



Test Report

Nº B26-20-CJ-01Ev2

v2: This version cancels the report B26-20-CJ-01E. Error correction.



Type and routine tests

TEST OBJECT	Current transformer
DESIGNATION	CA-123
MANUFACTURER	ELECTROTECNIA ARTECHE HNOS, S.A
CUSTOMER	ELECTROTECNIA ARTECHE HNOS, S.A Derio Bidea, 28 – 48100 MUNGIA (BIZKAIA)
STANDARD	IEC 61869-2:2012
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1. IDENTIFICATION OF THE TEST OBJECT

The characteristics of the test object, according to the ratings plate supplied by the manufacturer, are the following:

Manufacturer:	ARTECHE					
Type:	CA-123					
Serial no.:	19011561					
Manufacturing year:	2020					
Ratio:	2000-1500-1000-500 / 1 A					
Primary terminal markings:	P1-P2					
Rated primary voltage, Upn:	2000	1000	500	1500	1500	1500
Secondary terminal markings:	1s1-1s4	1s1-1s3	1s1-1s2	2s1-2s2	3s1-3s2	4s1-4s2
Rated secondary voltage, Usn:	1	1	1	1	1	1
Rated output:	1-5 VA	1-5 VA	1-5 VA	10 VA	10 VA	10 VA
Accuracy class:	0.2S	0.2S	0.2S	5PR	5PR	5PR
Accuracy limit factor:				80	60	60
Security factor:	7	7	5			
Icth:	125 %	150 %	150 %	167 %	167 %	167 %
Iect:	125 %	130 %	130 %			
Rct:	8.7 Ω	3.9 Ω	1.7 Ω	7.5 Ω	6.7 Ω	6.5 Ω
Usat:	86 V	43 V	21.5 V			
Rated insulation level:	123/230/550 kV					
Ith:	40kA 1 s					
Idyn:	100kA					
Rated frequency (Hz):	50					
Class of insulation:	Oil Filled					
Weight:	195 Kg					
Temperature category:	-25°C / +40°C					
Mechanical Class:	Class II					

See the photographs of the test object and the ratings plate in the annex.

2. TESTS PLACE

Tests have been performed at TECNALIA'S Electrical Equipment Laboratories, located at the Scientific and Technological Park of Bizkaia, building 413—INGRID (Zamudio-Spain).

3. TESTS PERFORMED. STANDARD

Type and routine tests. Tests have been carried out according to:

- **IEC 61869-2:2012 "Instrument transformers. Part 2: Additional requirements for current transformers".**

Normative references:

- IEC 60060-1:2010, "High-voltage test techniques - Part 1: General definitions and test requirements".
- IEC 61869-1:2010, "Instrument transformers. Part 1. General requirements »

The calculation of the uncertainties of the measurements is available.

4. SUMMARY OF RESULTS

In the following table are shown the performed tests in the sequential order of execution with the result of each of the tests:

TEST	RESULT	TEST
1. Verification of terminal markings and ratings plate	CORRECT	Routine
2. Lightning Impulse test on primary winding	CORRECT	Type
3. Chopped lightning impulse test	CORRECT	Special
4. Wet test	CORRECT	Type
5. Power-frequency withstand test on the primary winding	CORRECT	Routine
6. Partial discharges measurement	CORRECT	Routine
7. Power-frequency withstand test on secondary windings	CORRECT	Routine
8. Determination of the secondary winding resistance	CORRECT	Routine
9. Inter-turn overvoltage	CORRECT	Routine
10. Test for accuracy	CORRECT	Type / Routine
11. Determination of the security factor (FS) for measuring secondaries	CORRECT	Routine
12. Determination of the remanence factor K_R	CORRECT	Routine
13. Short time current test	CORRECT	Type
14. Temperature rise test	CORRECT	Type
15. RIV test	CORRECT	Type
16. Mechanical test	CORRECT	Special

Performed test sequence is carried out according to IEC 61869-1: 2007 and IEC 61869-2:2011 standards.

5. TESTS

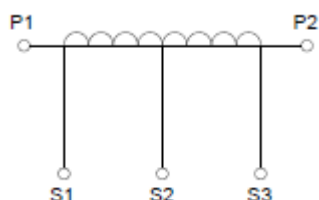
5.1. VERIFICATION OF MARKINGS

Verification of terminal markings

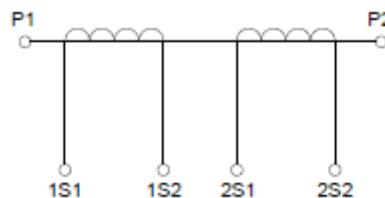
Terminals are identified according to standard, with the following letters:

Primary: P1-P2

Secondary: 1s1-1s4, 1s1-1s3, 1s1-1s2, 2s1-2s2, 3s1-3s2, 4s1-4s2



Transformer with an intermediate tapping on secondary winding



Transformer with some secondary winding each with its own magnetic core

Result: **CORRECT.**

Verification of ratings plate

It is verified that the ratings plate of the transformer contains the following information:

- a) Manufacturers identification
- b) Serial number and type designation
- c) Rated frequency
- d) Highest voltage of equipment
- e) Rated insulation level
- f) Temperature category
- g) Weight in kg
- h) Class of insulation
- i) Class of mechanical requirements
- j) Type of insulation fluid
- k) Insulating fluid mass
- l) The primary and secondary rated current
- m) The rated short time thermal current

- n) The rated dynamic current
- o) The rated continuous thermal current
- p) The rated accuracy class for each secondary winding

Result. **CORRECT.** Marking of the transformer and the information included in the ratings plate contains the information specified in the standard.

5.2. COMBINED FULL AND CHOPPED LIGHTNING IMPULSE TEST ON PRIMARY TERMINALS

The impulse voltage test is performed in accordance with IEC 60060-1.

The test is carried combined with the negative polarity of the full lightning impulse test as described below.

The test voltage is applied between the line terminal of the primary winding and earth. Terminals of the secondary winding and the frame are earthed during the test.

The impulse test consists of voltage application at reference and rated voltage levels. The reference impulse voltage has been between 50 % and 75 % of the rated impulse withstand voltage. The chopped occur between 2 μ s and 5 μ s on the tail of the impulse. The peak value and the waveshape of the impulse are recorded. The test is performed with both positive and negative polarities. The following impulse sequence is applied.

Positive polarity:

- One reduced reference impulse
- Fifteen full impulses

Negative polarity:

- One reduced reference impulse
- One full impulse
- Two chopped impulses
- Fourteen full impulses

The test voltage has the appropriate value, depending on the highest voltage for equipment and the specified insulation level.

Evidence of insulation failure due to the test may be given by variation in the waveshape at both reference and rated full impulses for positive; and at full wave application before and after the chopped impulses for negative.

Full impulse voltage: **550 kV**

Chopped impulse voltage: **632 kV**

Waveforms with the corresponding lightning impulse values are shown in the annex.

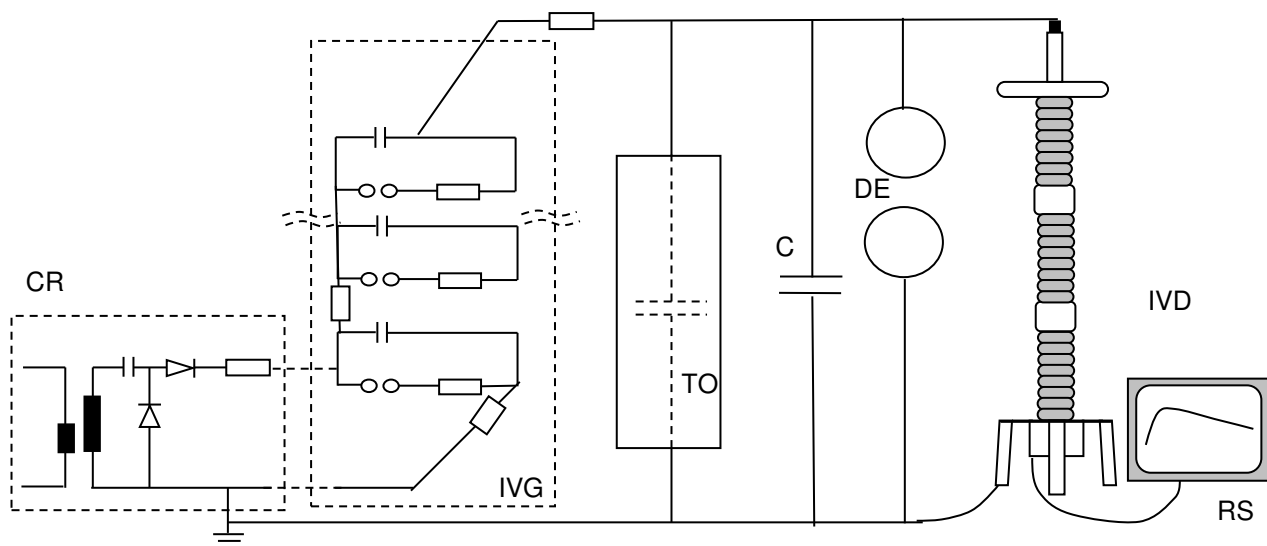
Ambient air conditions during the test:

Temperature: 26.2 °C

Pressure: 101 kPa

Relative humidity: 55 %

Test scheme:



CR: Rectifier

IVG: Impulse Voltage Generator

RS: Recording system

IVD: Impulse Voltage Divider

C: Capacitor

TO: Test object

DE: Chopping device

Result: **CORRECT**. For each polarity:

- no disruptive discharge occurs in the non-self-restoring internal insulation;
- no flashovers occur along the non-self-restoring external insulation;
- no flashovers occur across the self-restoring external insulation;
- no other evidence of insulation failure is detected (e.g. variations in the waveshape of the recorded quantities).

5.3. WET TEST

The wet test has been carried out in accordance with the Standard IEC 60060-1.

The voltage test is applied between the terminals of the primary winding and earth. The frame and the terminals of secondary windings are connected together and to earth.

According to the standard the test object is pre-wetted initially for 15 min under the specified wetting conditions, and these conditions remain within the specified tolerances throughout the test which is performed without interrupting the wetting.

Before the test, test object is in dry and clean conditions.

Precipitation conditions during the test (and standard conditions):

Characteristic	Test	Standard
Precipitation rate – vertical component (mm/min)	1.74	1.0 to 2.0
Precipitation rate – horizontal component (mm/min)	1.46	1.0 to 2.0
Limit for any individual measurement (mm/min)	Correct	±0.5 from average
Temperature of water (°C)	22.3	amb. temp. ±15 °C
Resistivity of water (Ωm)	100.2	100 ±15 Ωm

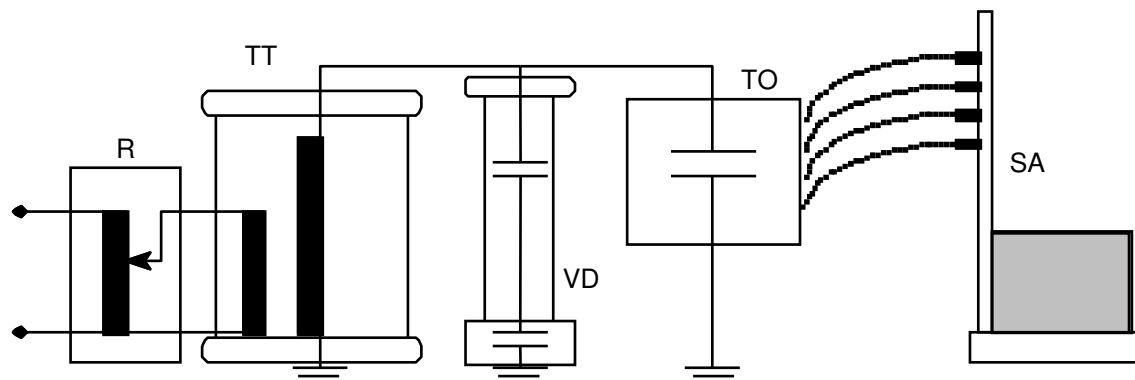
Test object is provided in supply condition with the insulated surfaces cleaned.

Test parameters are defined in subclause 5.4.

The air ambient conditions during the test performance have been the following ones:

- Ambient temperature: 23.8 °C
- Atmospheric pressure: 100.4 kPa
- Relative humidity: 57.0 %

Test scheme is represented in the following figure:



R: Regulator
 TT: Test Transformer
 VD: Voltage divider
 SA: Spray apparatus
 TO: Test object

Result: **CORRECT.** No disruptive discharge occurs on the test object during the test.

5.4. POWER-FREQUENCY WITHSTAND TEST ON THE PRIMARY WINDING

The test voltage is applied between the terminals of the primary winding, connected together, and earth. The terminals of the secondary windings, short-circuited, and the frame are connected to earth.

Test voltage value:	230 kV
Test duration:	60 s
Test voltage frequency:	50 Hz

Result: **CORRECT**. There are neither disruptive discharges nor damage in the insulation.

5.5. POWER-FREQUENCY WITHSTAND TEST ON SECONDARY WINDINGS

The test voltage is applied successively between the terminals of each secondary winding connected together and earth. The frame, the primary winding and the other secondary windings are connected to earth.

Test voltage value:	3 kV
Test duration:	60 s
Test voltage frequency:	50 Hz

Result: **CORRECT**. There are neither disruptive discharges nor damage in the insulation.

5.6. PARTIAL DISCHARGES MEASUREMENT

The instrument used measures the apparent charge q expressed in pC. Its calibration is performed in the test circuit.

The sensibility allows detecting a partial discharge level of 10 pC.

The prestress is performed according to procedure B: the partial discharge test is performed after the power frequency test. The applied voltage is raised to 80% of the power-frequency voltage (184 kV, 60 s).

After prestressing, the partial discharge test voltages are reached, and the corresponding partial discharge levels are measured in a time within 30 s.

Test voltages have been selected for a highest voltage for equipment ($U_m = 123 \text{ kV}$).

Test voltage (r.m.s.) (kV)	Duration (s)	Measurement (pC)	Permissible level (pC)
$1.2 \cdot U_m$ 147.6	30	3	10
$1.2 \cdot U_m / \sqrt{3}$ 85.2	30	2	5

Background noise: 1.5 pC

Result: **CORRECT**. The obtained values are below the specified limits.

5.7. INTER-TURN OVERVOLTAGE TEST

The test is performed according to procedure B: with the primary winding open-circuited, the prescribed test voltage (at some suitable frequency) is applied successively for 60 s to the terminals of each secondary winding, providing that the r.m.s. value of the secondary current does not exceed the rated extended current.

The value of the test frequency shall not be greater than 400 Hz. When the frequency exceeds twice the rated frequency, the duration of the test may be reduced from 60 s as below, with a minimum of 15 s.

Duration of test (in s) = (twice the rated frequency/test frequency) x 60

In this case:

Test frequency	400 Hz
Test duration	15 s

At this frequency, if the voltage value achieved at the rated extended secondary current is lower than 4.5 kV peak. The obtained voltage is to be regarded as the test voltage.

Result: **CORRECT**. There are neither disruptive discharges nor damage in the insulation.

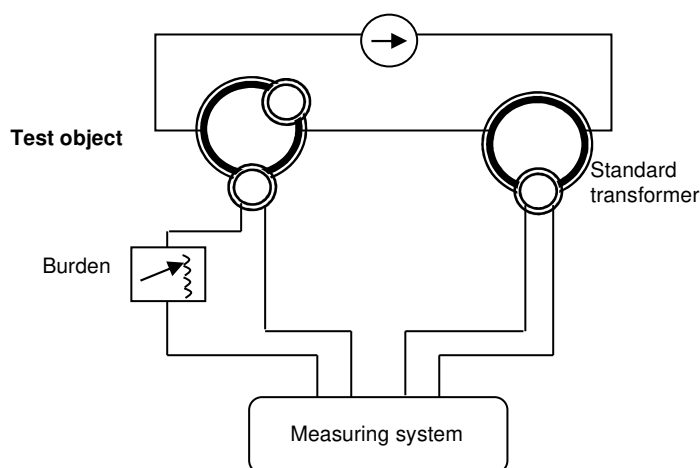
5.8. TEST FOR ACCURACY

5.8.1. Ratio error and phase displacement of measuring and protective current transformers

For 0.2S and 5PR class transformers, at rated frequency and with rated burden connected, the current error and phase displacement shall not exceed the values given in tables 201 and 205 of the standard.

The secondary burden used for test purposes shall have a power-factor of 0.8 inductive except that when the burden is less than 5 VA a power-factor of 1 shall be used. In no case shall the test burden be less than 1 VA.

Test scheme:



Secondary 1s1-1s4 2000A

Secondary (measurement)	Burden (VA)	% In	Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
1s1-1s4 Class 0,2S	1 20%	125	0.04	0.2	0	10
		120	0.04	0.2	0	10
		100	0.03	0.2	0	10
		20	0.03	0.2	1	10
		5	0.03	0.35	1	15
		1	0.03	0.75	1	30
	5 100%	125	0.03	0.2	0	10
		120	0.03	0.2	0	10
		100	0.03	0.2	0	10
		20	0.02	0.2	1	10
		5	0.01	0.35	1	15
		1	0.01	0.75	2	30

Secondary 1s1-1s3 1000A

Secondary (measurement)	Burden (VA)	% In	Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
1s1-1s3 Class 0,2S	1 20%	150	0.07	0.2	1	10
		130	0.07	0.2	1	10
		120	0.07	0.2	1	10
		100	0.07	0.2	1	10
		20	0.06	0.2	2	10
		5	0.07	0.35	3	15
		1	0.09	0.75	3	30
	5 100%	150	0.05	0.2	0	10
		130	0.04	0.2	0	10
		120	0.04	0.2	0	10
		100	0.04	0.2	0	10
		20	0.01	0.2	2	10
		5	-0.01	0.35	4	15
		1	-0.01	0.75	5	30

Secondary 1s1-1s2 500A

Secondary (measurement)	Burden (VA)	% In	Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
1s1-1s2 Class 0,2S	1 20%	130	0.13	0.2	1	10
		120	0.13	0.2	1	10
		100	0.12	0.2	1	10
		20	0.10	0.2	3	10
		5	0.10	0.35	6	15
		1	0.15	0.75	7	30
	5 100%	130	0.05	0.2	0	10
		120	0.04	0.2	0	10
		100	0.03	0.2	0	10
		20	-0.07	0.2	3	10
		5	-0.15	0.35	8	15
		1	-0.15	0.75	15	30

Secondary 2s1-2s2 1500A

Secondary (protection)	Burden (VA)	% In	Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
2s1-2s2 Class 5PR	2.5 25%	100	0.01	1	16	60
	10 100%	100	-0.32	1	26	60

Secondary 3s1-3s2 1500A

Secondary (protection)	Burden (VA)	% In	Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
3s1-3s2 Class 5PR	2.5 25%	100	-0.01	1	16	60
	10 100%	100	-0.35	1	25	60

Secondary 4s1-4s2 1500A

Secondary (protection)	Burden (VA)	% In	Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
3s1-3s2 Class 5PR	2.5 25%	100	0.25	1	17	60
	10 100%	100	-0.13	1	27	60

Result: **CORRECT**, measured values are inside the limits specified in the standard.

5.8.2. Determination of the instrument security factor (FS) of measuring current transformers

The test is performed using the following indirect method:

With the primary winding open-circuited, the secondary winding is energized at rated frequency by a substantially sinusoidal voltage. The voltage is increased until the exciting current I_e reaches $I_{sr} \times FS \times 10\%$, (minimal current).

The r.m.s. value of the measured terminal voltage shall be less than the secondary limiting e.m.f. E_{FS} .

CURRENT MEASUREMENT SECONDARY							
Secondary windings terminals	Class	Rated FS	R_s (75°C) Ω	Minimal current A	Exciting current I_e A	Measured e.m.f. V	Limiting e.m.f. E_{FS} V
1S1 - 1S2	0.2S	5	1.70	1	0.5	19.6	32.2
1S1 - 1S3	0.2S	7	3.87	1	0.7	39.9	59.0
1S1 - 1S4	0.2S	7	8.65	1	0.7	81.9	91.0

Result: **CORRECT**. The r.m.s value of the measured voltages of the secondary windings are less than the secondary limiting e.m.f.

5.8.3. Test for composite error of class P and PR protective current transformers

For current transformers having substantially continuous ring cores, uniformly distributed secondary windings and having either a centrally located primary conductor(s) or a uniformly distributed primary winding, the direct test may be replaced by the following indirect test provided that the effect of the return primary conductor(s) is negligible.

With the primary winding open-circuited the secondary windings are energized at rated frequency by a substantially sinusoidal voltage having an r.m.s. equal to the secondary limiting e.m.f.. The secondary limiting e.m.f. is the product of the accuracy limit factor (ALF), the rated secondary current and the vectorial sum of the rated burden and the impedance of the secondary winding (corrected to 75 °C).

The resulting measured current, expressed as a percentage of the rated secondary current I_{sr} (1 A) multiplied by the accuracy limit factor must not exceed the limit of composite error ϵ_c , in table 205 of standard (5%), to compare directly the measured current with the limiting current, the calculation formulae equivalent is:

$$\text{Limiting current} = I_{sr} \cdot \text{ALF} \cdot \epsilon_c / 100$$

CURRENT PROTECTIVE SECONDARY							
Secondary windings terminals	Class	Rated ALF	Rs (75°C) Ω	Limiting e.m.f (E _{ALF}) V	Applied e.m.f V	Measured current A	Limiting current A
2S1 - 2S2	5PR	80	7.46	1327	1335	0.98	4
3S1 - 3S2	5PR	60	6.71	953	958	0.96	3
4S1 - 4S2	5PR	60	6.47	940	944	0.60	3

Result: **CORRECT**. The measured current does not exceed the limiting current.

5.9. Determination of the secondary winding resistance

The resistances of the windings are measured and detailed as follow:

The resistance was measured by passing a current through the winding and recording the correspondent voltage drop.

Winding	Current (A)	VA	SF/ALF	ALF	Class	Resistance results (Ω)
1S1 – 1S2	1	5	5	---	0.2S	1.40
1S1 – 1S3	1	5	7	---	0.2S	3.20
1S1 – 1S4	1	5	7	---	0.2S	7.14
2S1 – 2S2	1	10	---	80	5PR	6.16
3S1 – 3S2	1	10	---	60	5PR	5.54
4S1 – 4S2	1	10	---	60	5PR	5.34

Result: **CORRECT**. According to the specified values on the rating plate.

5.10. Determination of the remanence factor class PR, TPY, and PXR protective current transformers

The test was performed following the annex 2B.2 of the standard:

- A voltage $u(t)$ is applied to the secondary terminals.
- The values of $u(t)$ and $i_m(t)$ are measured.
- Using the following function:

$$\psi(t) = \int_0^t (u(t) - R_{ct} \times i_m(t)) dt$$

The integrated voltage with the corresponding current will display a hysteresis loop (see chart 11 below), showing the saturation flux (Ψ_{sat}).

The flux value at zero crossing of current represent the remanent flux (Ψ_r).

- Remanence factor K_R is then calculated as

$$K_R = \frac{\Psi_r}{\Psi_{sat}}$$

Summary of the results table:

Terminal	Rated Rct	MEASURED		RESULTS		LIMIT
		Saturation flux Ψ_{sat}	Remanent flux Ψ_r	Remanence factor K_R	Remanence factor %	Remanence factor %
2S1 – 2S2	7.46	5900	255	0.043	4.3	10
3S1 – 3S2	6.71	4567	249	0.054	5.4	10
4S1 – 4S2	6.47	4567	199	0.043	4.3	10

Result: **CORRECT**. The remanence factor (K_R) do not exceed 10%.

5.11. SHORT-CIRCUIT WITHSTAND CAPABILITY TEST

For the thermal short-time current I_{th} test, the transformer must initially be at a temperature between 10 °C and 40 °C.

This test is made with the secondary winding(s) short-circuited and the primary winding in series, at a current I for a time t , so that (I^2t) is not less than (I_{th}^2t) , and provided t has a value between 0.5 s and 5 s.

The dynamic test is made with secondary winding(s) short-circuited and the primary winding in series. The peak value of primary current is not less than the rated dynamic current (I_{dyn}) for at least one peak.

The dynamic test and the thermal test cannot be combined because the specified duration is less than 0.5 s. According to the standard, two tests are performed, one, in which is verified the requirements of rated short-time thermal current (I_{th}) and, another one, in which the rated dynamic current is verified (I_{dyn}).

Rated values for the test are the following:

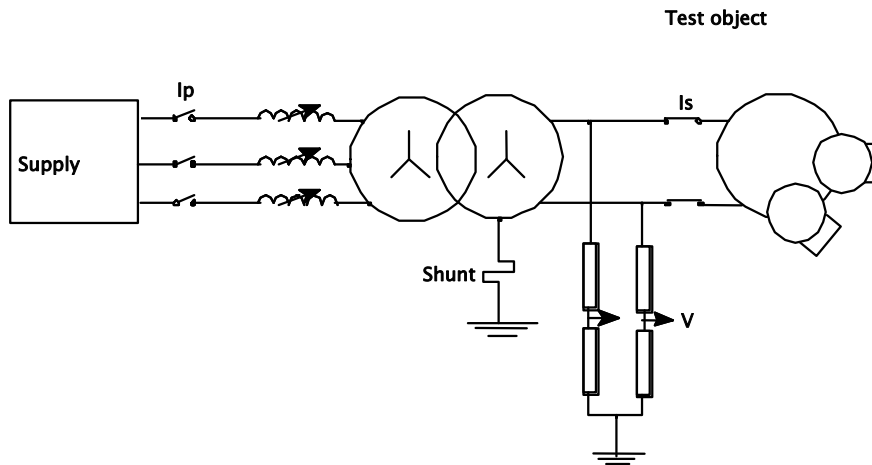
Rated short-time thermal current. I_{th} :	40 kA – 1 s
Rated dynamic current. I_{dyn} :	100 kA

See oscilogram in the annex of the report.

The transformer is deemed to have passed these tests if, after cooling to ambient temperature (between 10 °C and 40 °C), it satisfies the following requirements:

- a) it is not visible damaged;
- b) it withstands the dielectric tests specified in the standard, but with the test voltages or currents reduced to 90 % of those given;
- c) its errors after demagnetization do not differ from those recorded before the tests by more than half the limits of error appropriate to its accuracy class according to the standard.

Test circuit is as follows:



Recorded values:

Short circuit applied to	To all secondaries
Oscillogram N°	57
Primary Current (RMS) (kA)	40.5
Primary Current (Peak) (kA)	104.0
I^2t (AAs)	$1.76e^9$
Duration (ms)	1,012
Frequency (Hz)	50
Temperature (°C)	19.9

See oscillogram in the annex.

Result:

CORRECT.

- No visible damage is observed
- According to the following verifications in the following subclauses 5.11.1, 5.11.2, 5.11.3, 5.11.4 and 5.11.5

5.11.1. Power-Frequency withstand test on primary winding

The test voltage is applied between the terminals of the primary winding, connected together, and earth. The terminals of the secondary windings, short-circuited, and the frame are connected to earth.

Test voltage value: **207 kV**

Test duration: 60 s

Test voltage frequency: 50 Hz

Result: **CORRECT**, there are neither disruptive discharges nor damage in the insulation.

5.11.2. Power-Frequency withstand test on secondary windings

The test voltage is applied successively between the terminals of each secondary winding connected together and earth. The frame, the primary winding and the other secondary windings are connected to earth.

Test voltage value: **2.7 kV**

Test duration: 60 s

Test voltage frequency: 50 Hz

Result: **CORRECT**. There are neither disruptive discharges nor damage in the insulation.

5.11.3. Partial Discharges measurement

The instrument used measures the apparent charge q expressed in pC. Its calibration is performed in the test circuit.

The sensibility allows detecting a partial discharge level of 10 pC.

The prestress is performed according to procedure B: the partial discharge test is performed after the power frequency test. The applied voltage is raised to 80% of the power-frequency voltage (184 kV, 60 s).

After prestressing, the partial discharge test voltages are reached, and the corresponding partial discharge levels are measured in a time within 30 s.

Test voltages have been selected for a highest voltage for equipment ($U_m = 123$ kV).

Test voltage (r.m.s.) (kV)	Duration (s)	Measurement (pC)	Permissible level (pC)
$1.2 \cdot U_m$ 147.6	30	3	10
$1.2 \cdot U_m / \sqrt{3}$ 85.2	30	2	5

Background noise: 1.5 pC

Result: **CORRECT**. The obtained values are below the specified limits.

5.11.4. Inter-turn overvoltage test

The test is performed according to procedure B: with the primary winding open-circuited, the prescribed test voltage (at some suitable frequency) is applied successively for 60 s to the terminals of each secondary winding, providing that the r.m.s. value of the secondary current does not exceed the rated extended current.

The value of the test frequency shall not be greater than 400 Hz. When the frequency exceeds twice the rated frequency, the duration of the test may be reduced from 60 s as below, with a minimum of 15 s.

Duration of test (in s) = (twice the rated frequency/test frequency) x 60

In this case:

Test frequency	400 Hz
Test duration	15 s

At this frequency, if the voltage value achieved at the rated extended secondary current is lower than 4.5 kV peak. The obtained voltage is to be regarded as the test voltage.

Result: **CORRECT**. There are neither disruptive discharges nor damage in the insulation.

5.11.5. Test for Accuracy after short circuit

Secondary 1s1-1s4 2000A

Burden (VA)	% In		Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
1 20%	125	Before	0.04	0.1	0	5
		After	0.05		1	
		Diference	0.01		0	
	120	Before	0.04	0.1	0	5
		After	0.05		1	
		Diference	0.01		0	
	100	Before	0.03	0.1	0	5
		After	0.05		1	
		Diference	0.01		0	
	20	Before	0.03	0.1	1	5
		After	0.04		1	
		Diference	0.01		0	
	5	Before	0.03	0.175	1	7.5
		After	0.05		1	
		Diference	0.02		0	
	1	Before	0.03	0.375	1	15
		After	0.07		2	
		Diference	0.04		1	
5 100%	125	Before	0.03	0.1	0	5
		After	0.03		1	
		Diference	0.00		0	
	120	Before	0.03	0.1	0	5
		After	0.03		1	
		Diference	0.00		0	
	100	Before	0.03	0.1	0	5
		After	0.03		1	
		Diference	0.01		0	
	20	Before	0.02	0.1	1	5
		After	0.02		1	
		Diference	0.01		0	
	5	Before	0.01	0.175	1	7.5
		After	0.02		2	
		Diference	0.01		1	
	1	Before	0.01	0.375	2	15
		After	0.05		3	
		Diference	0.03		1	

Secondary 1s1-1s3 1000A

Burden (VA)	% In		Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
1 20%	130	Before	0.07	0.1	1	5
		After	0.07		2	
		Diference	0.00		1	
	120	Before	0.07	0.1	1	5
		After	0.07		2	
		Diference	0.00		1	
	100	Before	0.07	0.1	1	5
		After	0.07		2	
		Diference	0.00		1	
	20	Before	0.06	0.1	2	5
		After	0.07		3	
		Diference	0.01		1	
	5	Before	0.07	0.175	3	7.5
		After	0.09		4	
		Diference	0.02		2	
	1	Before	0.09	0.375	3	15
		After	0.15		5	
		Diference	0.06		1	
5 100%	130	Before	0.04	0.1	0	5
		After	0.04		1	
		Diference	0		1	
	120	Before	0.04	0.1	0	5
		After	0.04		1	
		Diference	0.00		1	
	100	Before	0.04	0.1	0	5
		After	0.04		1	
		Diference	0.00		1	
	20	Before	0.01	0.1	2	5
		After	0.00		3	
		Diference	-0.01		1	
	5	Before	-0.01	0.175	4	7.5
		After	-0.01		5	
		Diference	0.00		1	
	1	Before	-0.01	0.375	5	15
		After	0.04		7	
		Diference	0.05		1	

Secondary 1s1-1s2 500A

Burden (VA)	% In		Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
1 20%	130	Before	0.13	0.1	1	5
		After	0.13		3	
		Diference	0		2	
	120	Before	0.13	0.1	1	5
		After	0.13		3	
		Diference	0		2	
	100	Before	0.12	0.1	1	5
		After	0.13		3	
		Diference	0.01		2	
	20	Before	0.10	0.1	3	5
		After	0.12		6	
		Diference	0.02		3	
	5	Before	0.10	0.175	6	7.5
		After	0.14		8	
		Diference	0.04		2	
	1	Before	0.15	0.375	7	15
		After	0.22		9	
		Diference	0.07		2	
5 100%	130	Before	0.05	0.1	0	5
		After	0.04		0	
		Diference	-0.01		0	
	120	Before	0.04	0.1	0	5
		After	0.04		0	
		Diference	0		0	
	100	Before	0.03	0.1	0	5
		After	0.03		1	
		Diference	0		1	
	20	Before	-0.07	0.1	3	5
		After	-0.08		4	
		Diference	-0.01		1	
	5	Before	-0.15	0.175	8	7.5
		After	-0.16		9	
		Diference	-0.01		1	
	1	Before	-0.15	0.375	15	15
		After	-0.15		15	
		Diference	0		0	

Secondary 2s1-2s2 1500A

Burden (VA)	% In		Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
2.5 25%	100	Before	0.01	0,5	16	30
		After	0.02		16	
		Diference	0.01		0	
10 100%	100	Before	-0.32	0,5	26	30
		After	-0.31		26	
		Diference	0.01		0	

Secondary 3s1-3s2 1500A

Burden (VA)	% In		Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
2.5 25%	100	Before	-0.01	0,5	16	30
		After	0		15	
		Diference	0.01		-1	
10 100%	100	Before	-0.35	0,5	25	30
		After	-0.34		25	
		Diference	0.01		0	

Secondary 4s1-4s2 1500A

Burden (VA)	% In		Current error (%)		Phase displacement (minutes)	
			Measured	± Limit	Measured	± Limit
2.5 25%	100	Before	0.25	0,5	17	30
		After	0.26		16	
		Diference	0.01		-1	
10 100%	100	Before	-0.13	0,5	27	30
		After	-0.12		27	
		Diference	0.01		0	

Result: **CORRECT**, measured values are inside the limits specified in the standard.

5.12. RIV TEST

Test description

The test voltage is applied between one of the terminals of the primary winding and earth. The frame, and all the terminals of the secondary windings are connected to earth.

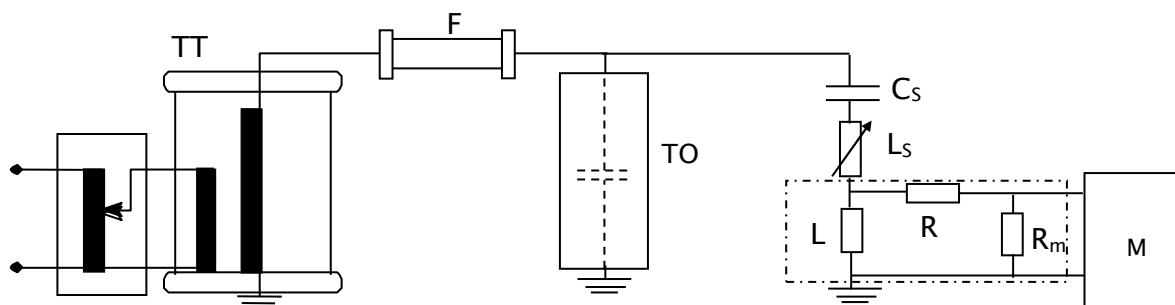
A pre-stress voltage of $1.5 U_m/\sqrt{3}$ is applied and maintained for 30 s. The voltage is then decreased to $1.1 U_m/\sqrt{3}$ in about 10 s and maintained at this value for 30 s before measuring the radio interference voltage.

The voltage transformer is considered to have passed the test if the radio interference level at $1.1 U_m/\sqrt{3}$ is lower than $2500 \mu V$.

U_m	123 kV
Test voltage	78.11 kV
Measuring frequency	0.6 MHz

Test circuit

The measuring circuit is in accordance with standard CISPR 18-2:2010.



TT: Test transformer

F: High voltage filter

L_s : Adjustable inductance

R: Resistor of 275Ω

M: measurement

TO: Test object

C_s : Coupling capacitance (1090 pF)

L: Low impedance inductance at 50 Hz

R_m : Resistor in parallel with the measuring equipment (50Ω)

Impedance between high voltage and earth ($Z_s + R_L$ according to CISPR 18-2)

Modulus:	337 Ω
Phase Angle:	15°
Measuring frequency:	0.6 MHz
Attenuation (measured with 1 V at 0.6 MHz), A:	0.78 dB
Resistors net factor, R:	21.5 dB/1 μ V/300 Ω

Ambient air conditions

Ambient temperature:	18.4 °C
Atmospheric pressure:	101.6 kPa
Relative humidity:	50.1 %

Results

The radio interference value obtained at $1.1 U_m/\sqrt{3}$ has been 800 μ V.

Result: **CORRECT**. The obtained value does not exceed the limit value given in the Standard.

5.13. TEMPERATURE RISE TEST

Test Method

The test is made to prove compliance with the requirements of the Standard and customer specifications.

For the purpose of this test, current transformer is deemed to have attained a steady temperature when the rate of temperature rise does not exceed 1 K per hour.

The temperature-rise of the current transformer when carrying the specified primary current, through the primary terminals, must not exceed the limits given in the in table 5 of IEC 61869-1 Standard.

The test-site ambient temperature shall be between 10 °C and 30 °C.

The secondary windings are loaded with their corresponding rated output.

The temperature rise of the windings is measured by the increase in resistance method.

The temperature-rise test on the primary terminals has been measured by thermocouples. The temperature-rise of parts other than windings has been also measured by thermocouples.

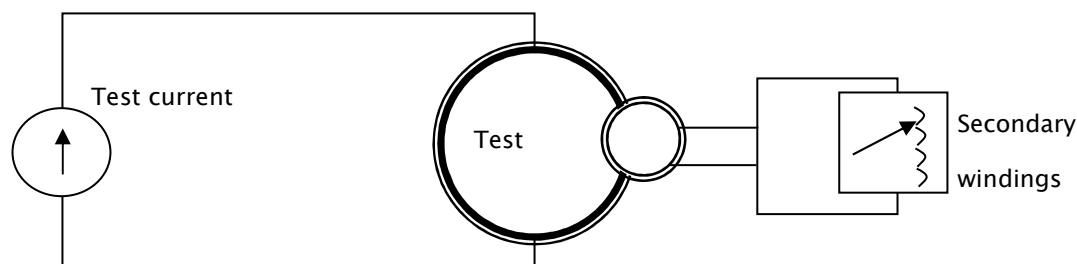
Test Parameters

The test has been performed at the maximum extended rated current of 2500A

The supply of the transformer has been performed using two aluminium plates of 1500 mm².

Test Arrangement

Test scheme:



Test Result

Part of transformer	Limited by	Limit	Temperature-rise
1S1-1S4 Secondary Winding	Winding average, hermetically sealed	65 K	56 K
2S1-2S2 Secondary Winding	Winding average, hermetically sealed	65 K	56 K
3S1-3S2 Secondary Winding	Winding average, hermetically sealed	65 K	56 K
4S1-4S2 Secondary Winding	Winding average, hermetically sealed	65 K	57 K
Primary terminal P1	Aluminium	50 K	43 K
Primary connection P1 busbar-terminal	Aluminium	50 K	43 K
Primary terminal P2	Aluminium	50 K	34 K
Primary connection P2 busbar-terminal	Aluminium	50 K	36 K
Primary supply busbar P2 at 1m	No limit	-	39 K
Primary supply busbar P1 at 1m	No limit	-	42 K
Oil expansion vessel	Top-oil hermetically sealed	55 K	23 K
External head enclosure	Other metallic parts in contact with oil	50 K	21 K
Ambient temperature 1	No limit	-	22 °C
Ambient temperature 2	No limit	-	23 °C

*The ambient temperature is shown in degrees

5.14. MECHANICAL TEST

Test Method

The instrument transformer is completely assembled, installed in a vertical position with the frame rigidly fixed.

Liquid-immersed instrument transformer is tested filled of its specific insulation medium and submitted to its rated operating pressure.

For each modality of application, the test load is increased smoothly within a period of 30s and 90s. When the value is reached, it will be maintained for at least 60s. During this time the deflection is measured. Then, the test load is smoothly released. and the residual deflection is measured again.

The instrument transformer is considered to have passed the test if no evidence of deformation, rupture or leakage is detected.

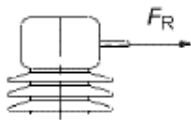
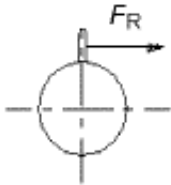
Test Parameters

The relevant test parameters have been:

- Force 3000 N (according to customer requirements)
- Duration 60 s

Test Arrangement

The following table show the modality of application of the test loads:

Modality of application	
Horizontal (X)	
Horizontal (Z)	
Vertical (Y)	

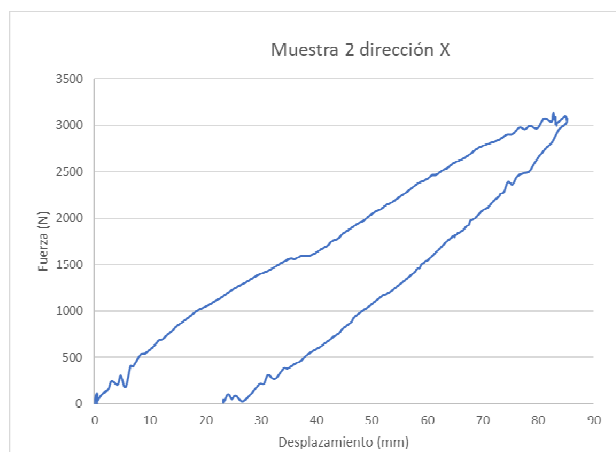
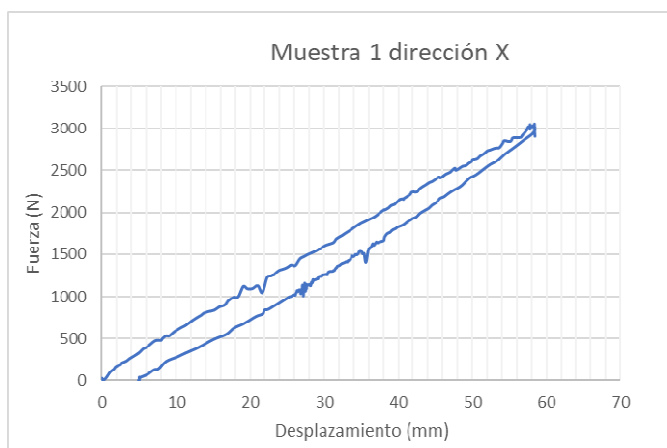
Test results

The following have been the obtained results.

Horizontal in X Direction

Description	Deflection terminal 1	Deflection terminal 2
During the test with 4000 N	58.4 mm	85.1 mm
Residual after the test	4.9 mm	23.2 mm

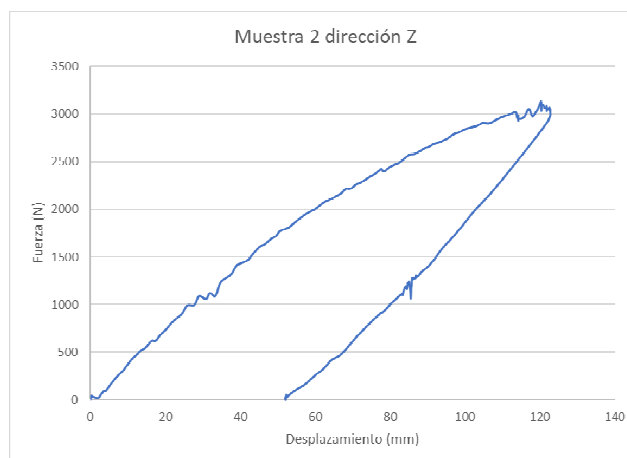
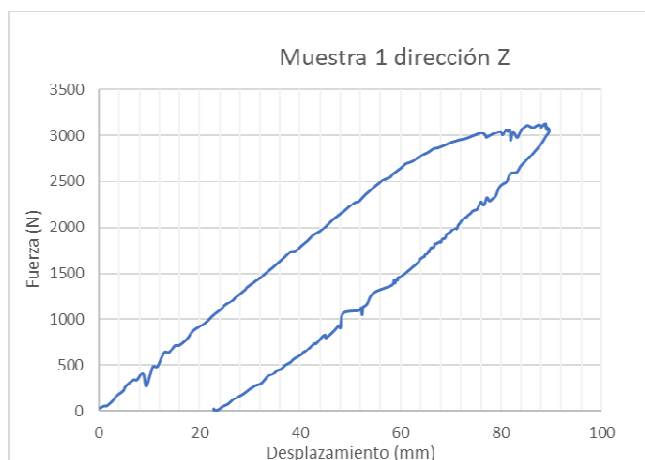
Graph 1. Force and deflection during the test



Horizontal in Z Direction

Description	Deflection terminal 1	Deflection terminal 2
During the test with 4000 N	89.7 mm	122.7 mm
Residual after the test	22.8 mm	51.9 mm

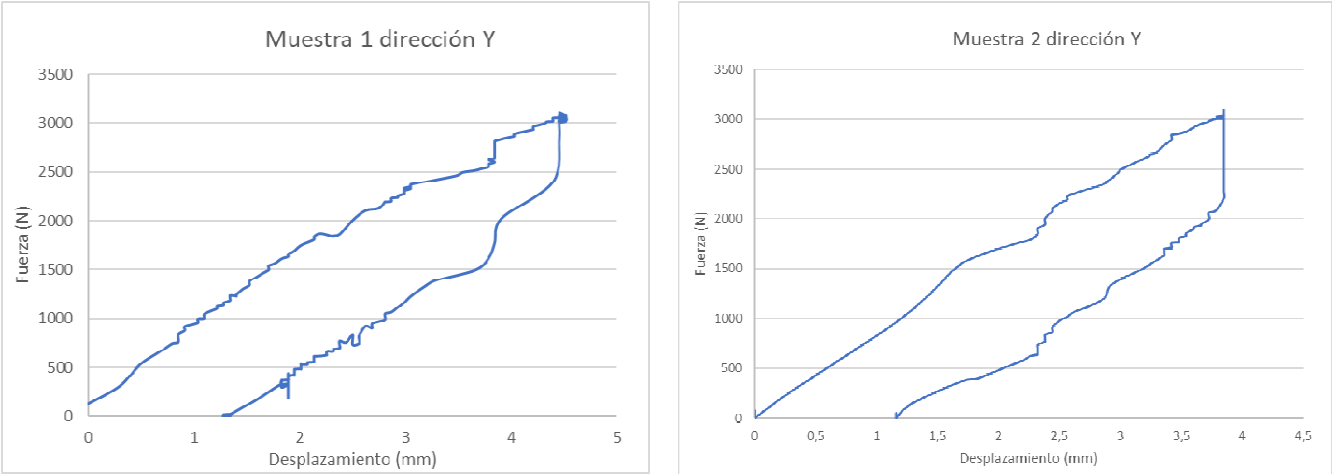
Graph 2. Force and deflection during the test



Vertical in Y Direction

Description	Deflection terminal 1	Deflection terminal 2
During the test with 4000 N	4.5 mm	3.9 mm
Residual after the test	1.3 mm	1.2 mm

Graph 3. Force and deflection during the test



Result. CORRECT. No evidence of deformation, rupture or leakage is detected.

6. ANNEX 1. PHOTOGRAPHS.

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MADE IN SPAIN

STROOMTRANSFORMATOR

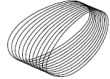
CA-123

Nr. 19011561 2019 IEC 61869-2:2012

Niv. Isol.: 123/230/550 kV Olie: NYNAS NYTRO 10XN

l_{pn}: 2000A l_{ct}: 125% f_N: 50Hz Oliegewicht: 40kg

l_{th}: 40kA 1s l_{dyn}: 100kA Temp. bereik: -25°/+40°C Gewicht totaal: 195kg



Sec.	1S1-1S4	1S1-1S3	1S1-1S2	2S1-2S2	3S1-3S2	4S1-4S2		
I _{pn} (A)	2000	1000	500	1500	1500	1500		
I _{sn} (A)	1	1	1	1	1	1		
VA	1-5	1-5	1-5	10	10	10		
Klasse	0.2S	0.2S	0.2S	5PR	5PR	5PR		
SF-ALF	7	7	5	80	60	60		
I _{ct} (%)	125	150	150	167	167	167		
I _{ext} (%)	125	130	130					
R _{ct} (Ohm)<	10	4.31	2.5	9.22	8.25	8.25		
Load klasse II						5PR: Ts=400ms		

Usat (V): 1S1-1S4: 86V, 1S1-1S3: 43V, 1S1-1S2: 21.5V

BELANGRIJK: HERMETISCH GESLOTEN UNIT. NIET OPENEN

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MADE IN SPAIN

TRANSFORMATEUR DE COURANT

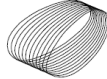
CA-123

N° 19011561 2019 IEC 61869-2:2012

Niv. Isol.: 123/230/550 kV Huile: NYNAS NYTRO 10XN

l_{pn}: 2000A l_{ct}: 125% f_N: 50Hz Poids Huile: 40kg

l_{th}: 40kA 1s l_{dyn}: 100kA Plage temp.: -25°/+40°C Poids Total: 195kg



NOYAU	1S1-1S4	1S1-1S3	1S1-1S2	2S1-2S2	3S1-3S2	4S1-4S2		
I _{pn} (A)	2000	1000	500	1500	1500	1500		
I _{sn} (A)	1	1	1	1	1	1		
VA	1-5	1-5	1-5	10	10	10		
Classe	0.2S	0.2S	0.2S	5PR	5PR	5PR		
FS-FLP	7	7	5	80	60	60		
I _{ct} (%)	125	150	150	167	167	167		
I _{ext} (%)	125	130	130					
R _{ct} (Ohm)<	10	4.31	2.5	9.22	8.25	8.25		
Classe de charge II						5PR: Ts=400ms		

Usat (V): 1S1-1S4: 86V, 1S1-1S3: 43V, 1S1-1S2: 21.5V

IMPORTANT: ÉTANCHÉITÉ TOTALE. NE PAS DÉMONTÉ

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Rating plate



Test Object



Combined chopped Lightning Impulse test



Wet test



Test for accuracy



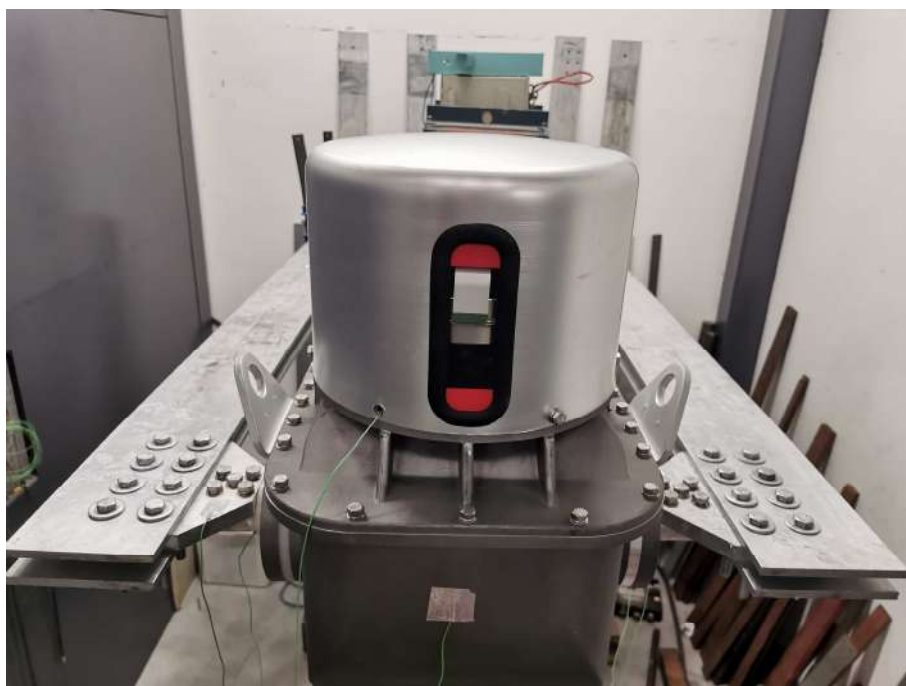
Short circuit withstand capability test



Power frequency and partial discharge test



Temperature rise test



Thermocouples on primary terminals at temperature rise test



RIV test

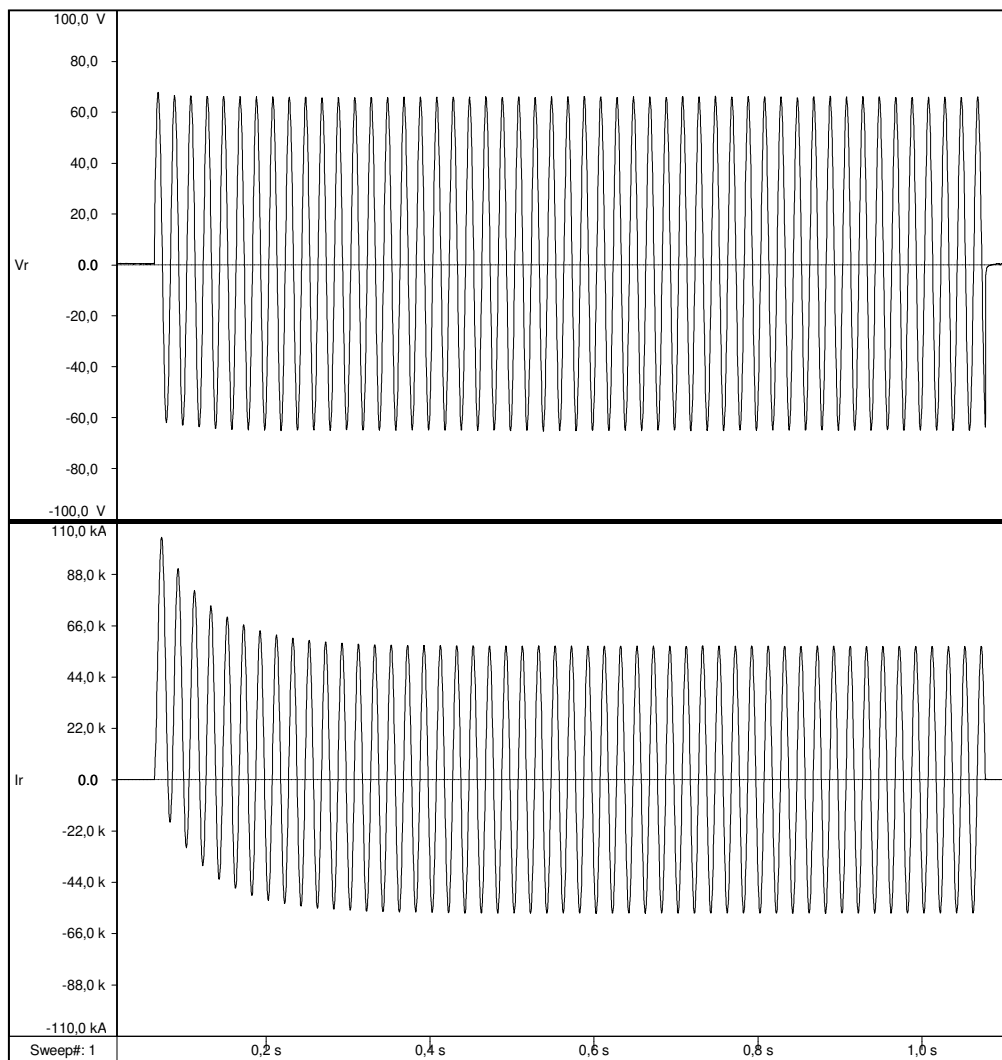


Mechanical test

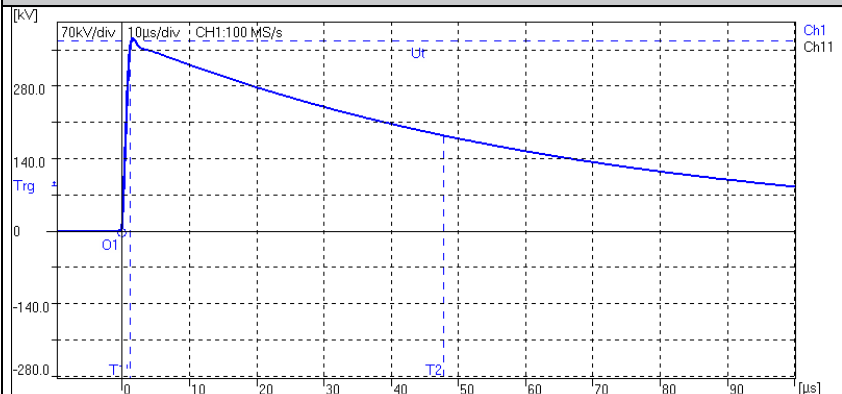
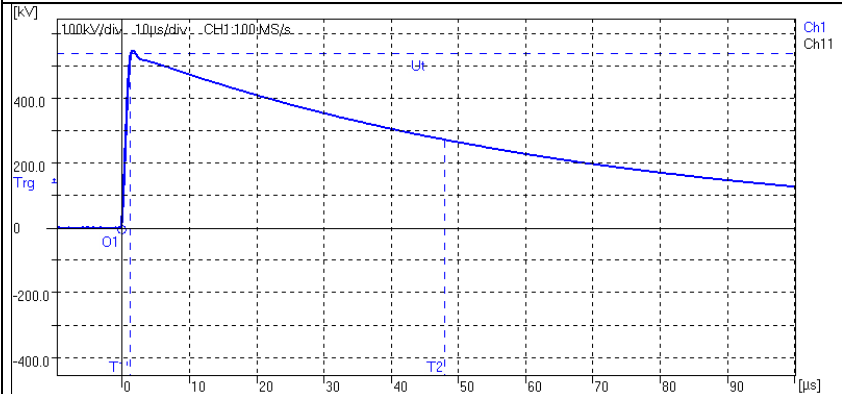
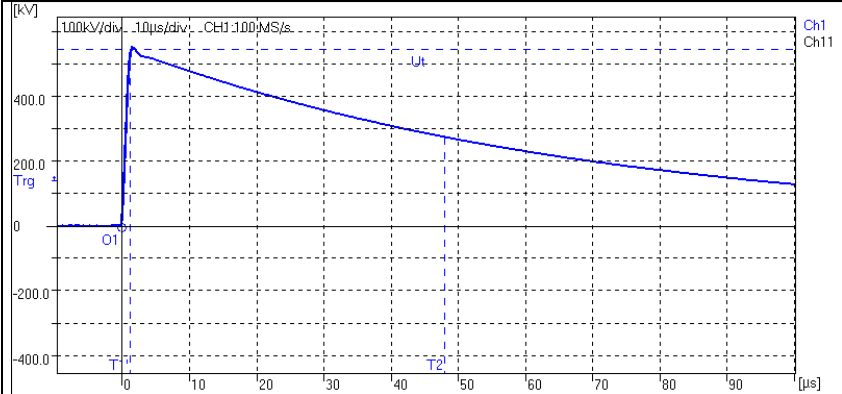
7. ANNEX 2. OSCILLOGRAMS.

Date: 02/10/2020
Osc. no: B26-20-BZ 057

V_r	45,85 V
I_r (rms)	40,53 kA
I_r (peak)	104,0 kA
t_r	1,012 s
$I_r^2 t$	1,76E+09 AAs



8. ANNEX 3. IMPULSE WAVESHAPES.

PICTURES	
	Fig.: 1 $U_t = 370,514 \text{ kV}$ $T_1 = 1,229 \text{ µs}$ $T_2 = 47,809 \text{ µs}$ $T_c = \text{µs}$
Comment: 63.64% LI RW 	Fig.: 2 $U_t = 545,097 \text{ kV}$ $T_1 = 1,228 \text{ µs}$ $T_2 = 48,007 \text{ µs}$ $T_c = \text{µs}$
Comment: 100% LI FW 	Fig.: 3 $U_t = 550,125 \text{ kV}$ $T_1 = 1,236 \text{ µs}$ $T_2 = 47,998 \text{ µs}$ $T_c = \text{µs}$
Comment: 100% LI FW	

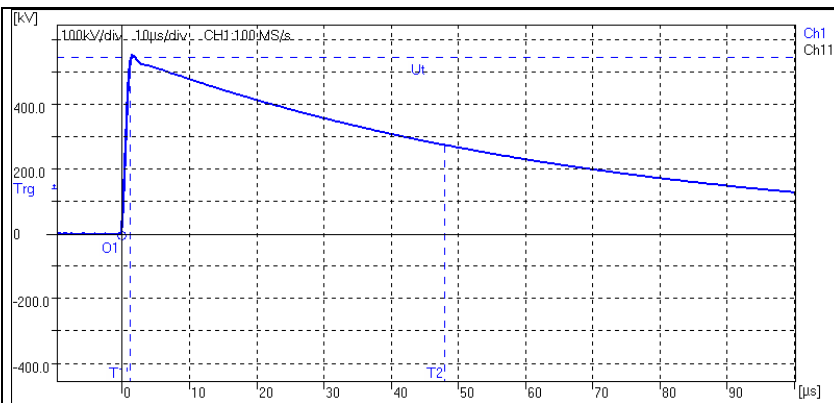


Fig.: 4

 $U_t = 549,993 \text{ kV}$
 $T_1 = 1,234 \text{ μs}$
 $T_2 = 47,989 \text{ μs}$
 $T_c = \text{μs}$

Comment: 100% LI FW

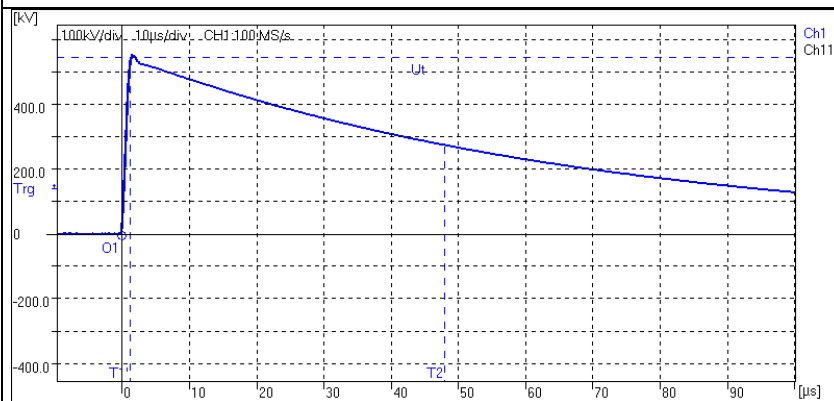


Fig.: 5

 $U_t = 549,395 \text{ kV}$
 $T_1 = 1,231 \text{ μs}$
 $T_2 = 48,001 \text{ μs}$
 $T_c = \text{μs}$

Comment: 100% LI FW

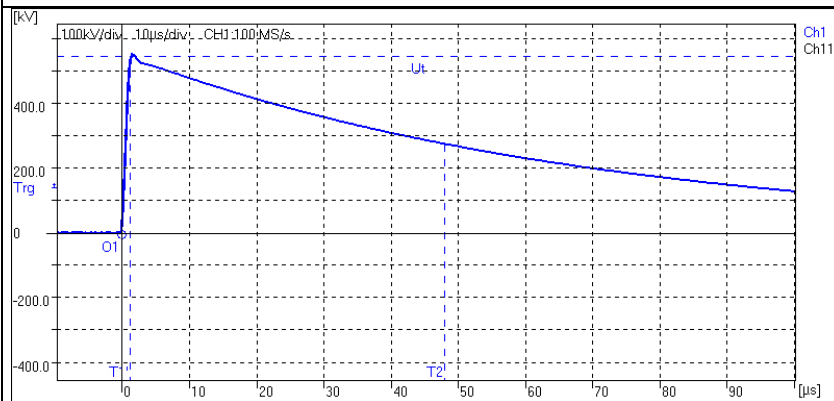


Fig.: 6

 $U_t = 549,928 \text{ kV}$
 $T_1 = 1,235 \text{ μs}$
 $T_2 = 48,030 \text{ μs}$
 $T_c = \text{μs}$

Comment: 100% LI FW

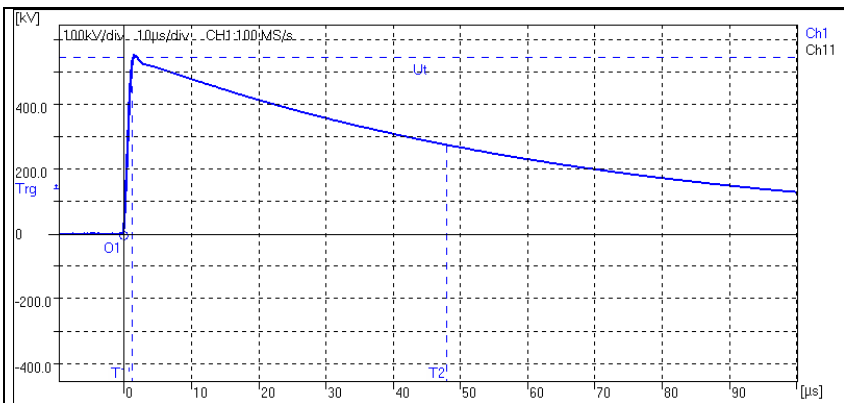


Fig.: 7
 $U_t = 550,114 \text{ kV}$
 $T_1 = 1,232 \text{ } \mu\text{s}$
 $T_2 = 48,046 \text{ } \mu\text{s}$
 $T_c = \text{ } \mu\text{s}$

Comment: 100% LI FW

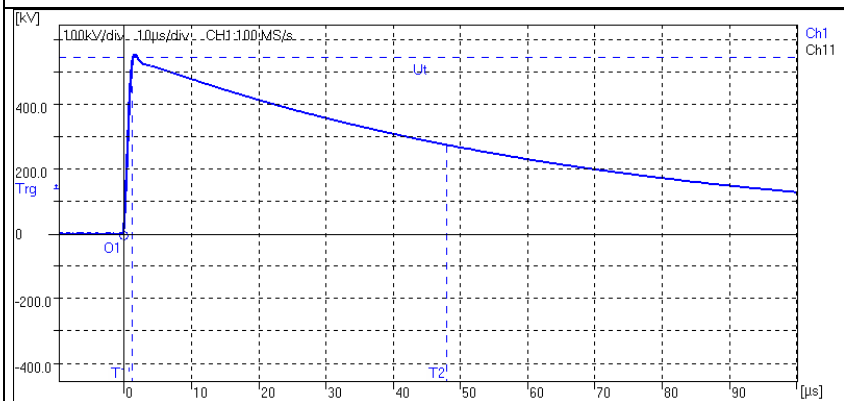


Fig.: 8
 $U_t = 549,933 \text{ kV}$
 $T_1 = 1,231 \text{ } \mu\text{s}$
 $T_2 = 48,032 \text{ } \mu\text{s}$
 $T_c = \text{ } \mu\text{s}$

Comment: 100% LI FW

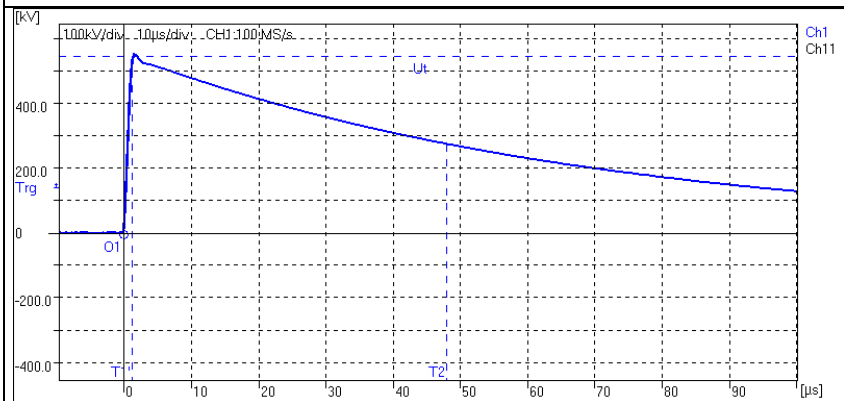


Fig.: 9
 $U_t = 550,120 \text{ kV}$
 $T_1 = 1,236 \text{ } \mu\text{s}$
 $T_2 = 48,069 \text{ } \mu\text{s}$
 $T_c = \text{ } \mu\text{s}$

Comment: 100% LI FW

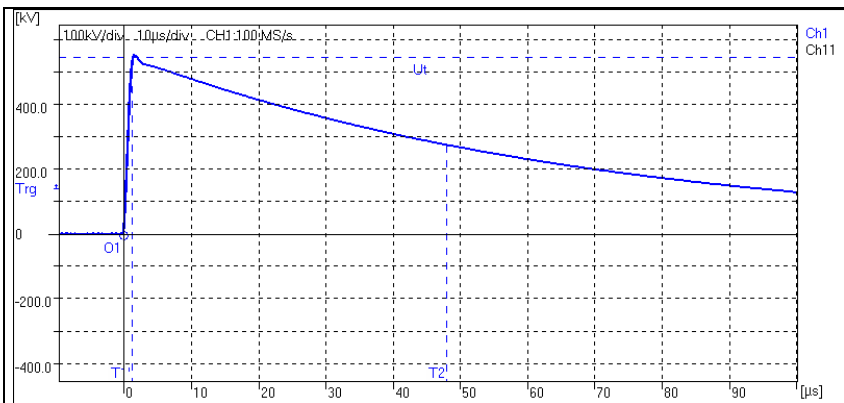


Fig.: 10

$U_t = 550,201 \text{ kV}$

$T_1 = 1,230 \text{ μs}$

$T_2 = 48,035 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

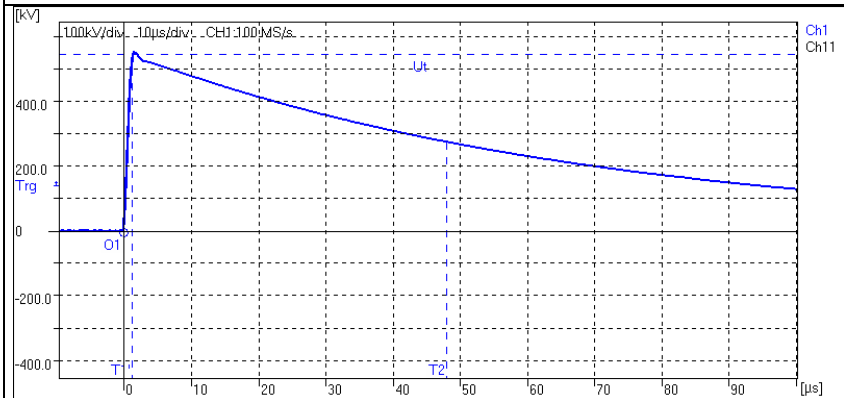


Fig.: 11

$U_t = 550,240 \text{ kV}$

$T_1 = 1,236 \text{ μs}$

$T_2 = 48,057 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

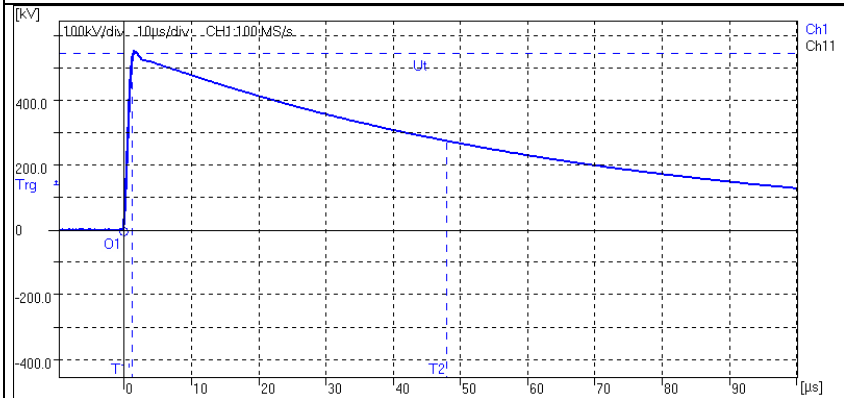


Fig.: 12

$U_t = 549,676 \text{ kV}$

$T_1 = 1,238 \text{ μs}$

$T_2 = 48,059 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

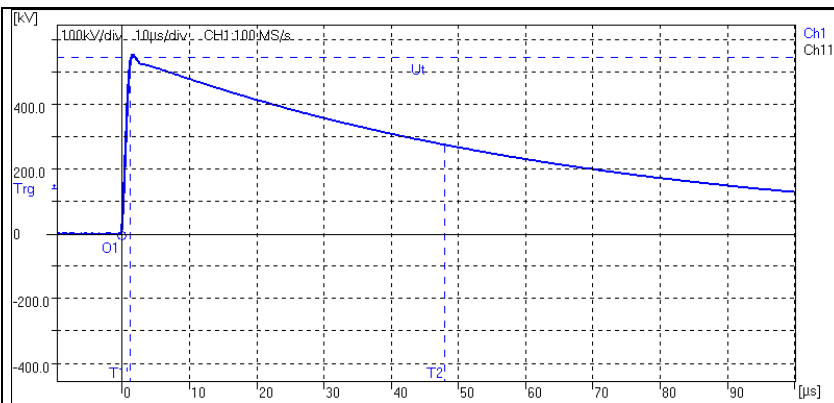


Fig.: 13

 $U_t = 550,251 \text{ kV}$ $T_1 = 1,237 \text{ μs}$ $T_2 = 48,078 \text{ μs}$ $T_c = \text{μs}$

Comment: 100% LI FW

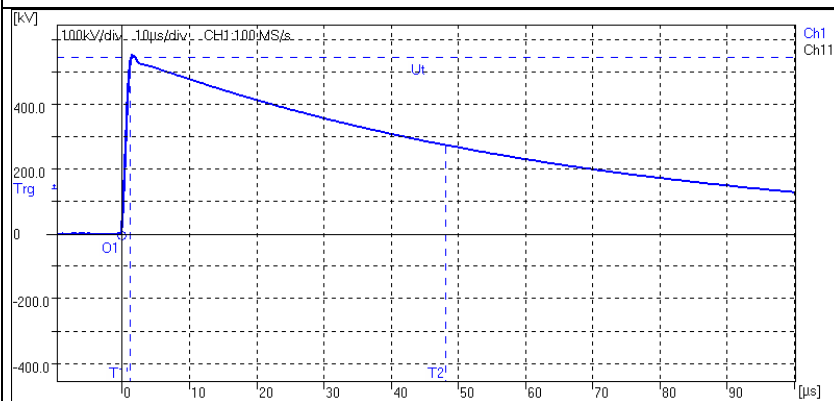


Fig.: 14

 $U_t = 549,682 \text{ kV}$ $T_1 = 1,237 \text{ μs}$ $T_2 = 48,102 \text{ μs}$ $T_c = \text{μs}$

Comment: 100% LI FW

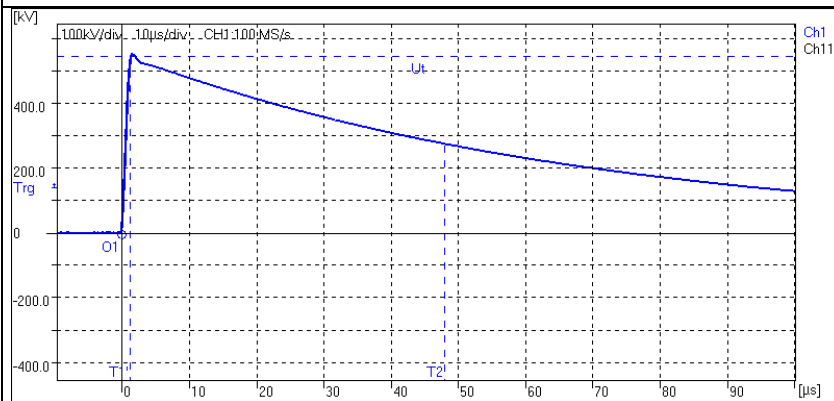


Fig.: 15

 $U_t = 550,050 \text{ kV}$ $T_1 = 1,232 \text{ μs}$ $T_2 = 48,088 \text{ μs}$ $T_c = \text{μs}$

Comment: 100% LI FW

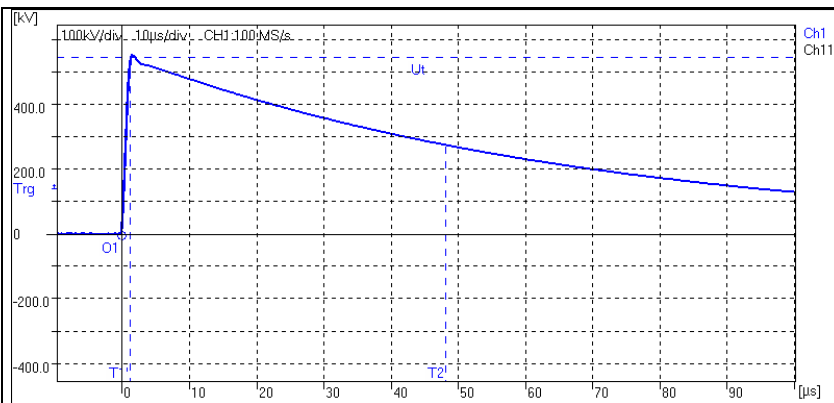


Fig.: 16

$U_t = 550,052 \text{ kV}$

$T_1 = 1,236 \text{ μs}$

$T_2 = 48,101 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

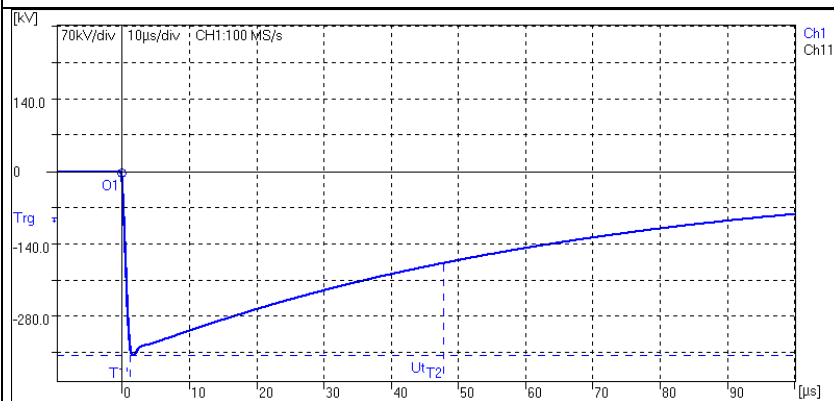


Fig.: 17

$U_t = -354,099 \text{ kV}$

$T_1 = 1,233 \text{ μs}$

$T_2 = 47,907 \text{ μs}$

$T_c = \text{μs}$

Comment: 63.64% LI RW

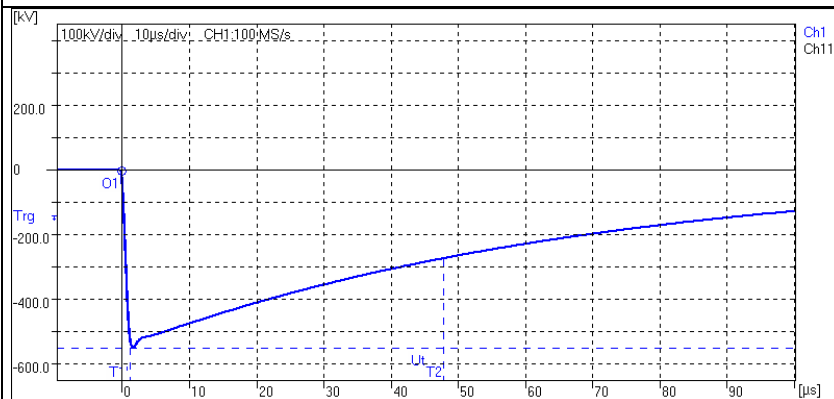


Fig.: 18

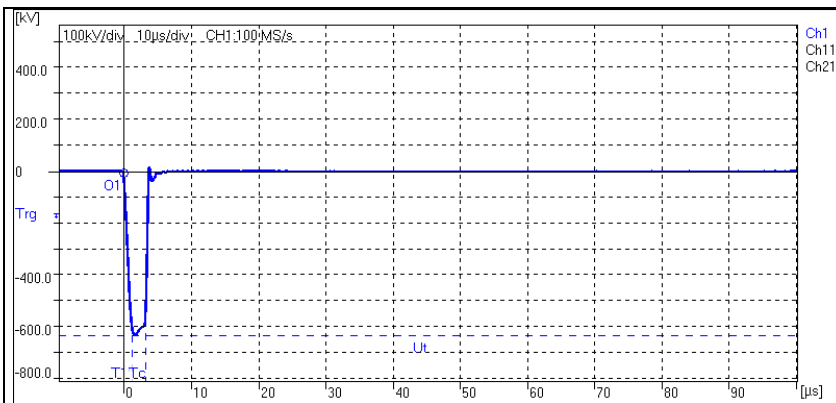
$U_t = -545,721 \text{ kV}$

$T_1 = 1,231 \text{ μs}$

$T_2 = 47,928 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW



Comment: 115.09% LI CFW

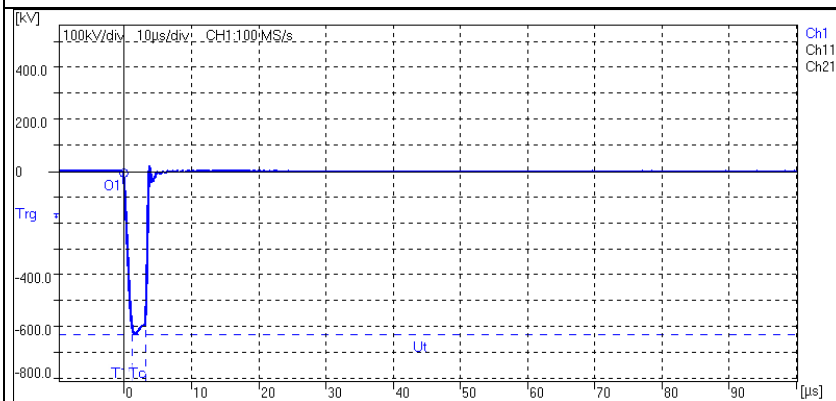
Fig.: 19

$U_t = -631,150 \text{ kV}$

$T_1 = 1,240 \text{ } \mu\text{s}$

$T_2 = \text{ } \mu\text{s}$

$T_c = 3,258 \text{ } \mu\text{s}$



Comment: 115.09% LI CFW

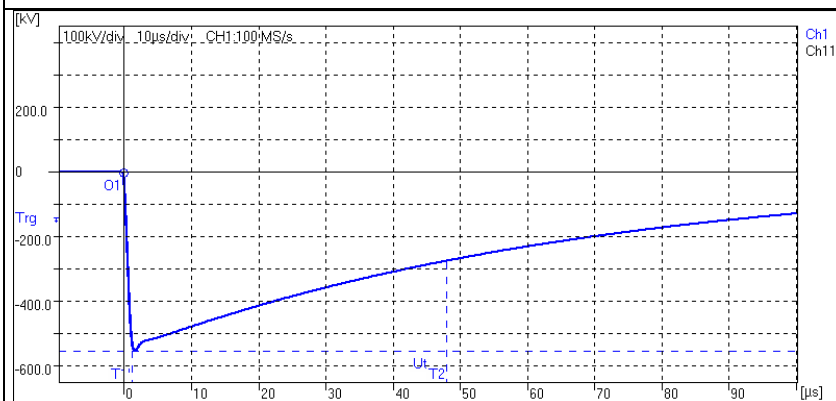
Fig.: 20

$U_t = -626,915 \text{ kV}$

$T_1 = 1,242 \text{ } \mu\text{s}$

$T_2 = \text{ } \mu\text{s}$

$T_c = 3,289 \text{ } \mu\text{s}$



Comment: 100% LI FW

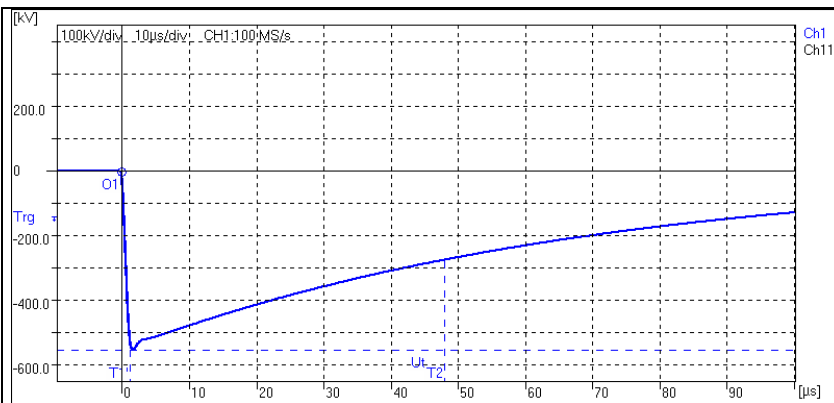
Fig.: 21

$U_t = -549,965 \text{ kV}$

$T_1 = 1,231 \text{ } \mu\text{s}$

$T_2 = 47,955 \text{ } \mu\text{s}$

$T_c = \text{ } \mu\text{s}$



Comment: 100% LI FW

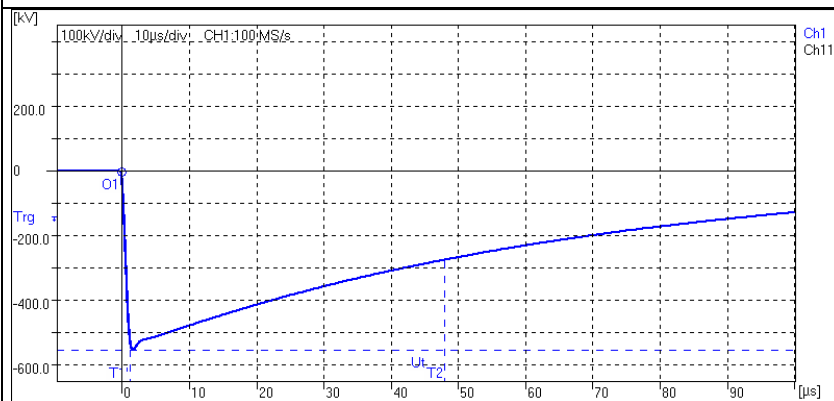
Fig.: 22

$U_t = -549,522 \text{ kV}$

$T_1 = 1,230 \text{ μs}$

$T_2 = 47,965 \text{ μs}$

$T_c = \text{μs}$



Comment: 100% LI FW

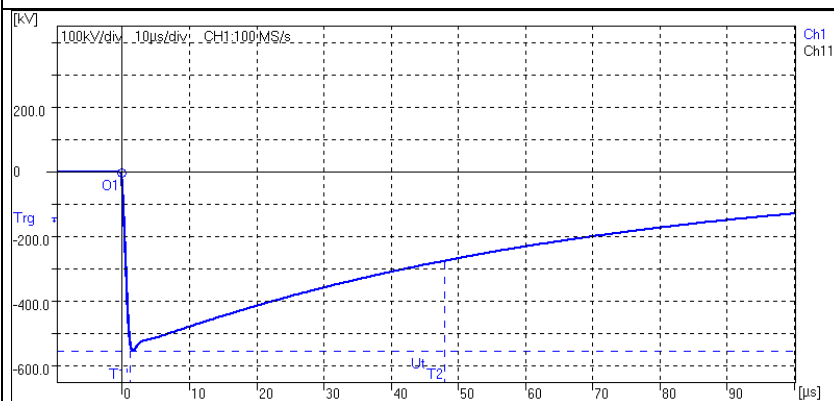
Fig.: 23

$U_t = -549,664 \text{ kV}$

$T_1 = 1,228 \text{ μs}$

$T_2 = 47,960 \text{ μs}$

$T_c = \text{μs}$



Comment: 100% LI FW

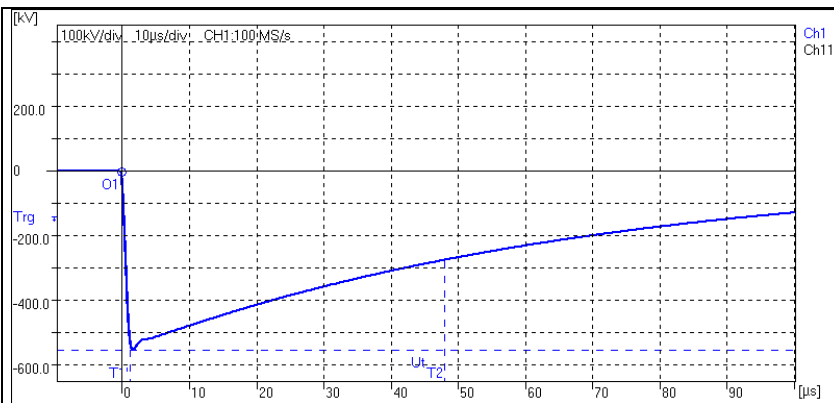
Fig.: 24

$U_t = -549,983 \text{ kV}$

$T_1 = 1,232 \text{ μs}$

$T_2 = 47,983 \text{ μs}$

$T_c = \text{μs}$



Comment: 100% LI FW

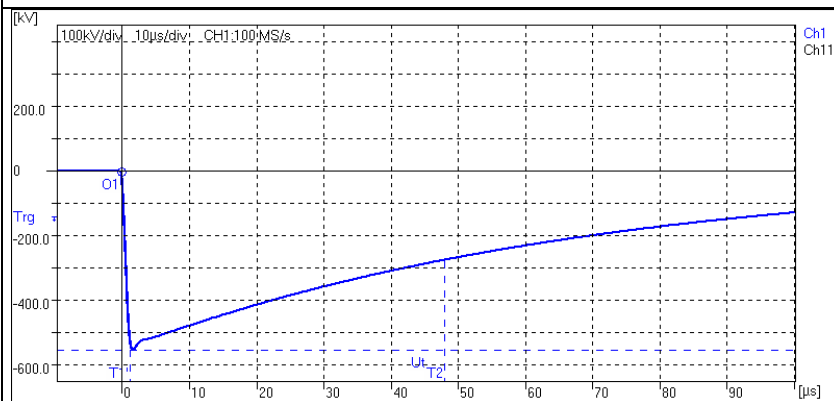
Fig.: 25

$U_t = -550,157 \text{ kV}$

$T_1 = 1,234 \text{ μs}$

$T_2 = 47,989 \text{ μs}$

$T_c = \text{μs}$



Comment: 100% LI FW

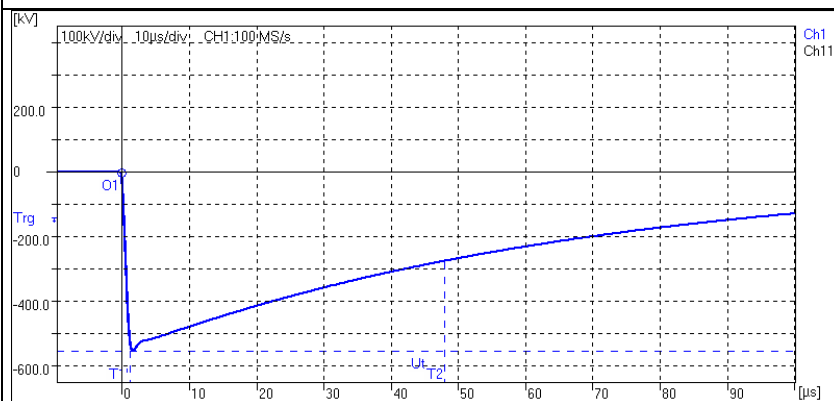
Fig.: 26

$U_t = -550,102 \text{ kV}$

$T_1 = 1,232 \text{ μs}$

$T_2 = 47,948 \text{ μs}$

$T_c = \text{μs}$



Comment: 100% LI FW

Fig.: 27

$U_t = -550,249 \text{ kV}$

$T_1 = 1,231 \text{ μs}$

$T_2 = 47,959 \text{ μs}$

$T_c = \text{μs}$

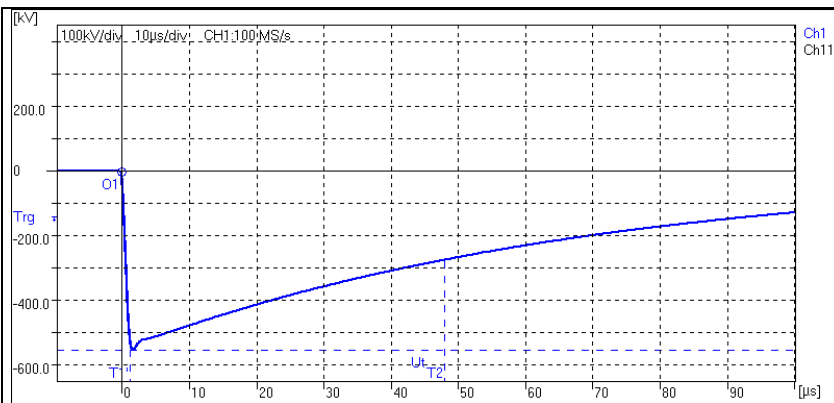


Fig.: 28

$U_t = -549,449 \text{ kV}$

$T_1 = 1,228 \text{ μs}$

$T_2 = 48,002 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

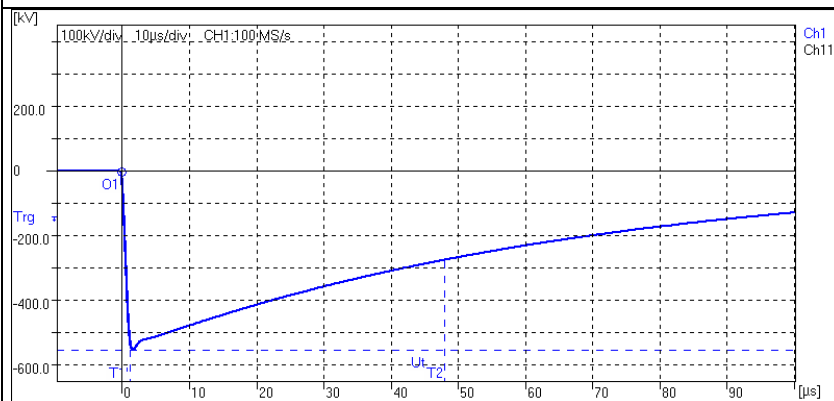


Fig.: 29

$U_t = -549,858 \text{ kV}$

$T_1 = 1,234 \text{ μs}$

$T_2 = 47,979 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

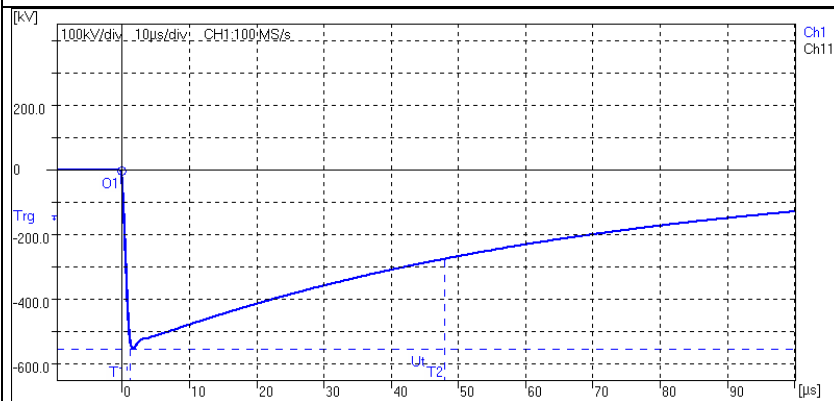


Fig.: 30

$U_t = -550,052 \text{ kV}$

$T_1 = 1,229 \text{ μs}$

$T_2 = 48,029 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

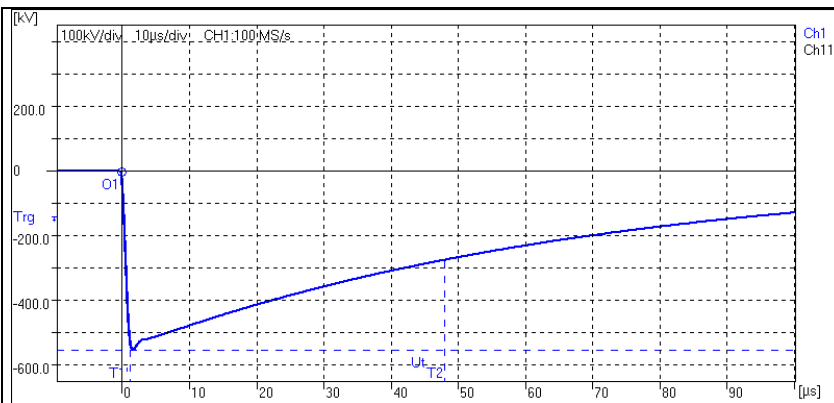


Fig.: 31

$U_t = -549,875 \text{ kV}$

$T_1 = 1,233 \text{ μs}$

$T_2 = 48,005 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

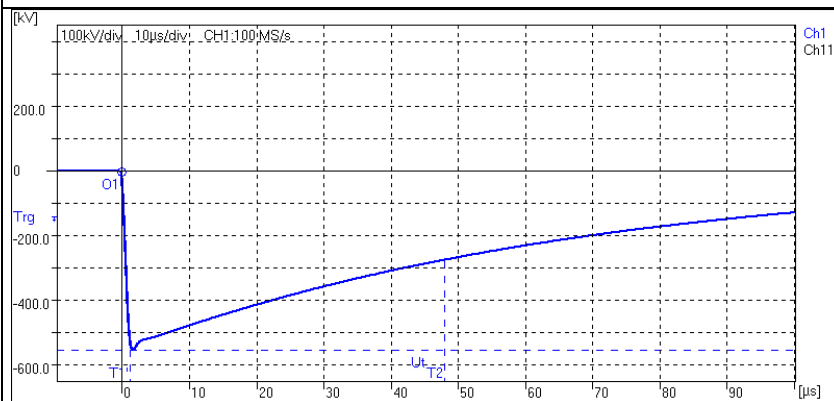


Fig.: 32

$U_t = -549,467 \text{ kV}$

$T_1 = 1,226 \text{ μs}$

$T_2 = 47,990 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW

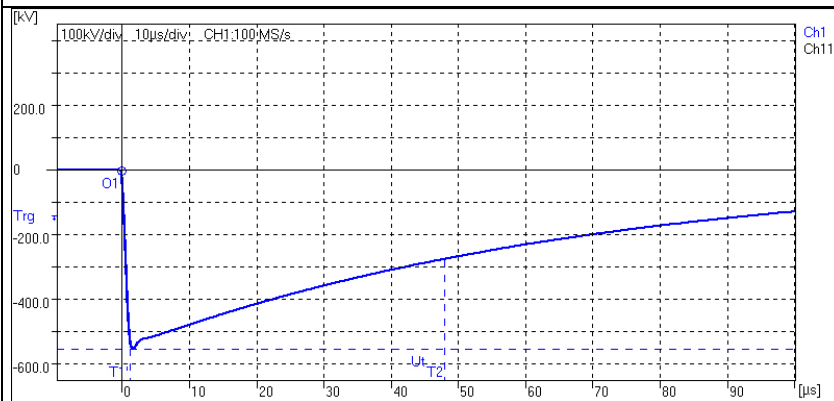


Fig.: 33

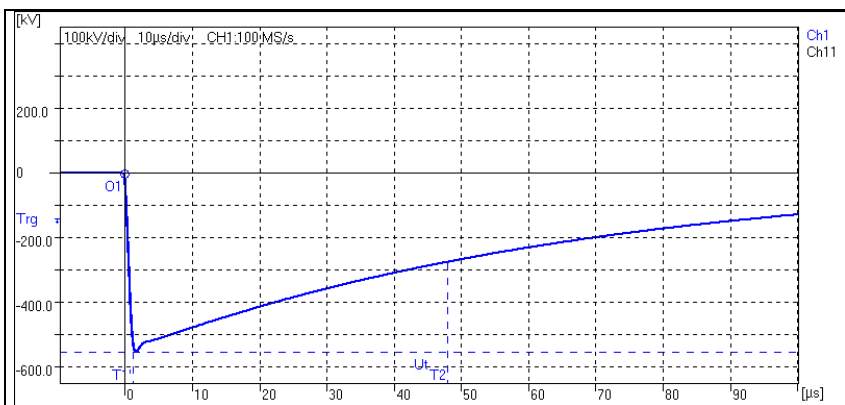
$U_t = -550,508 \text{ kV}$

$T_1 = 1,228 \text{ μs}$

$T_2 = 48,014 \text{ μs}$

$T_c = \text{μs}$

Comment: 100% LI FW



Comment: 100% LI FW

Fig.: 34

$U_t = -549,669 \text{ kV}$

$T_1 = 1,230 \text{ μs}$

$T_2 = 48,014 \text{ μs}$

$T_c = \text{μs}$