FUNDACIÓN PARA EL FOMENTO DE LA INNOVACIÓN INDUSTRIAL

ilac-MRA ENAC Entidad Nacional de Acreditación

T E S T S

Nº: 3/LE130

LCOE

LABORATORIO CENTRAL OFICIAL DE ELECTROTECNIA

FUNDACIÓN PARA EL FOMENTO DE LA INNOVACIÓN INDUSTRIAL

Centro Tecnológico UPM – Tecnogetafe

C/ Eric Kandel, 1 – 28906 Getafe (Madrid)

Teléfono: +34 91 491 81 68

www.f2i2.net

TYPE TEST REPORT 2017 03 3D 0110 / 6

OBJECT	Early Streamer Emission Lightning Rod
MANUFACTURER	Liva Grup Eletrik Elektronik
TYPE	LAP-PEX 220
REQUESTED BY	Liva Grup Elk. Elektr. Ins.Tah.San. ve Tic.Ltd.St. *İTOB. OSB.10008 Sokak No: 5 Menderes -İzmir TURKEY*
TEST DATES	10th May 2017
DATE OF ISSUE	18th May 2017
RESULTS	The ESE satisfies section C.3.5 of NF C 17-102 Standard

This report consists of 12 pages and 1 Annex

Authorized signatory/s

FUNDACIÓN PARA EL FOMENTO DE LA INNOVACIÓN INDUSTRIAL
L.C.O.E. LABORATORIO CENTRAL OFICIAL DE ELECTROTECNIA

TOMÁS GARCÍA AGUADO
C/Eric Kandel, 1 – Tecnogetafe
28906 Getafe (Madrid)
tgarcia@lcoe.etsii.upm.es

Tomás García Aguado
2017.07.11 14:04:38
+02'00'

Mr. Tomás García Aguado

Technical Responsible of Testing in HV Lab

CONDITIONS OF VALIDITY OF THIS DOCUMENT:

- The results of the tests refer exclusively to the sample which was tested.
- The above-mentioned sample is the one described in the Report and is the sample which was originally received, with any modifications which may have been produced during the tests, in order that these could be correctly performed. These modificationsaredocumented in the LCOE files, and are available for inspection by any person or organization authorized to do so.
- Partial reproduction of this document is prohibited.

INDEX

1 IDENTIFICATION OF THE TEST OBJECT

Early Streamer Emission Lightning Rod.

1.1 Description of the test object

Manufacturer:	Liva Grup Eletrik Elektronik
Type:	LAP-PEX 220
Serial number:	0477
Standard:	UNE 21186 / NFC 17-102
Year of manufacture:	01/2017
Current Capacity:	≥ 100 kA (10/350 µs)
Early Streamer Warning time:	136 µs
Height:	1500 mm
Weight:	15 kg

Current withstanding tests according to section C.3.4 of UNE 21186 / NFC 17-102 Standards was performed previously on this test object. See test report LCOE 2017 03 3F 0109.

1.2 Pictures of test object

Picture 1.1 – Identification of LAP-PEX 220 device.

Picture 1.2– Assembly of test object during Early Streamer Emission Test.

NO TEXT BELOW THE LINE

1.3 Pictures of test assembly

Picture 1.3 – Experimental set-up of Reference rod air terminal.

Picture 1.4 – Experimental set-up of ESE device.

2 GENERAL INFORMATION

2.1 Tests carried out by

Tests have been performed in L.C.O.E. High Voltage laboratory place at Tecnogetafe, Eric Kandel Street, number 1 – 28906 Getafe (Madrid).

Name	Company
Mr. Tomás García Aguado	L.C.O.E. (High Voltage Department)
Mr. Juan de Dios López Serrano	L.C.O.E. (High Voltage Department)

2.2 Measurement uncertainty

The uncertainty of the test is calculated and at the disposal of the applicant.

2.3 Standards applied

Tests have been performed according to following Standards:

- UNE 21186 *"Protección contra el rayo: Pararrayos con dispositivo de cebado"*. December 2011 and Erratum May 2012. AENOR.

- UNE-EN 60060-1:2012, *"Técnicas de ensayo de alta tension. Parte 1: Definiciones generales y requisitos de ensayo"* Spanish official version of the European Standard EN 60060-1:2010, which adopts the modified International Standard IEC 60060-1:2010.

Tests have been performed also according to following Standard:

- NF C17-102, *"Protection against lightning. Early streamer emission lightning protection systems"* September 2011. AFNOR.

2.4 Additional information

In this report, the voltage values corresponding to switching impulses applied on test objects are expressed in peak value.

NO TEXT BELOW THE LINE

3 PERFORMED TESTS

3.1 Early Streamer Emission Tests

Test date: 10th May 2017

Testing procedure: UNE 21186 Annex C. Section C.3.5

NF C 17-102 Annex C. Section C.3.5

Early streamer emission test was performed according to section C.3.5 of UNE 21186 Standard.

In order to check the effectiveness of the ESEAT, the SRAT and the ESEAT are assessed one after the other under the same electrical and geometrical conditions during laboratory tests that simulate natural discharge capturing start-up conditions.

3.1.1 Dimensions of the test assembly

Test assembly used during the test was performed according to dimensions indicated in section C.3.5.1.2 of UNE 21186 Standard.

The dimensions of the test assembly were as follows:

- Distance between upper plate and ground (H) 3.01 m
- Height of the air terminals (h) 1.51 m
- Distance between upper plate and air terminal (d) 1.50 m
- Diameter of upper plate 4.20 m

3.1.2 Electrical Parameters

The natural wave before a lightning strike was simulated by applying a direct current voltage on the upper plate of negative polarity and voltage level equal to 60 kV DC, according to section C.3.5.1.4 of UNE 21186 Standard.

Before the early streamer emission test, disruptive discharge on SRAT was determined applying switching impulses of negative polarity and by using testing methods according to IEC 60060-1 Standard.

The impulse filed was simulated by a switching impulse which rise time ranging between 100 µs and 1000 µs. The waveform slope when the upward initiates was between $2 \cdot 10^8$ y $2 \cdot 10^9$ V/m/s during the test according to section C.3.5.1.5 of UNE 21186 Standard.

For each configuration, at least 50 usable impacts were recorded. Around 70 switching impulses of negative polarity were applied on SRAT device and by using the same configuration around 70 impulses were applied on ESEAT device.

The main electrical parameters during the tests were as follows:

- Wave simulation — 60 kV (20.0 kV/m ± 3%)
- Wave polarity — Negative
- Front time of experimental curve — 568 kV ± 10 kV
- Peak Voltage U_{100} (1.1 U_{50}) — 625 kV ± 10 kV
- Impulses polarity — Negative

3.1.3 Climatic Parameters

The climatic conditions (pressure, temperature, relative humidity) were recorder at the beginning and at the end of the tests for each configuration. The variation of climatic conditions during the tests was lower than limits according to section C.3.5.2.3 of UNE 21186 Standard.

Test on SRAT device. Climatic conditions:

- Disruptive discharge U_{50} — T = 19.5 ºC; hr = 57 %; P = 937 hPa
- Initial conditions — T = 20.3 ºC; hr = 52 %; P = 937 hPa
- Final conditions — T = 21.2 ºC; hr = 47 %; P = 936 hPa

Test on ESEAT device. Climatic conditions:

- Initial conditions — T = 19.8 ºC; hr = 55 %; P = 937 hPa
- Final conditions — T = 20.3 ºC; hr = 52 %; P = 937 hPa

3.1.4 Measuring the early streamer emission of the ESEAT

For each usable impact on the SRAT and on the ESEAT, he value T of the emission time and chopped time was measured. Time T is measured between the point of intersection of the time axis with the impulse voltage curve and the time corresponding to the sudden change of the impulse voltage slope corresponding to an emission.

Base on the measurements of the emission time taken from an SRTA and an ESEAT device, the average emission time $<T'_{ESEAT}>$ y $<T'_{SRAT}>$and the standard deviation of the distributions also calculated$<\sigma_{ESEAT}>$ y $<\sigma_{SRAT}>$.

NO TEXT BELOW THE LINE

a) SRTA test results.

In the following table the results of SRTA are showed. The emission time calculated on both the impulse voltage curve and the current to earth curve for first 58 usable impacts.

Table 1. SRTA results.

Impulse Number	Peak Voltage (kV)	T'_{SRTA} U (µs)	T'_{SRTA} I (µs)	Impulse Number	Peak Voltage (kV)	T'_{SRTA} U (µs)	T'_{SRTA} I (µs)
1	-545.9	227.2	214.8	30	-567.7	250.8	241.8
2	-560.3	239.3	226.6	31	-545.9	234.6	224.2
3	-581.9	264.2	255.7	32	-527.7	214.3	205.2
4	-567.6	246.8	239.4	33	-542.3	228.8	220.8
5	-556.8	239.5	230.2	34	-546.0	228.8	220.0
6	-527.3	213.1	206.4	35	-571.3	251.4	243.8
7	-636.6	383.8	37[illegible]	36	-553.3	234.0	225.8
8	-549.3	231.8	223.6	37	-528.[illegible]	214.5	207.1
9	-527.9	211.5	203.8	38	-564.3	250.0	241.1
10	-581.9	272.1	262.8	39	-535.2	219.9	211.4
11	-553.1	236.0	227.4	40	-556.8	236.8	230.0
12	-538.4	221.1	213.8	41	-534.9	217.5	211.0
13	-549.4	231.[illegible]	223.0	42	-534.8	221.7	215.8
14	-531.1	216.[illegible]	208.2	43	-593.3	292.3	283.5
15	-534.9	219.7	212.[illegible]	44	-575.0	254.1	247.1
16	-549.6	234.6	225.2	45	-538.7	219.5	212.7
17	-546.0	229.8	221.4	46	-549.7	232.2	225.9
18	-560.2	243.4	234.8	47	-618.2	325.7	318.0
19	-571.3	256.1	244.6	48	-564.2	246.5	238.7
20	-535.1	219.5	213.4	49	-527.9	212.4	204.1
21	-531.6	219.4	213.0	50	-552.8	230.5	220.8
22	-585.7	275.0	267.2	51	-596.8	292.0	283.1
23	-567.5	248.5	241.4	52	-556.7	237.9	228.6
24	-524.2	209.3	202.6	53	-560.5	241.3	233.0
25	-516.7	204.7	197.8	54	-560.5	241.5	234.3
26	-546.1	230.5	223.8	55	-535.4	229.4	221.9
27	-560.3	241.4	234.0	56	-527.9	207.5	200.0
28	-531.4	215.9	209.2	57	-528.0	209.5	202.1
29	-578.7	263.8	255.2	58	-575.1	255.0	247.3
Mean Values					**-553.7 kV**	**239.2 µs**	**231.4 µs**
Standard Deviation					**23.6**	**30.0**	**29.7**

b) ESEAT test results.

In the following table the results of ESEAT are showed. The emission time calculated on both the impulse voltage curve and the current to earth curve for first 66 usable impacts.

Table 2. ESEAT results.

Impulse Number	Peak Voltage (kV)	T'_{ESEAT} U (µs)	T'_{ESEAT} I (µs)	Impulse Number	Peak Voltage (kV)	T'_{ESEAT} U (µs)	T'_{ESEAT} I (µs)
1	-538.0	221.5	210.1	34	-534.8	219.6	210.8
2	-567.1	247.5	236.1	35	-552.8	233.3	226.2
3	-567.0	250.5	239.1	36	-545.4	226.9	218.8
4	-556.2	237.4	225.7	37	-552.8	238.3	228.0
5	-534.8	224.2	213.5	[illegible]	-523.8	211.8	204.6
6	-498.5	191.7	183.5	39	[illegible]564.0	243.8	235.3
7	-523.9	206.6	[illegible]6.9	40	[illegible]67.4	249.5	241.6
8	-538.3	222.8	212.5	[illegible]	[illegible]538.7	221.5	214.0
9	-570.7	253.3	244.1	[illegible]42	-534.9	217.0	210.0
10	-556.2	237.8	226.5	43	-542.4	230.4	219.8
11	-549.1	[illegible]2.6	224.9	44	-484.2	180.7	173.4
12	-542.1	226.0	21[illegible].9	[illegible]45	-560.1	241.0	230.2
13	-563.4	256.9	244.5	[illegible]46	-589.3	269.9	261.4
14	-516.4	204.6	193.5	47	-552.8	232.2	225.2
15	-548.9	236.9	224.9	48	-524.0	209.1	200.2
16	-564.8	[illegible]43.8	[illegible]6.1	49	-563.9	243.7	232.7
17	-568.2	254.8	245.3	50	-563.7	242.8	234.8
18	-554.0	234.5	227.9	51	-556.6	240.8	228.9
19	-546.5	236.0	227.9	52	-549.5	231.4	223.5
20	-578.7	261.5	253.3	53	-553.3	236.5	222.2
21	-528.2	216.2	209.6	54	-560.1	237.1	226.1
22	-539.4	222.3	214.1	55	-571.1	252.3	241.3
23	-557.6	237.9	228.9	56	-549.6	228.2	222.4
24	-528.2	215.2	208.1	57	-520.5	205.1	195.6
25	-564.6	246.3	239.3	58	-563.8	244.8	233.5
26	-535.5	222.3	214.1	59	-560.2	242.5	230.0
27	-564.3	250.7	243.1	60	-567.4	249.6	238.5
28	-525.1	213.9	206.1	61	-509.6	200.2	190.5
29	-524.4	208.9	201.3	62	-538.6	220.4	208.9
30	-519.1	205.7	262.2	63	-560.3	242.1	229.3
31	-509.6	198.7	191.8	64	-564.0	246.0	236.8
32	-545.9	230.1	222.6	65	-571.0	250.8	239.4
33	-495.0	187.0	180.2	66	-509.8	198.0	185.6
Mean Values					**-545.8 kV**	**229.9 µs**	**221.5 µs**
Standard Deviation					**21.6**	**19.0**	**19.0**

c) Final results

The average emission time<T'_{ESEAT}> y <T'_{SRAT}>have been related to the reference curve (figure C.4 of UNE 21186 Standard) defined by a build up time T_M equal to 650 µs and the field is set to the maximum experimental field value.

By using the reference wave shape, the emission times related to the reference curve T_{SRAT} and T_{ESEAT} are used to calculate the early streamer emission $\Delta T = T_{SRAT} - T_{ESEAT}$.

The early streamer emission time calculated by using the emission time obtained of the impulse voltage curves is showed in the following table.

Table 3. Early Emission Time. Voltage wave.

$T'_{SRAT}U$ (µs) Mean Time	$T'_{ESEAT}U$ (µs) Mean Time	$\Delta T'$ (µs) $T'_{SR} - T'_{ESE}$ Exp Wave	ΔT (µs) $T_{SR} - T_{ESE}$ Reference Wave	Uncertainty Expanded (*)
239.2 µs	229.9 µs	9.4 µs	**13.7 µs**	± 8 µs

The early streamer emission time calculated by using the emission time obtained of the current to earth curves is showed in the following table.

Table 4. Early Emission Time. Current wave.

$T'_{SRAT}I$ (µs) Mean Time	$T'_{ESEAT}I$ (µs) Mean Time	$\Delta T'$ (µs) $T'_{SR} - T'_{ESE}$ Exp Wave	ΔT (µs) $T_{SR} - T_{ESE}$ Reference Wave	Uncertainty Expanded (*)
231.4 µs	221.5 µs	9.9 µs	**14.6 µs**	± 8 µs

(*) The expanded uncertainty of the measurements has been obtained by multiplying the combined Standard uncertainty by a coverage factor k, equal to two, corresponding to a confidence level of approximately 95 %.

NO TEXT BELOW THE LINE

3.1.5 Test result

The early streamer emission of ESEAT has been determined according to section C.3.5 of UNE 21186 Standard and NF C 17-102 Standard.

Table 5. Test results.

Device ESE	0.8 σ_{SRAT}	σ_{ESEAT}	ΔT (µs) $T_{SR} - T_{ESE}$
LAP-PEX 220 0477	23.9 µs	19.0 µs	14.1 µs

The device satisfies the requirements indicated in section C.2.2 of UNE 21186 and NF C 17-102 Standards because the early emission time determined during the test is higher than 10 µs.

The tested lightning rod can be considered as ESEAT because satisfies the following conditions according to section C.3.5.3 of UNE 21186 and NF C 17-102 Standard.

$T_{ESEAT} < T_{SRAT}$

$\sigma_{ESEAT} < 0.8\ \sigma_{SRAT}$

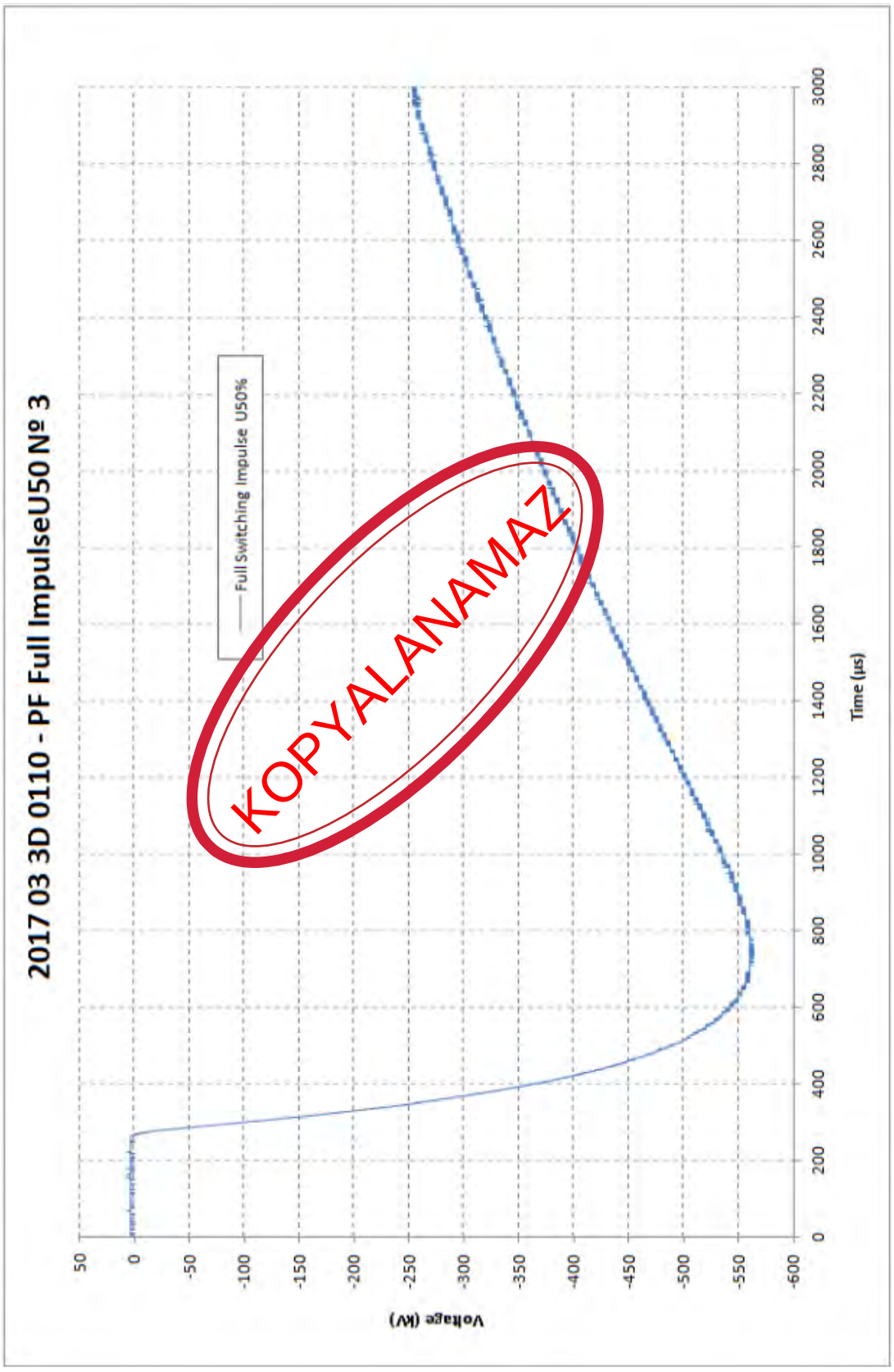
$T_{SRAT} - T_{ESEAT} \geq 10$ µs

NO TEXT BELOW THE LINE

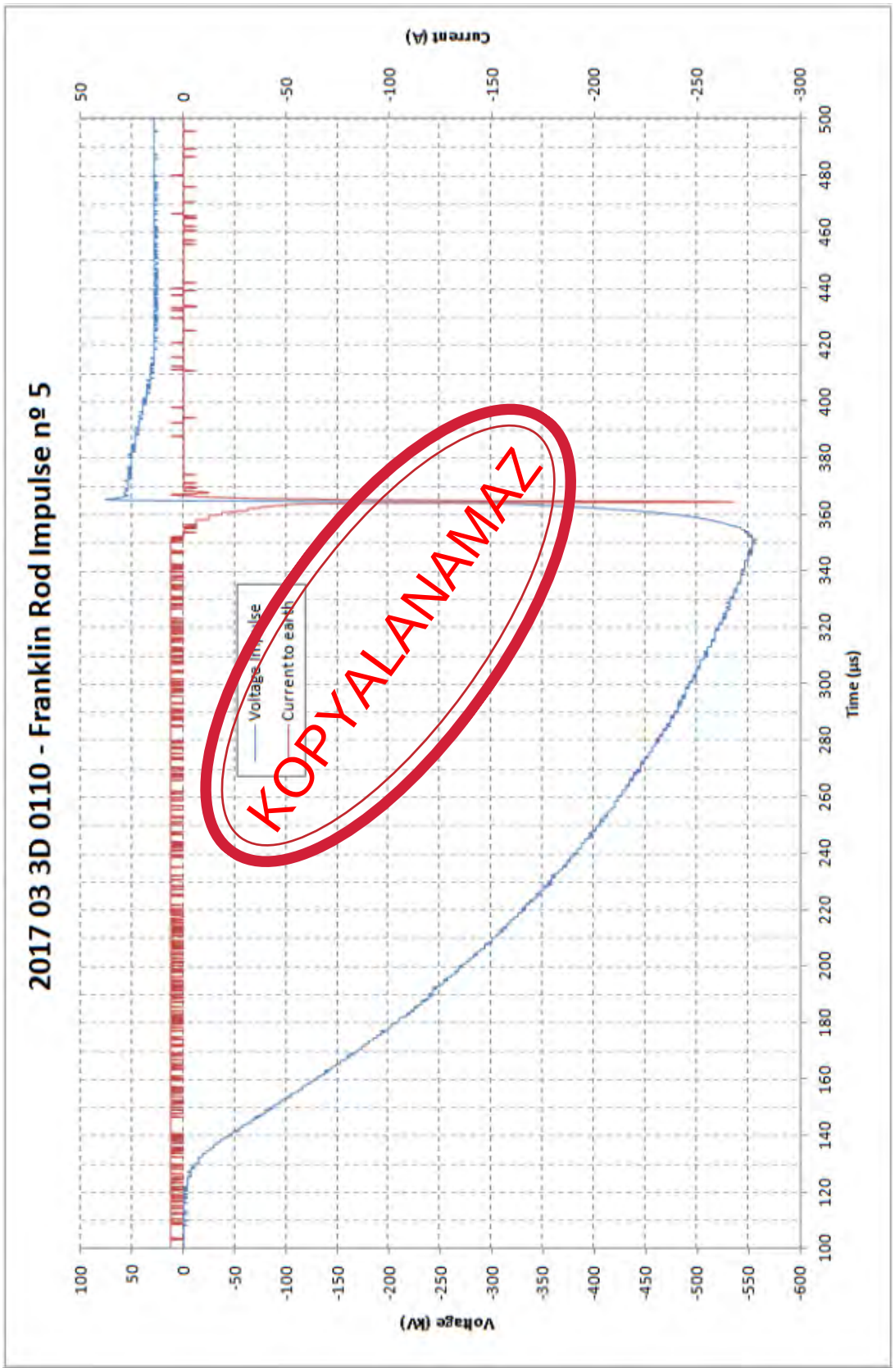
Annex 1

Impulse Waveforms

➢ Full switchimg impulse $U_{50.}$



➢ Chopped Impulse on SRAT device.



- Chopped Impulse on ESEAT device.