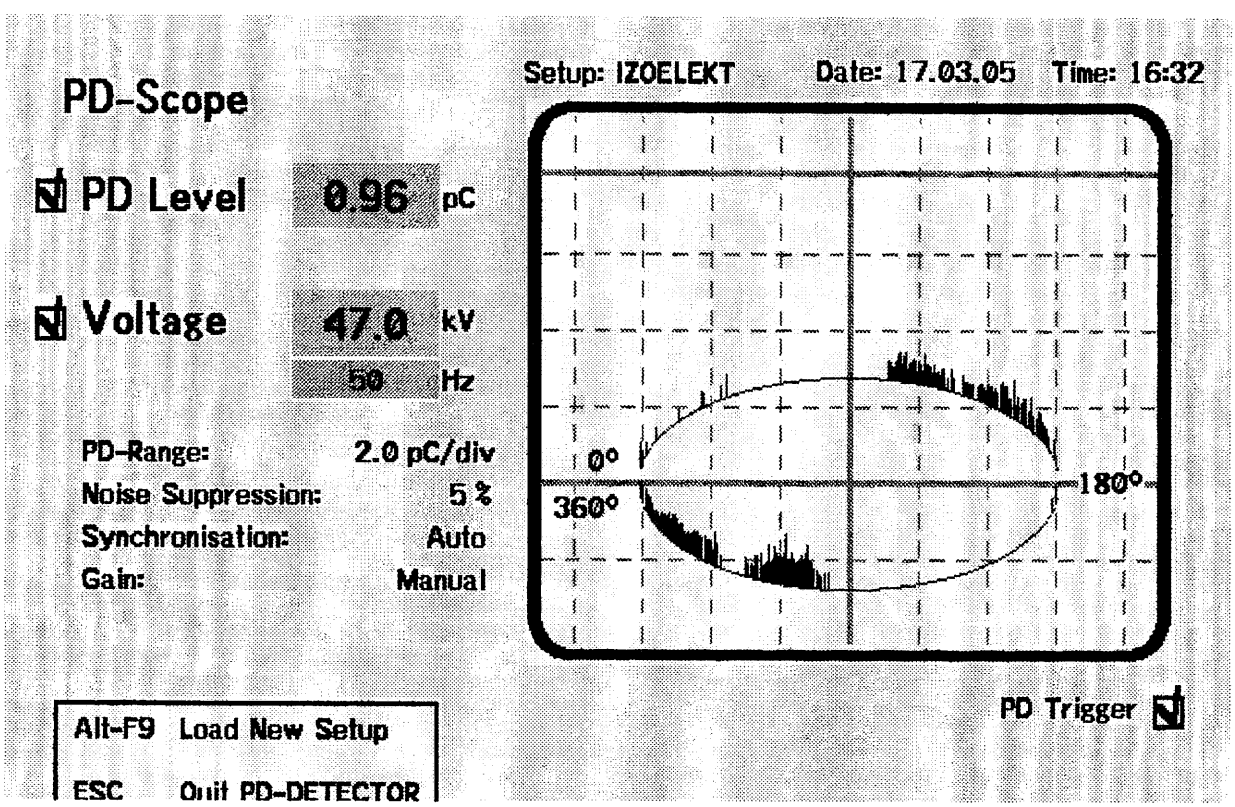
continued



Oscillogram No.1



Oscillogram No.2



Oscillogram No.3

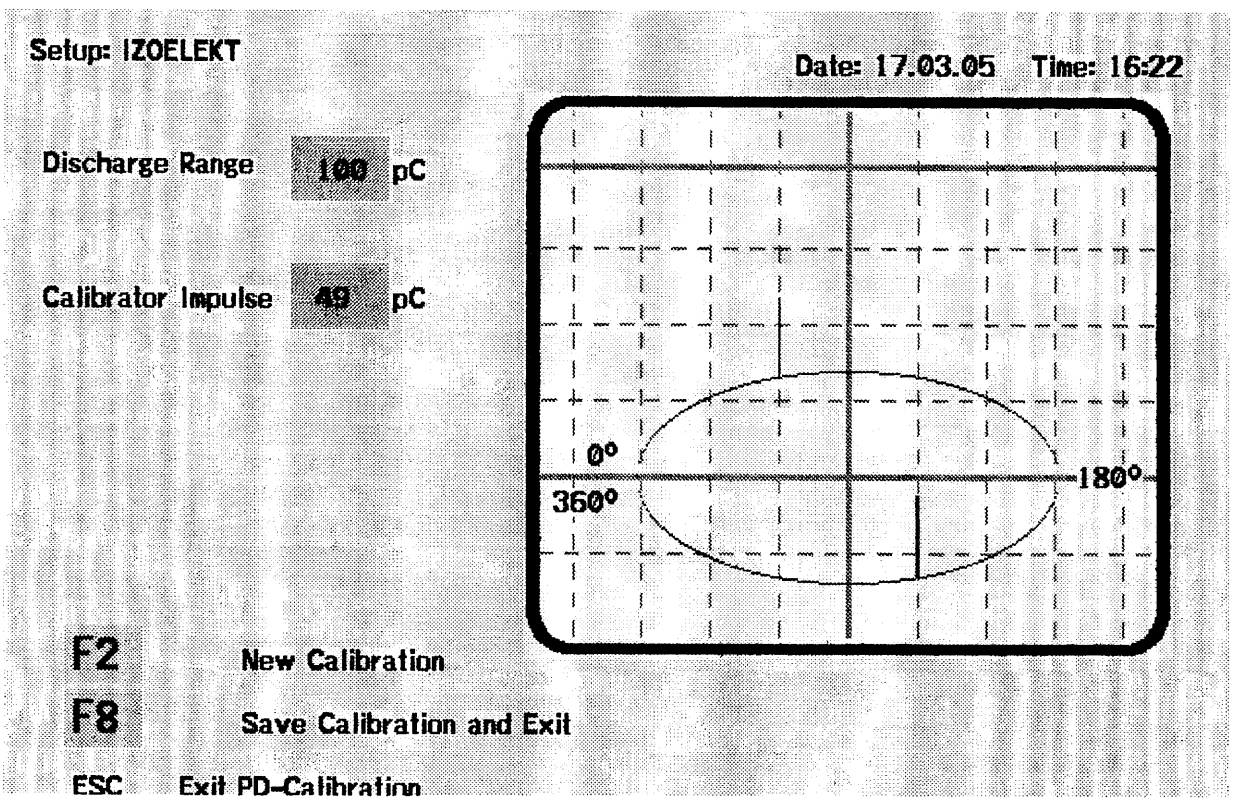
HAEFELY TRENCH TETTEX PD-DETECTOR

Info: 1
Measurement name:
Comment:
1st PD Range: 100 pC
Noise Suppression: 5 %
Test Measuring Time: 15 s

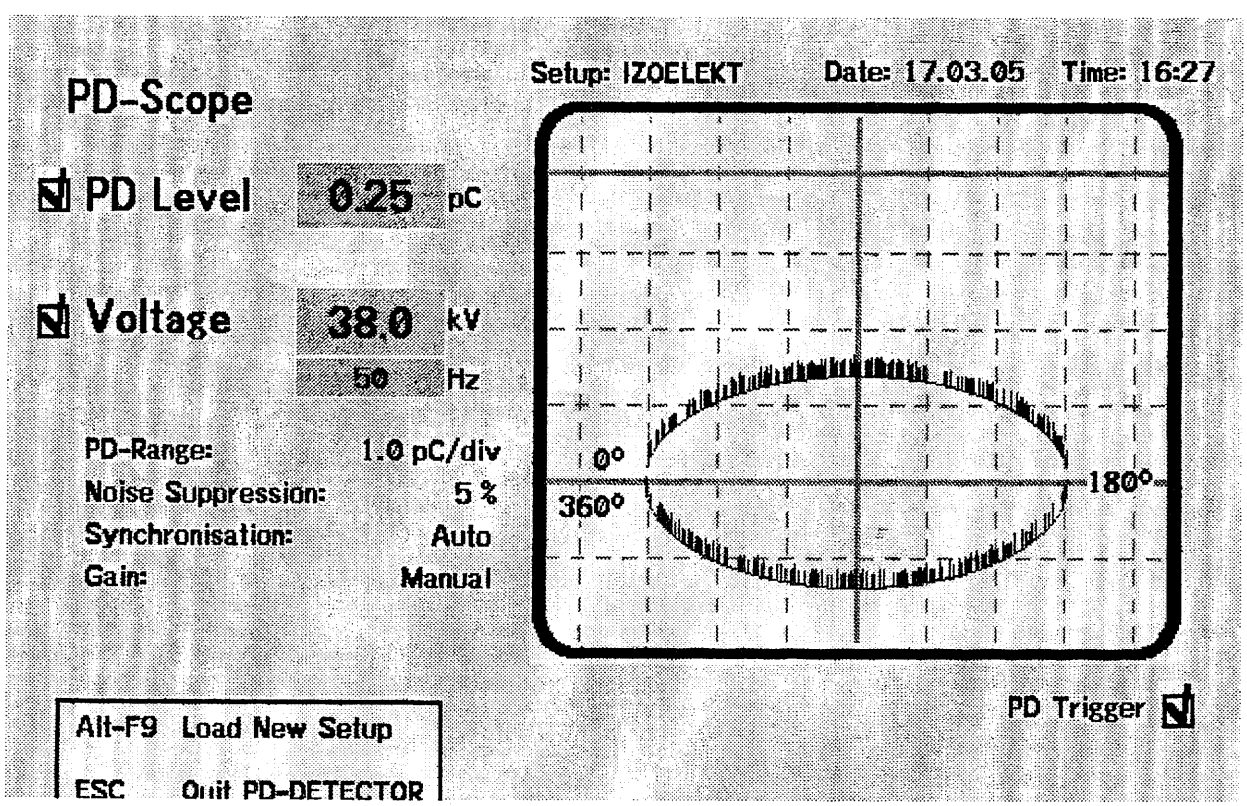
Start date: 00.00.00
Start time: 00:00

2nd PD Range: Not applied
Lockout Time: 7.3 usec
Voltage Range: 50 kV

Remarks:



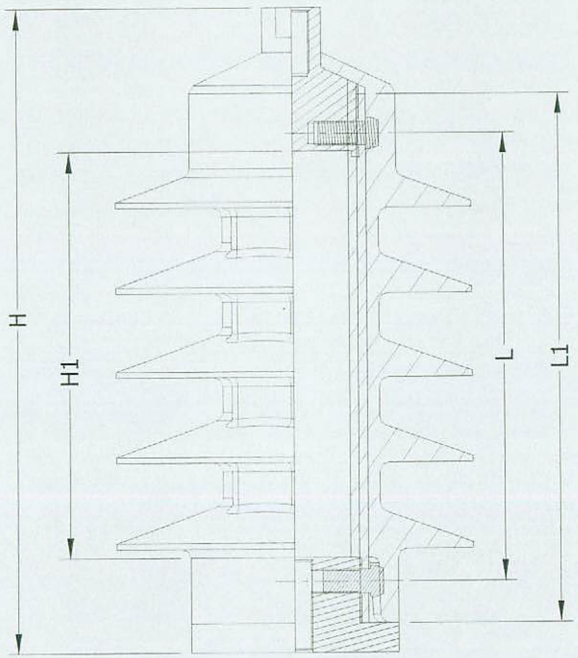
Oscillogram No.4



Oscillogram No.5

LASTNINA IZO ELEKTRO d.o.o.
Pri prenehanju proizvodnje ali spremembi risbo vrniti!

Razmnoževanje, predaja tretji osebi ali uporaba v nedogovorjene namene ni dovoljena!



Code	Ur (kV)	Arrester heigh H (mm)	Number of ribs (pcs)	Area for ZnO bloks H1 (mm)	Lenght of strips L1 (mm)	Lenght L (mm)
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21-48-03	7,50	147	3	67	107	81
21-48-04	10	193	5	113	153	127
21-48-05	12,5	193	5	113	153	127
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21-48-09	22,5	243	6	163	203	177
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21-48-13	30	317	8	237	277	251
21-48-14	32,5	317	8	237	277	251
21-48-15	35	317	8	237	277	251
21-48-16	37,5	370	11	290	330	304
21-48-17	40	370	11	290	330	304
21-48-18	42,5	404	12	324	364	338
21-48-19	45	404	12	324	364	338

IZO ELEKTRO d.o.o. | ISO2768 -

	Datum	Name	Signature
Izdelal	27.9.03	R. Kurnik	
Pregledal	1.9.03	P. Pungercar	
Odobril	1.9.03	P. Pungercar	

Opombe:

Measure: 7:10 | Weight:

Material:

Type: SURGE ARRESTER 2SS15N

Code: 21-48-00

Sheet: 1/1

Izdelek: | Pritp:

Test Report

CESI

Client	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Tested equipment	Metal oxide resistors blocks section type 2SS15N
Tests carried out	Accelerated ageing test of the resistor blocks
Standards/Specifications	IEC 60099-4 (2004-05) clause 8.5.2,
Test date	**from** December 10, 2004 **to** February 24, 2005

No. of pages	14	**No. of pages annexed**	12
Issue date	March 23, 2005		
Prepared	BU PeC - L. Podavitte		
Verified	BU PeC - A. Sironi		
Approved	BU PeC - M. de Nigris		

L Podavitte
All. S

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Business Unit
Prove e Componenti
Il Responsabile del Laboratorio

Tests witnessed by:

Identification of the object: not requested

The data necessary to permit repetition of the tests are contained in the document marked: ---

- dielectric tests with impulse voltage	: **peak voltage: ± 3 %; time parameters: ± 10 %**
- dielectric tests with impulse current	: **peak value: ± 3 %; time parameters: ± 10 %**
- dielectric tests with alternating voltage	: **voltage (rms): ± 3 %**
dielectric tests with direct voltage	: **voltage: ± 3 %**

The measurement uncertainties are estimated at the level of twice the standard deviation (corresponding, in the case of normal distribution, to confidence level of about 95%) and have to be considered as maximum values

Laboratory information

Receipt date of the sample	November 29, 2004
Test location	CESI – Via Rubattino 54 – Milan
CESI testing team	Mr L.Podavitte , Mr I.Guacci, Mr M. Gregori
Test laboratory	P177
Activity code	19774B

Page annexed: 12

Rated characteristics of the tested object assigned by the Client

The test was carried out on three samples of resistor blocks section surrounded by the same material as in the actual surge arrester. A view of the test samples is shown at page 5. The characteristics of the test samples are listed in the tables below

Electrical characteristics claimed by the client	
Manufacturer	IZOELEKTRO d.o.o. – Pesnica Pri Mariboru (Slovenia)
Type	2SS15N
Rated voltage (Ur)	0.9912* Uref
Maximum continuous operating voltage (Uc)	0.7930* Uref
Reference current (Iref)	1,4 mA
Rated frequency	50 Hz
Nominal discharge current (8/20 µs impulse shape)	10 kA
Line discharge class	1
Year of manufacture	2004
Geometrical characteristics measured by Cesi	
Total height (mm)	148
Diameter (mm)	60 min - max 68

Photograph of the test sample

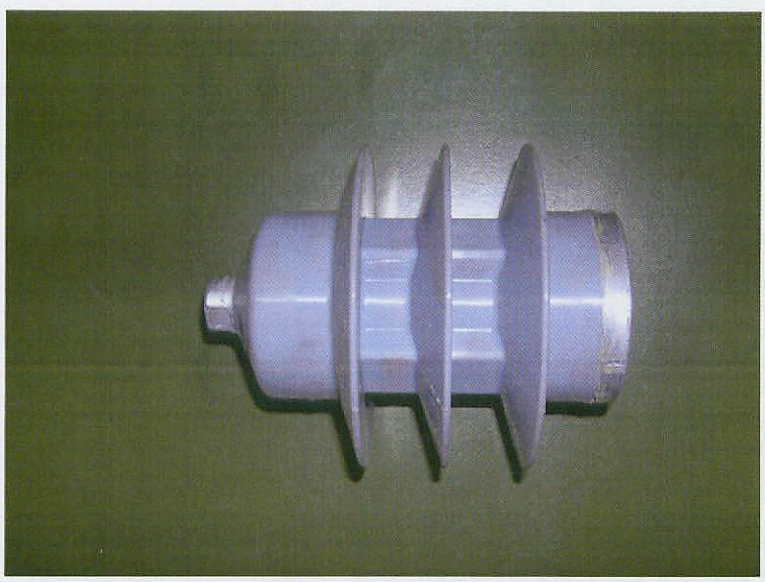


Photo no. 1

Reference Standard

IEC 60099-4 (2004 - 05): "Metal-oxide surge arrester without gaps for a.c. system", clause 8.5.2,

Test carried out and identification of the test objects

Test carried out	Number of test objects	Test object identification
accelerated ageing test	3	AG1-AG2-AG3

Test procedure

The test has been performed on three sample of resistor blocks section surrounded by the same material as in the actual surge arrester.

The test voltage U_{ct} has been calculated as:

$U_{ct} = K_c*(1+0.15*L) * U_{ref} = k_a * U_{ref} = 4.35$ kV

Where:

U_{ref}	is the reference voltage measured on the samples at ambient temperature
K_c	is the ratio $U_c/U_{ref\,min}$
(1+0.15*L)	is the correction factor related to the voltage unbalance
L	is the surge arrester length in meters

The factor k_a has been calculated for all the surge arresters of the series. The highest value found was 0,841. The test has been conducted at a test voltage equal to $U_{ct} = 0,841*U_{ref} = 4.35$ kV_{rms}

The test samples have been placed in separate chambers (not sealed) and then positioned in the oven.
The oven has been heated up to 115 °C and then the samples have been energized at the power-frequency voltage of 4,35 kV_{rms} for a total duration of 1000 hours while maintained at the temperature of 115 ± 4 °C.
Power losses and temperatures have been monitored continuously during the test (see oscillogram no. 10,11,12).
More detail data are given for measurements carried out at the beginning (2 hours after energization) and at the end of the test.

Note:
The scheme of the test chamber and test oven are shown in the test arrangements A8056 and A8057

Summary of test results

Details of the measurements carried out at the beginning (2 hours after energization) and at the end of the test are given in the table below.
The trend of the power losses monitored during the test is shown on the oscillogram n. 10,11 and 12

Test results	Test object identification		
	AG1	AG2	AG3
Ageing test voltage = U_{test} (kV)	4,35		
P_{1C} (W) (after 2 hours)	0,958	1,035	1,155
T_{1C} (°C) (after 2 hours)	114,0	114,1	114,0
P_{2C} (W) (after 1000 hours)	1,682	1,341	1,764
T_{2C} (°C) (after 1000 hours)	114,2	114,3	114,2
$k_{ct} = P_{2C}/P_{1C}$	1,755	1,296	1,527

Evaluation criteria according to IEC 60099-4 (2004-05)

The ratio P_{2C}/P_{1C} was higher than 1,0 for all samples

where:
- P_{2C} are the power losses measured at the end of the test
- P_{1C} are the power losses measured at the beginning of the test (2 hours after energization)

The results of the resistor aging test shall be considered in the operating duty test as prescribed in the reference standard at item 8.5.2.2 and table 7

Power frequency voltage-current characteristics. IEC 60099-4 Standard

Power frequency voltage-current characteristics at ambient temperature
Test circuit: A0019

Date: December 10, 2004

Sample No. AG1						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
1	5,12	1,41	1,11	0,602	1,73	--

Sample No.						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
2	5,17	1,43	1,23	0,623	1,90	--

Sample No.						
oscillogram	voltage	current	current	current	power	3rd harmonic amplitude
No.	kV	+ mA_{cr}	- mA_{cr}	mA_{rms}	W	µA
3	5,15	1,42	1,24	0,635	1,91	--

Accelerated ageing test. IEC 60099-4 Standard

Power frequency voltage-current characteristics at the beginning of the test

Test circuit: A0119

Date: January 13, 2005

Sample No. AG1					
oscillogram	voltage	current	current	power	temperature
No.	kV	+ mA_{cr}	- mA_{cr}	W	°C
4	4,35	0,708	0,684	0,958	114,0

Sample No. AG2					
oscillogram	voltage	current	current	power	temperature
No.	kV	+ mA_{cr}	- mA_{cr}	W	°C
5	4,35	0,723	0,723	1,035	114,1

Sample No.					
oscillogram	voltage	current	current	power	temperature
No.	kV	+ mA_{cr}	- mA_{cr}	W	°C
6	4,35	0,767	0,796	1,155	114,0

Accelerated ageing test. IEC 60099-4 Standard

Power frequency voltage-current characteristics at the end of the test

Test circuit: A0119

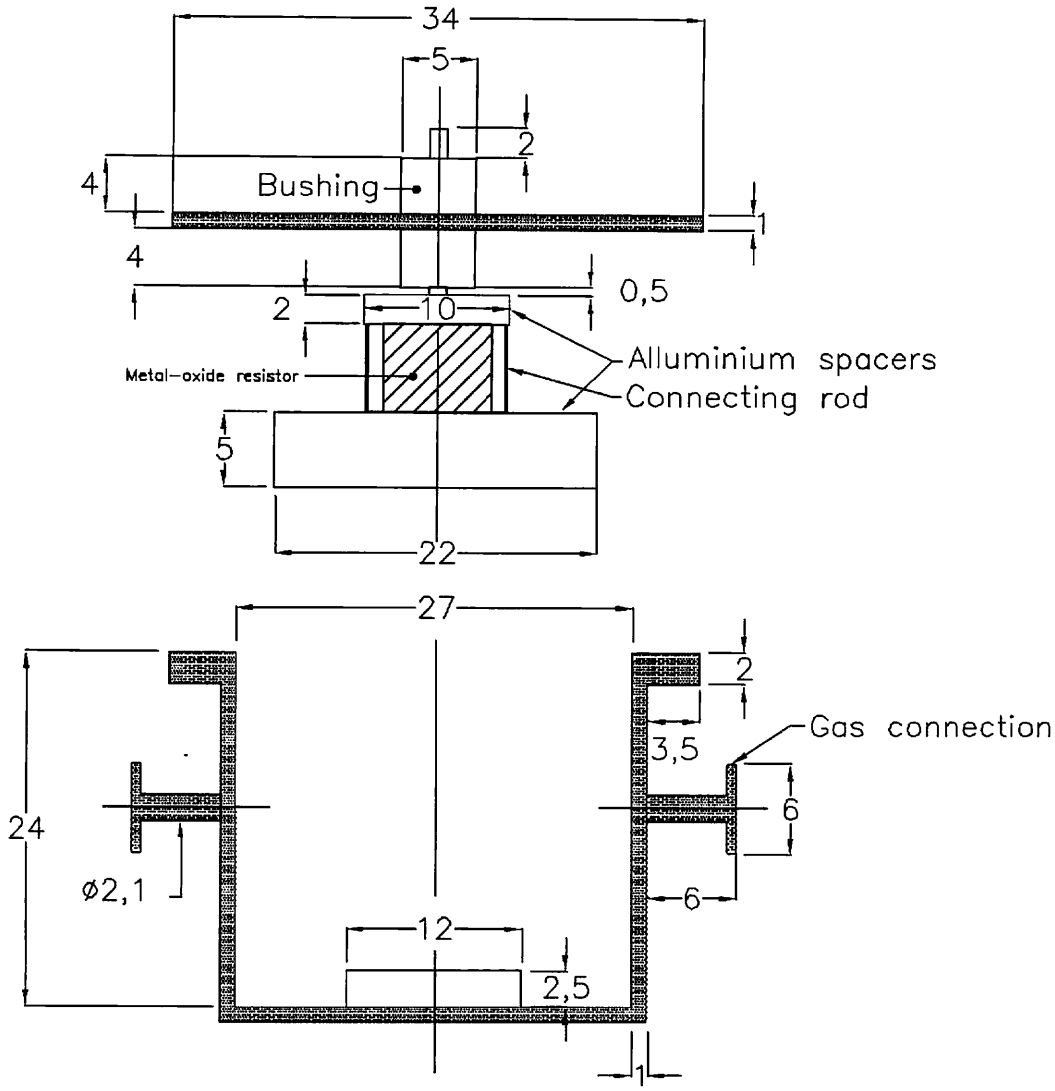
Date: February 24, 2005

Sample No. AG1					
oscillogram	voltage	current	current	power	temperature
No.	kV	+ mA_{cr}	- mA_{cr}	W	°C
7/10	4,35	0,957	0,966	1,68	114,2

Sample No AG2					
oscillogram	voltage	current	current	power	temperature
No.	kV	+ mA_{cr}	- mA_{cr}	W	°C
8/11	4,35	0,835	0,864	1,34	114,3

Sample No. AG3					
oscillogram	voltage	current	current	power	temperature
No.	kV	+ mA_{cr}	- mA_{cr}	W	°C
9/12	4,35	1,021	1,064	1,76	114,2

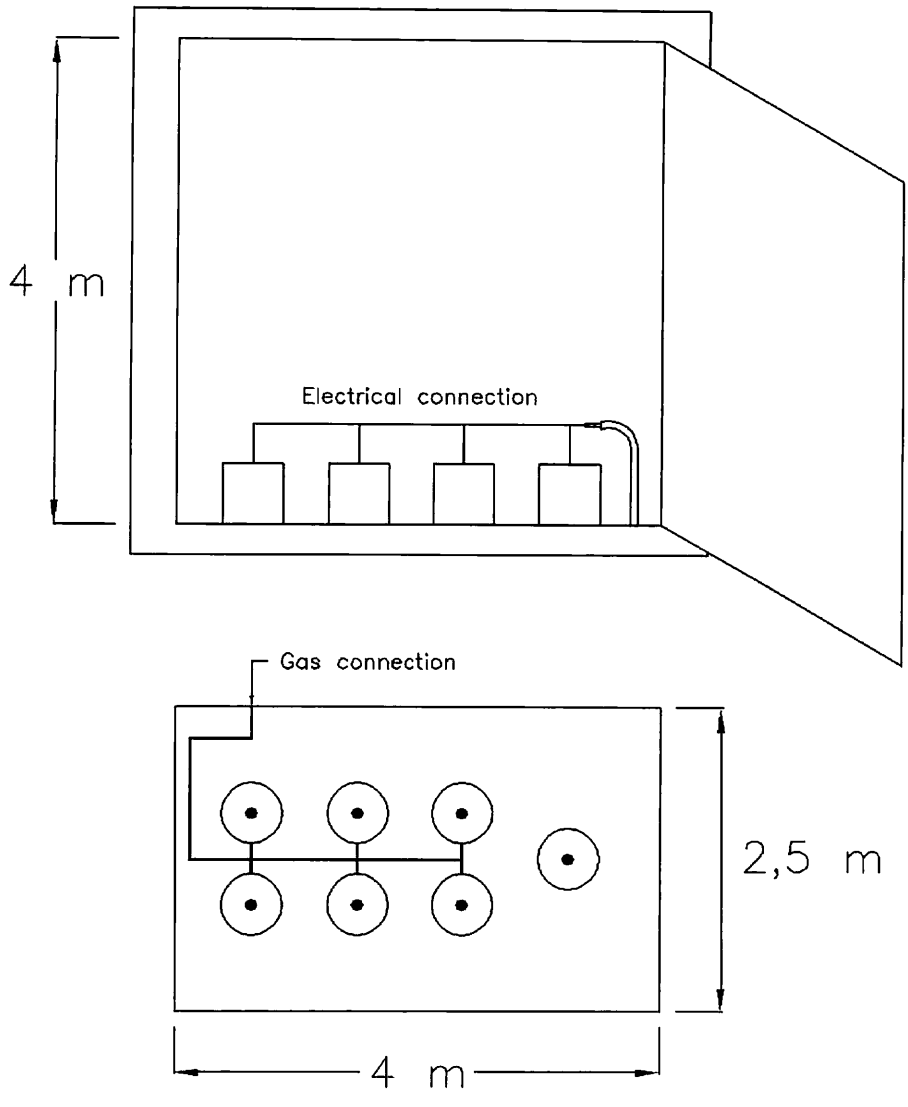
Test arrangement A8056



Dimensions in cm: all

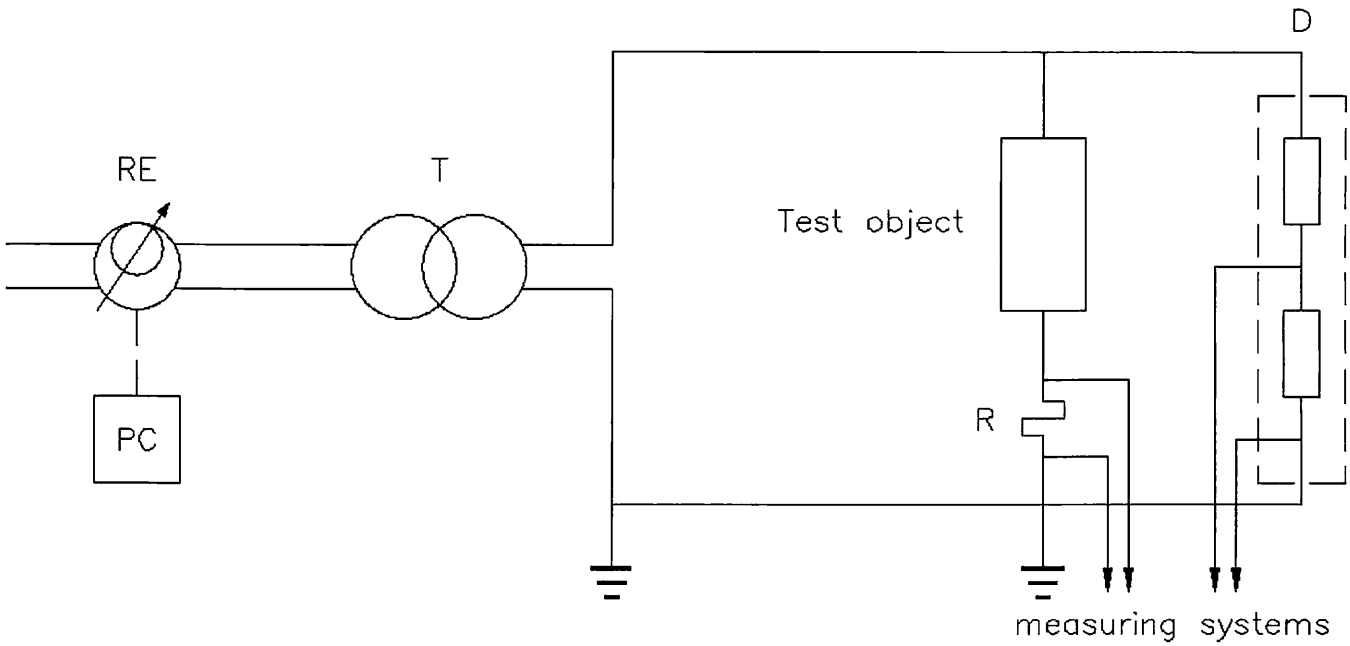
Notes:

Test arrangement A8057



Notes:

Circuit A0019



Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 5000 P.S.; CESI no. 23702-32191
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

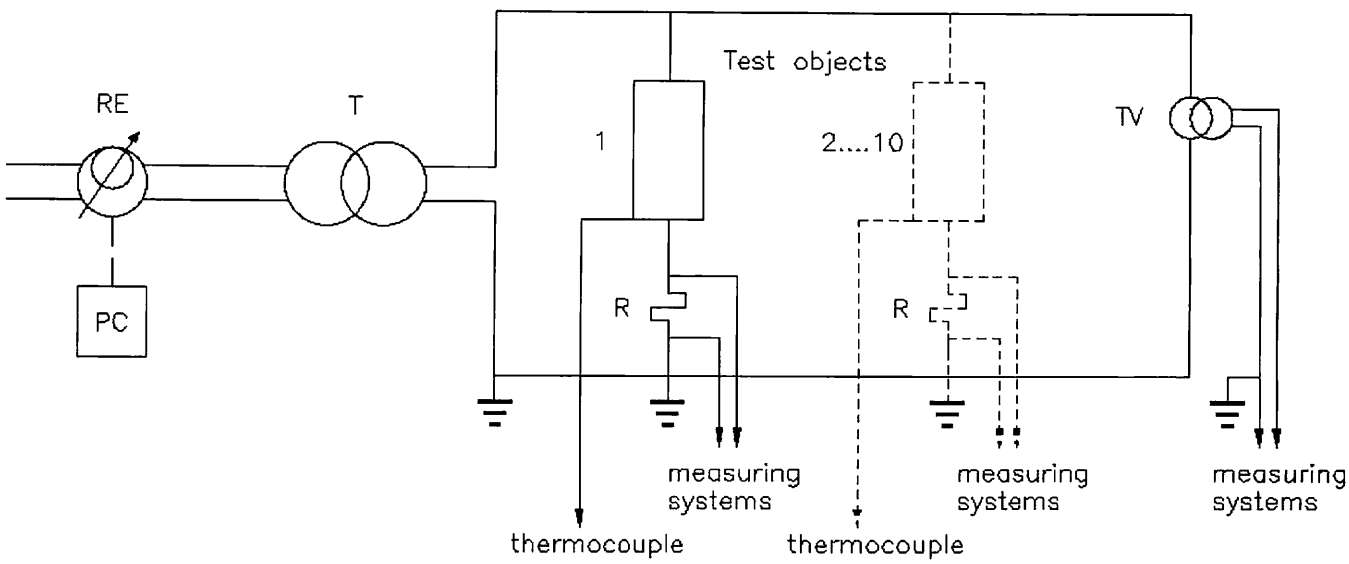
OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Voltage measuring system

D - Voltage divider SAGI; CESI No.11120
- Electro optical system CESI No.11521/11522;

OSC - Oscilloscope type SONY TEKTRONIX RTD 710A; CESI No.9090

Circuit A0119



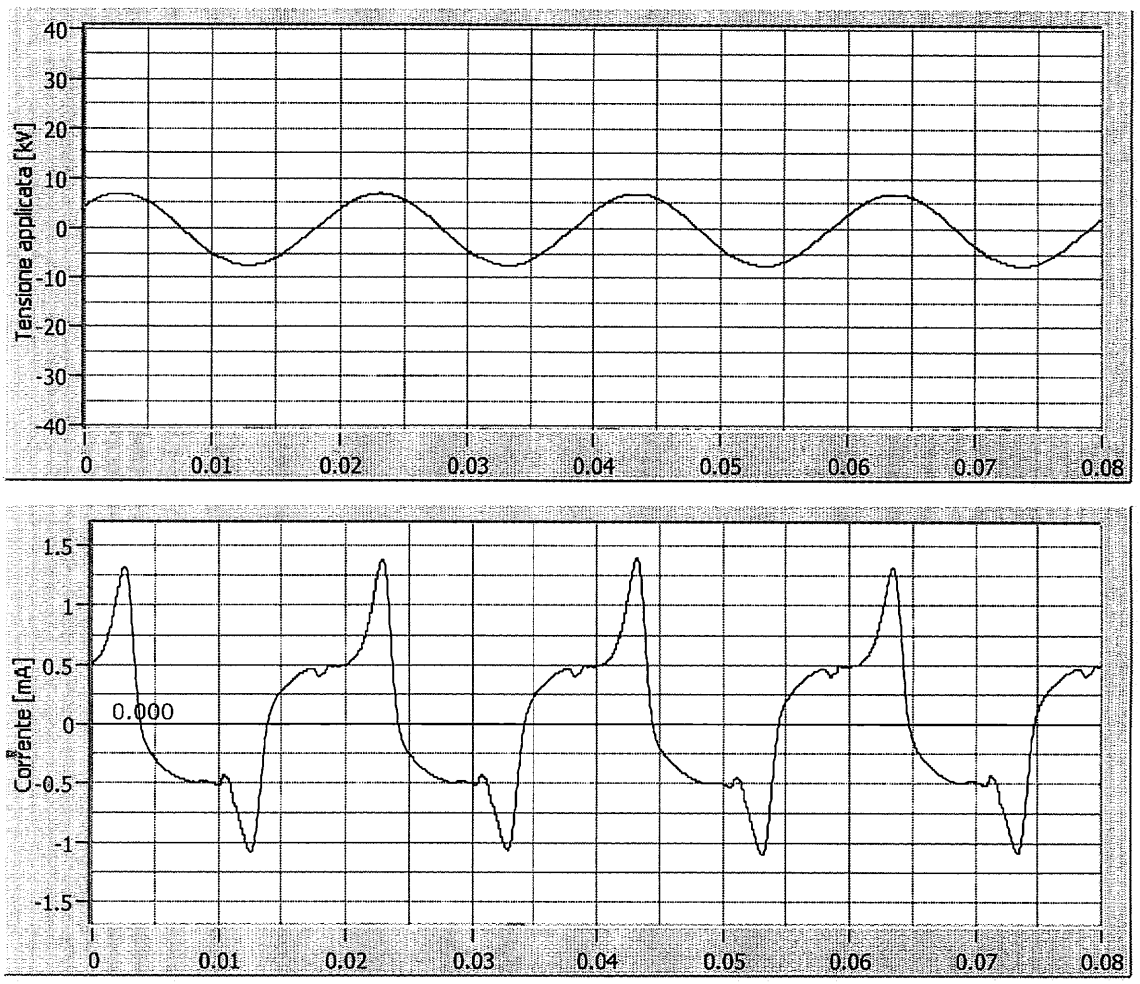
Power frequency supply

RE - programmable supply type LARCET A.C. Power Source 3000 P.S.; CESI no. 14315
PC - personal computer
T - voltage transformer type PIVI; power 10 kVA; voltage 220 V/12,5 kV

R - Current shunt type SECI ; R= 1000 Ω

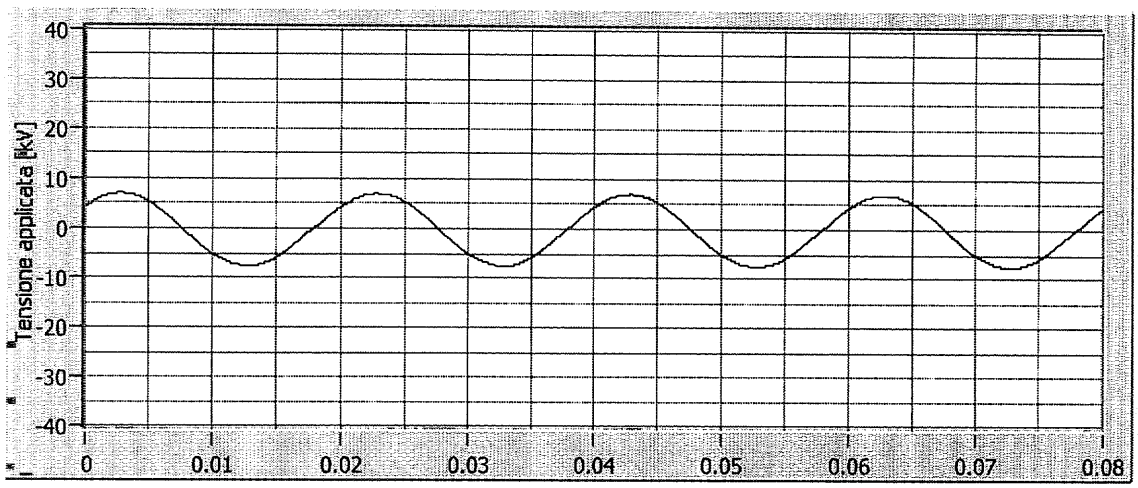
TV - Voltage trasformer; CESI 30000:100

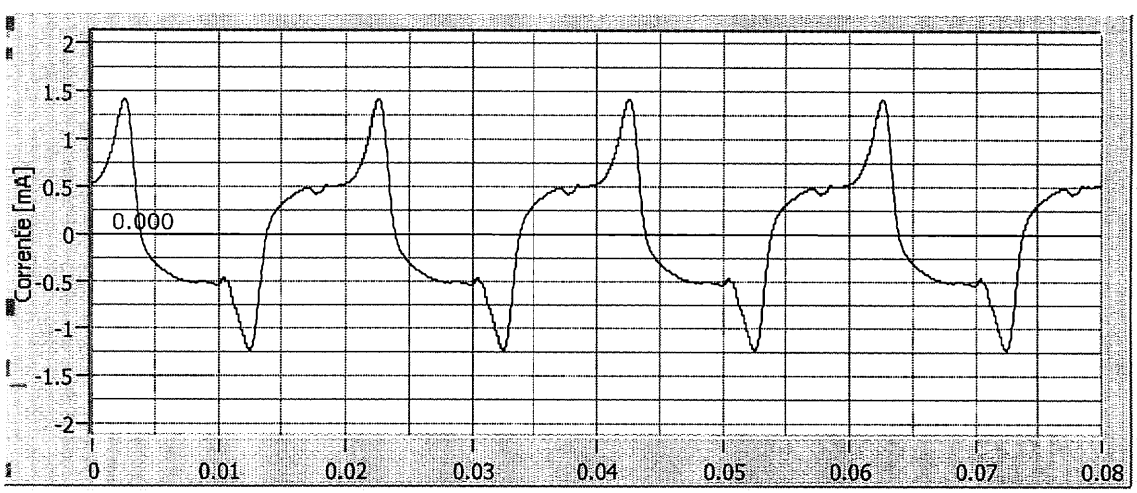
Data acquisition system type NATIONAL INSTRUMENTS SCXI-1001



AG1

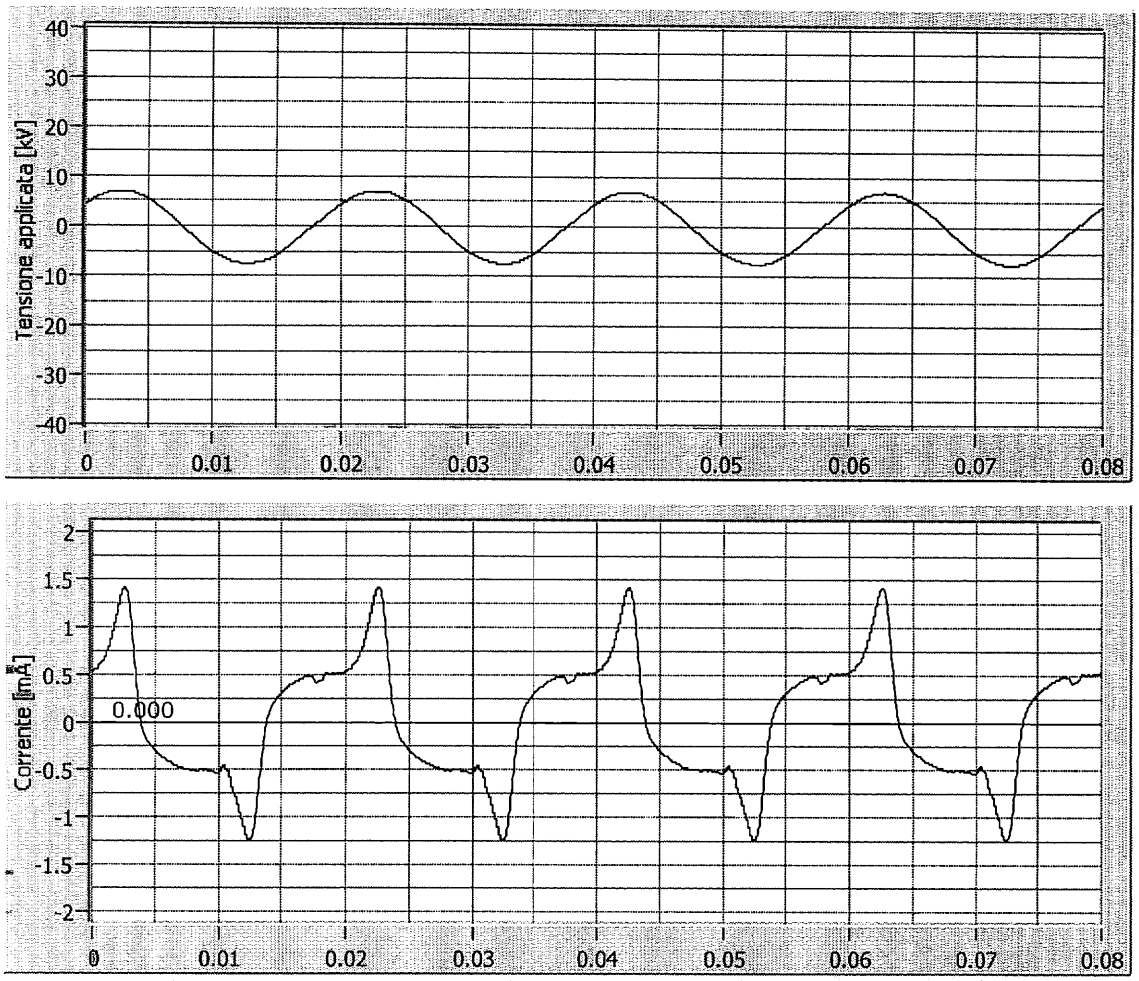
CESI PeC A5009883 oscillogram n. 1





AG2

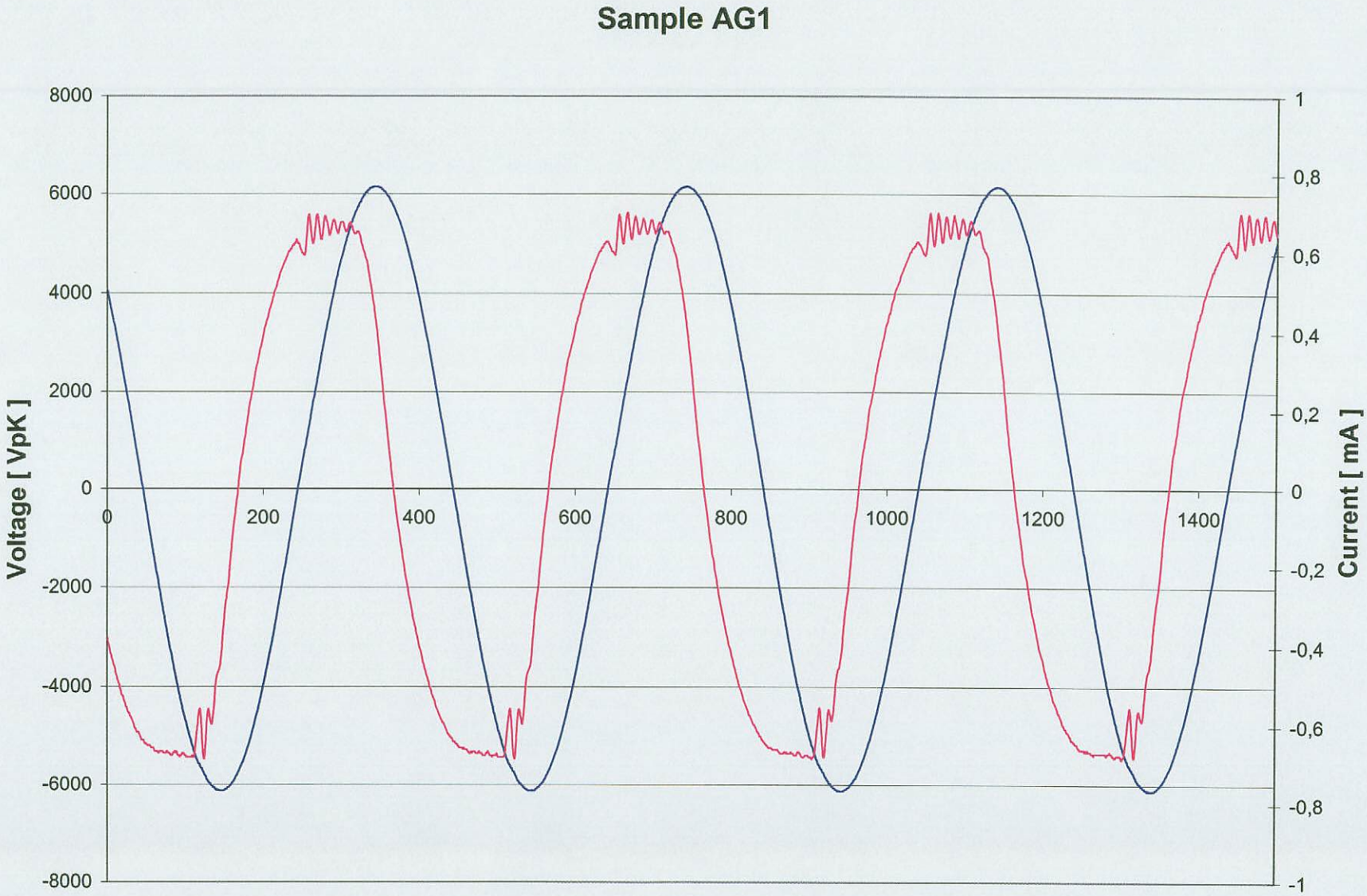
CESI PeC A5009883 oscillogram n. 2



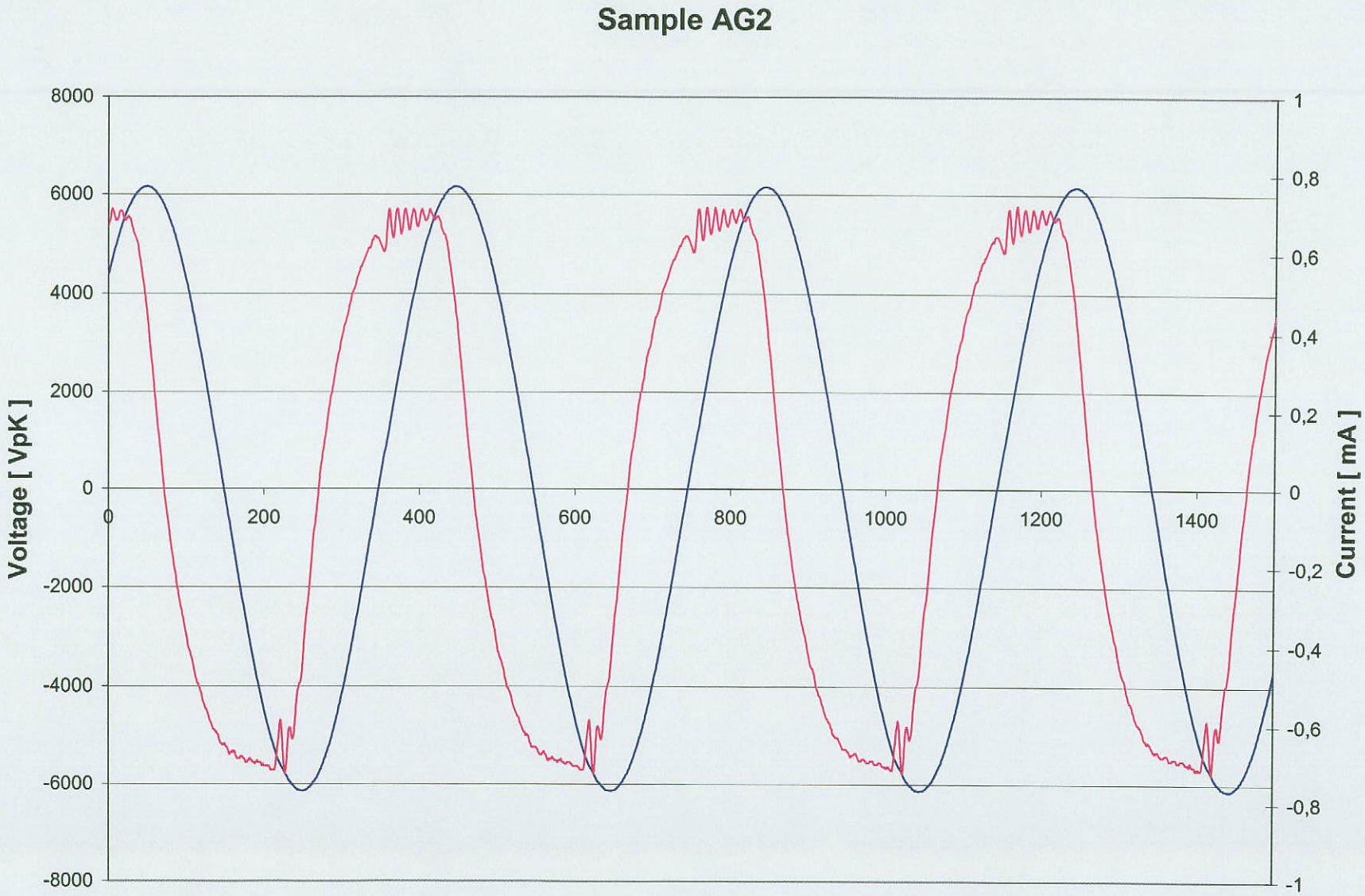
AG3

CESI PeC A5009883 oscillogram n. 3

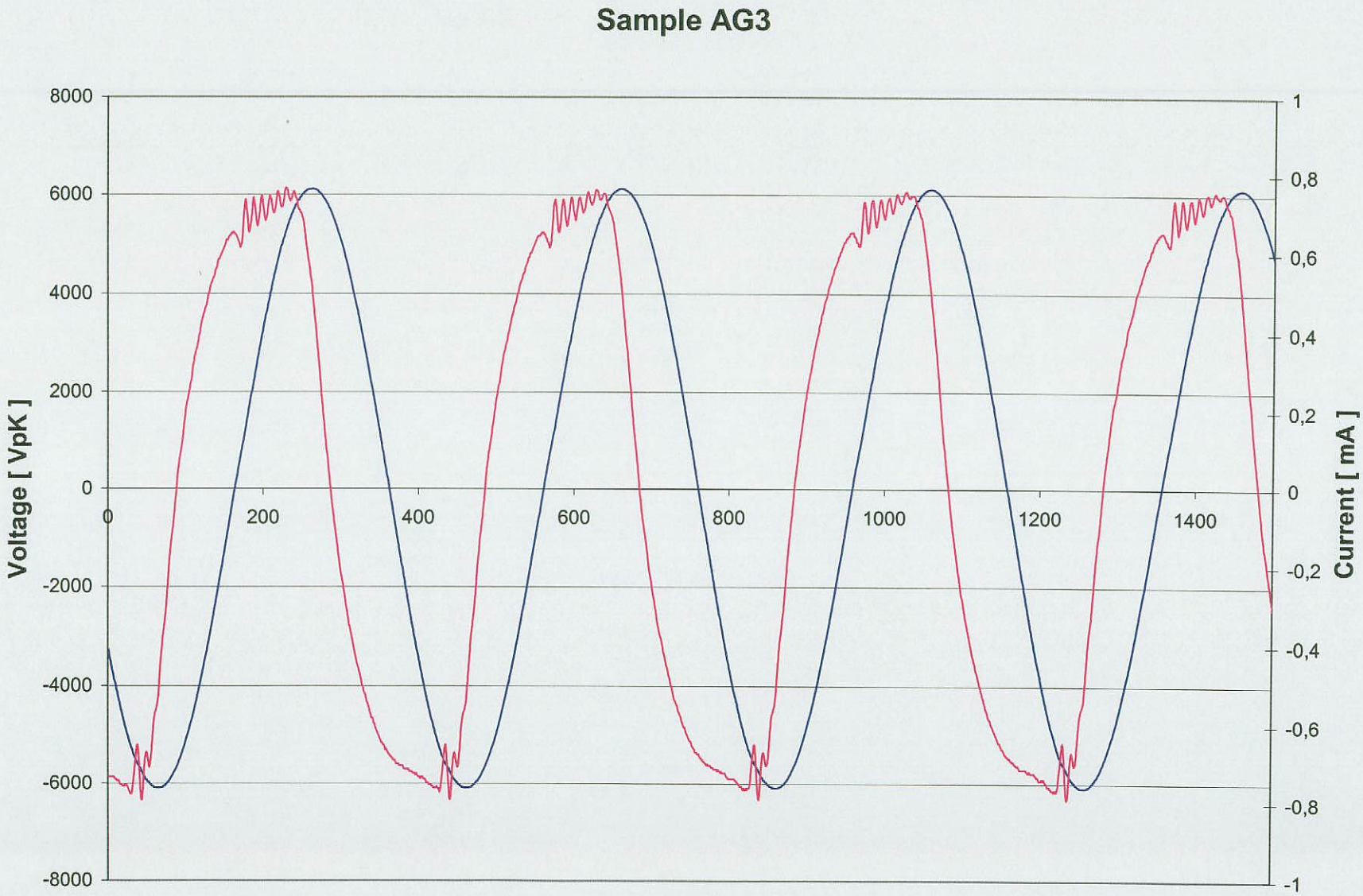
CESI PeC A5009883 oscillogram n. 4



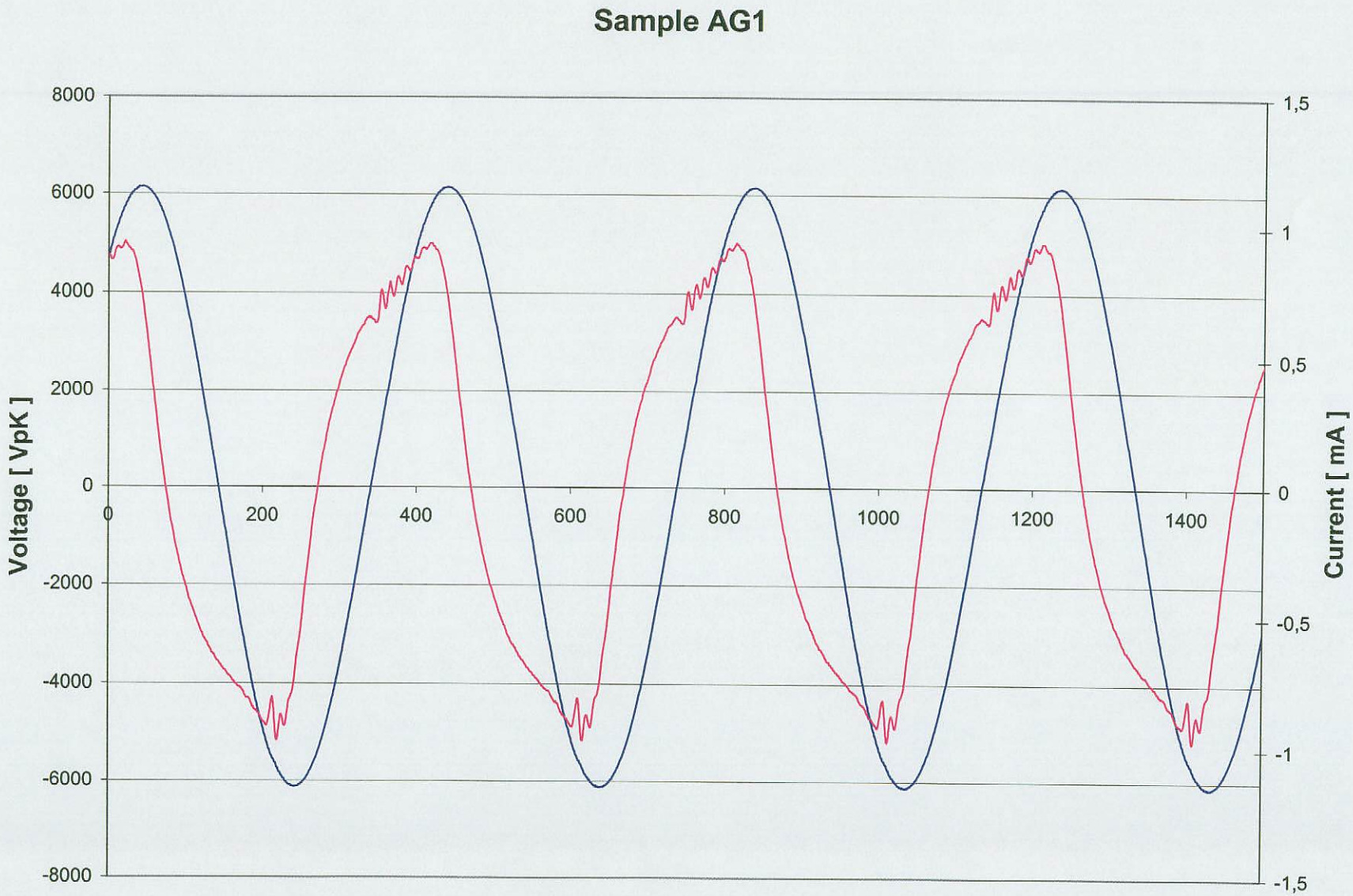
CESI PeC A5009883 oscillogram n. 5



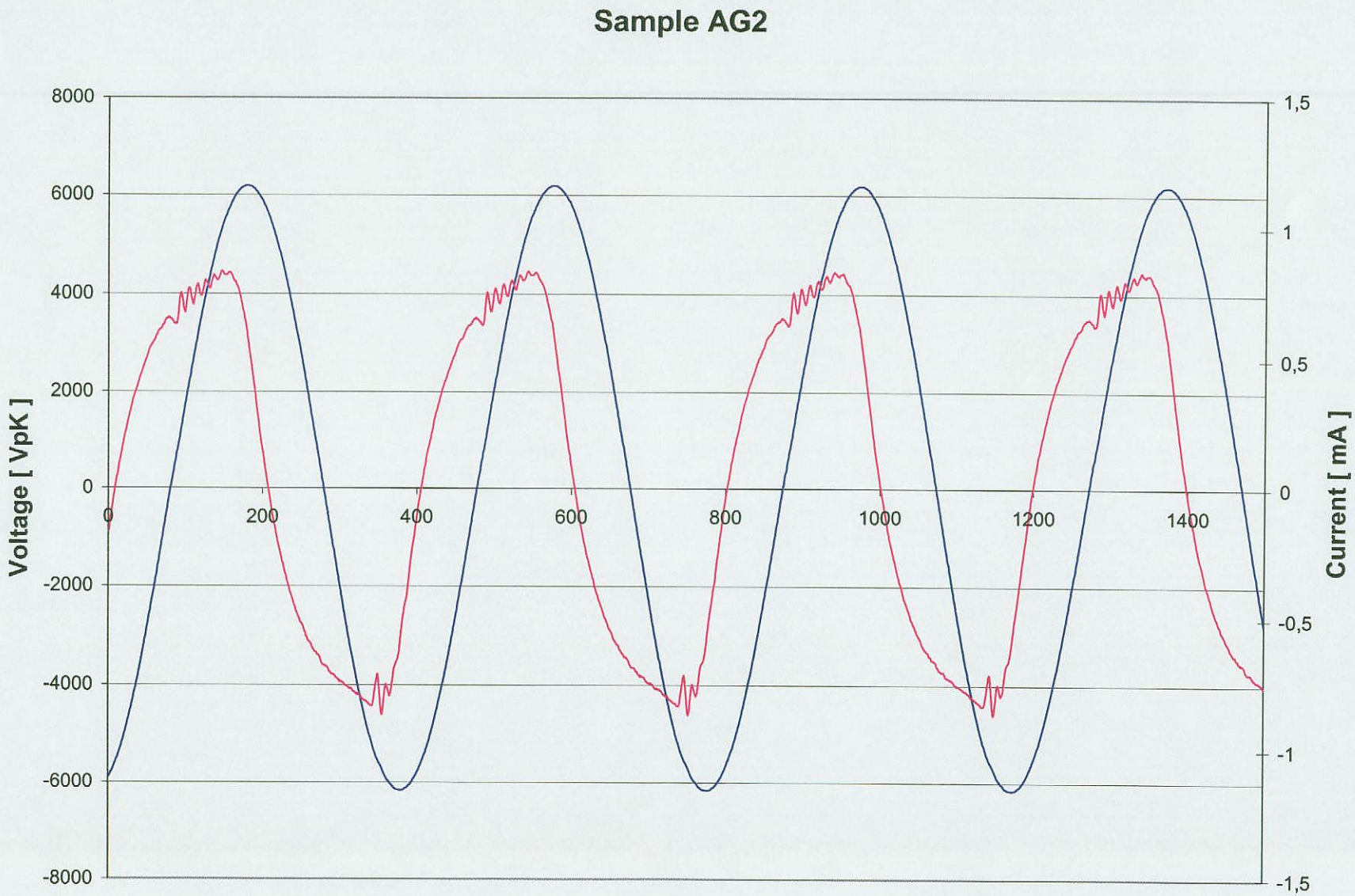
CESI PeC A5009883 oscillogram n. 6



CESI PeC A5009883 oscillogram n. 7

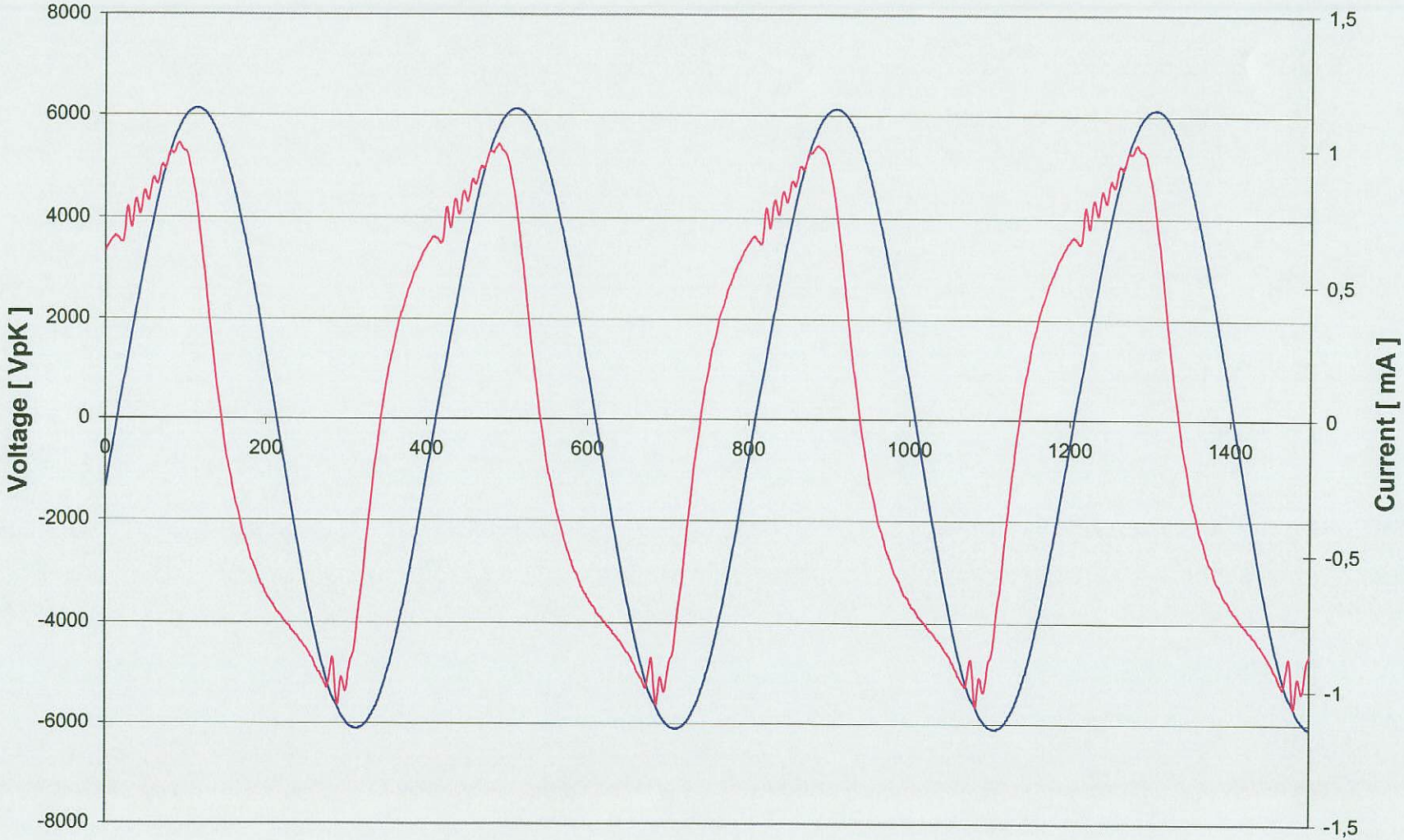


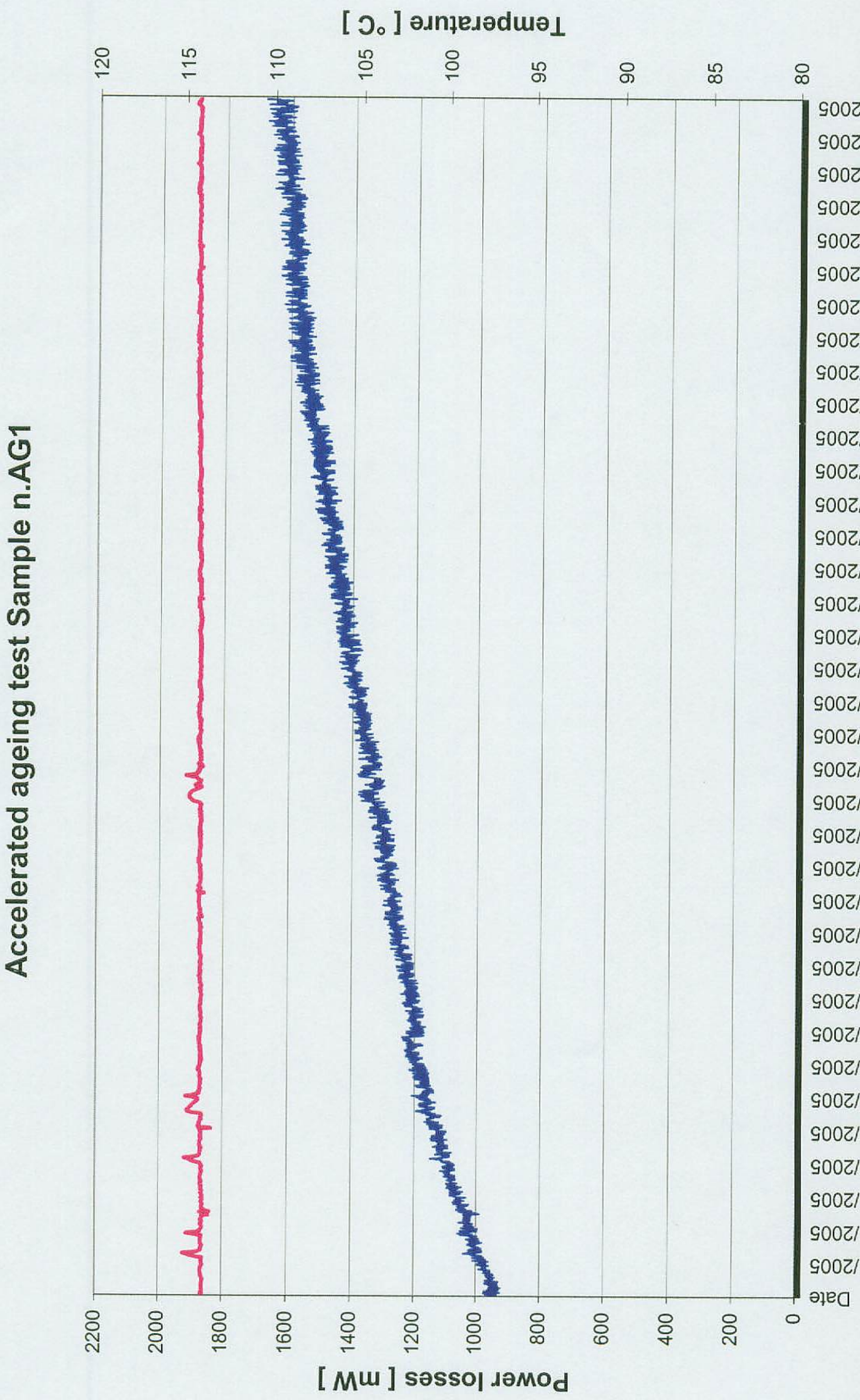
CESI PeC A5009883 oscillogram n. 8



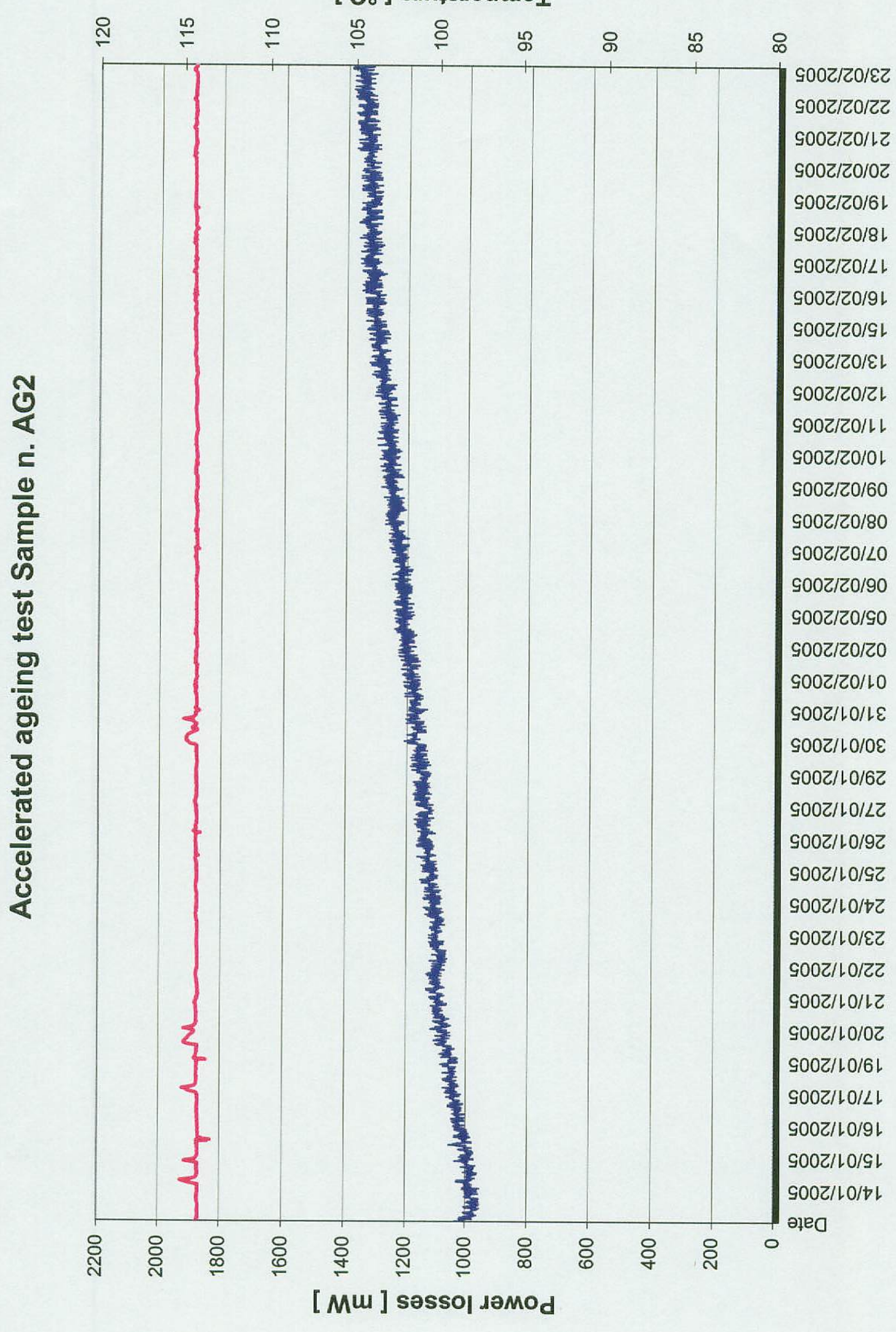
CESI PeC A5009883 oscillogram n. 9

Sample AG3





CESI PeC A5009883 oscillogram n. 10



CESI PeC A5009883 oscillogram n. 11

CESI PeC A5009883 oscillogram n. 12