ZKU

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HIGH
POWER
LABORATORY

14 - 134

ZKUŠEBNICTVÍ, a.s.

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e-version

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INDEPENDENT TESTING LABORATORY NO. 1035 ACCREDITED BY THE CZECH ACCREDITATION INSTITUTE ACCORDING TO ČSN EN ISO/IEC 17025

TYPE TEST CERTIFICATE
OF SHORT-CIRCUIT PERFORMANCE
No. 14 - 134

Test object	:	Three-phase oil-immersed power transformer
Type	:	ETR 36 P-0
Serial No.	:	0969196
Ratings		
Rated voltage	:	220 kV ± 8 x 1,25 % // 24 kV / 24 kV
Rated power	:	75 MVA // 75 MVA /25 MVA
Rated frequency	:	50 Hz
Manufacturer	:	ETD TRANSFORMÁTORY a.s., Zborovská 22/54, 301 00 Plzeň, Czech Republic
Customer	:	ETD TRANSFORMÁTORY a.s., Zborovská 22/54, 301 00 Plzeň, Czech Republic
Date of test	:	11. 09. 2014

The test object produced in accordance with the description, drawings and photographs incorporated in this Certificate, has been subjected to the type tests in accordance with the mentioned Standard and the respective STL Guide:

IEC 60076-5:2006, cl. 4.2

The results are shown in the tables and the record of proving tests attached hereto.

♦ Interpretation of results:

The values obtained and the general performance are considered to comply with the above standard and to justify the ratings assigned by the manufacturer as listed on sheet 3.

The test results apply only to the specific piece of apparatus tested from the particular place of manufacture. The responsibility for conformity of any product having the same designation with that tested rests with the manufacturer.

This document cannot substitute the product Certificate according to ISO/IEC 17065.

Copy No.: E

Praha 9, Běchovice on 28.11.2014

Tested by:

Martin Vaniš

ACCREDITED HIGH POWER LABORATORY zkratovna BECHOVICE PRAHA 9 No. 1035

Approved by:

Robert Jech
Head of the Laboratory

ilac-MRA

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Description of the test object

A three-phase oil-immersed power transformer with three circular concentric windings and non-uniform insulation of transformer windings. The high-voltage winding HV (220 kV) is made of a Cu conductor and the secondary windings MV (24 kV) and the tertiary winding TW (24 kV) are made of a Cu conductor as well. The regulating winding RW is made of a Cu rectangular conductor.

Type of windings:

TW (tertiary winding) – double layer helical winding with twin enamel axial positioned rectangular conductors wrapped together with the paper insulation.

MV side - double layer helical winding with epoxy CTC conductor. The particular conductors of CTC are with enamelled insulation.

HV side - the disc ordinary shielded winding with twin enamel axial positioned rectangular conductors wrapped together with the paper insulation.

Regulating side - single layer helical loop winding with the single rectangular conductor with the single insulation. The conductor is without enamelled insulation.

Pressing construction:

The windings are pressed by ten compression devices in limb of phase U and W and eight compression devices in limb of phase V on top of the windings arrangements.

Ratings assigned by the manufacturer

Type	:	ETR 36 P-0
Serial No.	:	0969196
Manufacturer	:	ETD TRANSFORMÁTORY a.s., Plzeň, Czech Republic
Year of manufacture	:	2014
Rated power	:	75 MVA // 75 MVA /25 MVA
MV side rated voltage	:	24 kV
MV side rated current	:	1804 A
TW side rated voltage	:	24 kV
TW side rated current	:	601 A
HV side rated voltage	:	220 kV ± 8 x 1,25 %
HV side rated current	:	197 A
Impedance voltage (95°C)	:	12,5 %
Load losses (95°C) – guarantee value	:	230 000 W
Insulation level HV	:	1050 kV LI / 230 kV AC
Insulation level MV and TW	:	125 kV LI / 50 kV AC
Rated frequency	:	50 Hz
Reference temperature	:	95 °C
Type of cooling	:	ONAN / ONAF
Connection symbol	:	YNyn0/d5
Weight of oil	:	28 000 kg
Total mass	:	119 000 kg
Weight of active part	:	63 100 kg
Total dimensions (length x width x height)	:	9115 mm x 3677 mm x 7325 mm

Documents presented by the manufacturer

The manufacturer has guaranteed that test object submitted for tests has been manufactured in accordance with the presented drawing.

TRANSFORMER 75/75/25 MVA	EGYPT SUEZ GULF	Drawing

The Testing Laboratory Zkratovna has verified that these drawings adequately represent the test object.

Eh 003727	KOSTRA	Drawing
Eh 003729	VINUTÍ 75MVA	Drawing
Eh 003737	VYVODY NN	Drawing
Eh 003738	VYVODY VN	Drawing
Eh 442370	PODLOŽKA	Drawing
Eh 428897 b Rev. IX	DOTLAČOVACÍ ŠROUB M 36x3	Drawing
Eh 448845	MANZETA	Drawing

Other documents presented by the manufacturer

---	Test Certificate No. ŘJ 14/137 A Date of test: 19. 08. 2014 ETD TRANSFORMÁTORY a.s., Plzeň, Czech Republic	The test results of routine tests before the short-circuit tests
---	Test Certificate No. ŘJ 14/168 A Date of test: 29. 09. 2014 ETD TRANSFORMÁTORY a.s., Plzeň, Czech Republic	The test results of routine tests after the short-circuit tests

Parameters measured at routine tests

HV-MV winding

Tapping position	Max. 1 – 242 000 V	Nom. 9b – 220 000 V	Min. 17 – 198 000 V
Impedance voltage	13,16 % / 95 °C	12,43 % / 95 °C	11,91 % / 95 °C
Load loss	227,9 kW / 95 °C	224,2 kW / 95 °C	226,9 kW / 95 °C

HV-TW winding

Tapping position	Max. 1 – 242 000 V	Nom. 9b – 220 000 V	Min. 17 – 198 000 V
Impedance voltage	18,51 % / 95 °C	17,77 % / 95 °C	17,24 % / 95 °C
Load loss	43,73 kW / 95 °C	43,07 kW / 95 °C	43,39 kW / 95 °C

Parameters proved by tests HV-MV winding

Tapping position Max. 1 - 242 000 V

		min. value	calculated value	max. value
HV symmetrical current	(kA)	1,19	1,32	1,45
LV symmetrical current	(kA)	12,0	13,3	14,7
LV peak current	(kA)	32,3	34,0	35,7
Peak factor			2,55	

Tapping position Nom. 9b - 220 000 V

		min. value	calculated value	max. value
HV symmetrical current	(kA)	1,37	1,53	1,68
LV symmetrical current	(kA)	12,6	14,0	15,4
LV peak current	(kA)	33,9	35,7	37,5
Peak factor			2,55	

Tapping position Min. 17 - 198 000 V

		min. value	calculated value	max. value
HV symmetrical current	(kA)	1,58	1,75	1,93
LV symmetrical current	(kA)	13,0	14,5	15,9
LV peak current	(kA)	35,0	36,9	38,7
Peak factor			2,55	

Parameters proved by tests HV-TW winding

Tapping position Max. 1 - 242 000 V

		min. value	calculated value	max. value
HV symmetrical current	(kA)	0,85	0,95	1,04
LV symmetrical current	(kA)	8,59	9,55	10,5
LV peak current	(kA)	23,1	24,4	25,6
Peak factor			2,55	

Tapping position Nom. 9b - 220 000 V

		min. value	calculated value	max. value
HV symmetrical current	(kA)	0,97	1,08	1,19
LV symmetrical current	(kA)	8,90	9,89	10,9
LV peak current	(kA)	24,0	25,2	26,5
Peak factor			2,55	

Tapping position Min. 17 - 198 000 V

		min. value	calculated value	max. value
HV symmetrical current	(kA)	1,11	1,23	1,35
LV symmetrical current	(kA)	9,12	10,1	11,1
LV peak current	(kA)	24,5	25,8	27,1
Peak factor			2,55	

Short-circuit duration : 0,25 s
Short-circuit apparent power of the system : 20 000 MVA

Summary of tests

Test	Test standard	Test results
Ability to withstand the dynamic effects of short circuit	IEC 60076-5:2006, cl. 4.2	Tab. 1, Sheet 8 Tab. 2, Sheet 9
Verification test		
Short-circuit inductance measurement	IEC 60076-5:2006, cl. 4.2	Tab. 3, Sheet 10 Tab. 4, Sheet 11

The tests were witnessed by

Pavel Černý, ETD TRANSFORMÁTORY a.s., Plzeň, Czech Republic
Ehab El Afany, Egyptian Electricity Transmission Company, Egypt
Abd Rabon Abdel Rahman, ETD Agent, Egypt

Test conditions

Working frequency f = 48,5 Hz ÷ 49,5 Hz

The short-circuit tests were performed in a single-phase test circuit with a value of the supply voltage of 200 kV.

The tested transformer was supplied from the HV side. MV and TW sides were short-circuited step by step by means of flexible conductors and earthed through the sensor for fault current measuring. The tank of the transformer was earthed through the sensor for fault current measuring as well. The pre-established short-circuit method was used for transformer testing.

The condition of the transformer windings was checked after the each test by measuring of the short-circuit inductance and the result of the measuring was compared with the value measured before the tests.

The visual inspection of the active part of the transformer was performed after short-circuit tests.

The short-circuit tests were recorded by means of a conventional digital camera (see enclosed CD).

The test circuits, including measurement points, are illustrated in the diagrams:

Winding HV-MV: TSV122-A, TSV122-B and TSV122-C

Winding HV-TW: TSV122-A-T, TSV122-B-T and TSV122-C-T

The connection of the tested transformer to the test circuit is documented by the photo in Fig. 1.

The other photos document the tested transformer after the short-circuit tests.

List of symbols

a) Used in the tables of test results

I_m	-	peak short-circuit current
I_1	-	symmetrical short-circuit current at the beginning of the test (t = 0,05 s)
I_2	-	symmetrical short-circuit current at the end of the test (t = 0,9 t_i)
I_e	-	equivalent r.m.s. value of symmetrical short-circuit current (N/A)
U_{HV}	-	supply voltage on the HV side
U_{MV}	-	supply voltage on the MV side (N/A)
U_{TW}	-	supply voltage on the TW side (N/A)
t_i	-	short-circuit duration
L	-	short-circuit inductance
ωL	-	short-circuit reactance
$\Delta\omega L$	-	percentage difference between the values of short-circuit reactance before and after the tests

b) Used in the oscillograms

1IR, 1IS, 1IT	-	current course of the supplied HV winding in the phases R, S, T
2IR1, 2IS1, 2IT1	-	current course of the short-circuited MV winding in the phases R, S, T
2IR2, 2IS2, 2IT2	-	current course of the short-circuited TW winding in the phases R, S, T
1URT	-	voltage course of the supplied HV winding
Ip1	-	fault current course through the transformer tank
Ip2	-	fault current course on the short-circuited side
Buch	-	Buchholz relay course
t	-	time

Note: The index R corresponds to the index U
The index S corresponds to the index V
The index T corresponds to the index W

The Certificate contains:

26 sheets i.e.:

1 introductory sheet
1 title sheet
5 text sheets
7 table sheets
6 test circuit diagrams
6 photograph sheets

18 oscillograms

4 enclosures

Drawing No. EGYPT SUEZ GULF
Test Certificate No. ŘJ 14/137 A from 19. 08. 2014
Test Certificate No. ŘJ 14/168 A from 29. 09. 2014
CD - Video-recordings from the test

1. Table of test results: Ability to withstand the dynamic effects of short-circuit - winding HV-MV
Test circuit diagram: TSV122-A, TSV122-B, TSV122-C
File denomination: trfa11ia

Test No.	Mode	Phase	HV side					MV side					TW side					t_i	Tapping	Observation
			U_{HV}	I_m	I_1	I_2	I_e	U_{MV}	I_m	I_1	I_2	I_e	U_{TW}	I_m	I_1	I_2	I_e			
			(kV)	(kA)	(kA)	(kA)	(kA)	(kV)	(kA)	(kA)	(kA)	(kA)	(kV)	(kA)	(kA)	(kA)	(kA)	(ms)		
005 [1)]	HV(1) -(MV)	U	180	3,28	---	1,21	---	---	32,2	11,8	12,1	---	---	---	---	---	---	250	max. 1	no fault
006	HV(1) -(MV)	U	190	3,46	---	1,27	---	---	34,6	12,6	12,8	---	---	---	---	---	---	250	max. 1	no fault
007	HV(1) -(MV)	U	190	3,37	---	1,28	---	---	33,5	12,6	12,8	---	---	---	---	---	---	250	max. 1	no fault
009	HV(9b) -(MV)	V	177	3,79	---	1,53	---	---	34,4	13,7	13,9	---	---	---	---	---	---	250	nom. 9b	no fault
010	HV(9b) -(MV)	V	179	4,02	---	1,56	---	---	36,5	13,9	14,2	---	---	---	---	---	---	250	nom. 9b	no fault
011	HV(9b) -(MV)	V	179	4,03	---	1,55	---	---	36,4	13,9	14,1	---	---	---	---	---	---	250	nom. 9b	no fault
013	HV(17) -(MV)	W	157	4,53	---	1,76	---	---	36,5	14,2	14,4	---	---	---	---	---	---	250	min. 17	no fault
014	HV(17) -(MV)	W	157	4,46	---	1,75	---	---	35,9	14,2	14,4	---	---	---	---	---	---	250	min. 17	no fault
015	HV(17) -(MV)	W	157	4,53	---	1,74	---	---	37,0	14,2	14,3	---	---	---	---	---	---	250	min. 17	no fault

Note: The short-circuit current values are the values of the short-circuit currents in respective terminal of the tested transformer .
[1)] failure of one measuring channel 1IT

2. Table of test results: Ability to withstand the dynamic effects of short-circuit - Tertiary winding HV-TW
Test circuit diagram: TSV122-A-T, TSV122-B-T, TSV122-C-T
File denomination: trfa11ia

Test No.	Mode	Phase	HV side					MV side					TW side					t_i	Tapping	Observation
			U_{HV}	I_m	I_1	I_2	I_e	U_{MV}	I_m	I_1	I_2	I_e	U_{TW}	I_m	I_1	I_2	I_e			
			(kV)	(kA)	(kA)	(kA)	(kA)	(kV)	(kA)	(kA)	(kA)	(kA)	(kV)	(kA)	(kA)	(kA)	(kA)	(ms)		
018	HV(1) -(TW)	U	197	2,43	---	0,94	---	---	---	---	---	---	---	21,0	8,03	8,23	---	250	max. 1	no fault
019	HV(1) -(TW)	U	197	2,40	---	0,95	---	---	---	---	---	---	---	20,5	8,02	8,22	---	250	max. 1	no fault
020	HV(1) -(TW)	U	196	2,46	---	0,94	---	---	---	---	---	---	---	20,8	8,00	8,19	---	250	max. 1	no fault
022	HV(9b) -(TW)	V	181	2,76	---	1,09	---	---	---	---	---	---	---	21,9	8,48	8,66	---	250	nom. 9b	no fault
023	HV(9b) -(TW)	V	180	2,71	---	1,08	---	---	---	---	---	---	---	21,3	8,38	8,57	---	250	nom. 9b	no fault
024	HV(9b) -(TW)	V	181	2,82	---	1,09	---	---	---	---	---	---	---	22,2	8,49	8,67	---	250	nom. 9b	no fault
026	HV(17) -(TW)	W	159	3,12	---	1,22	---	---	---	---	---	---	---	22,2	8,52	8,71	---	250	min. 17	no fault
027	HV(17) -(TW)	W	162	3,18	---	1,24	---	---	---	---	---	---	---	22,4	8,69	8,87	---	250	min. 17	no fault
028	HV(17) -(TW)	W	162	3,17	---	1,24	---	---	---	---	---	---	---	22,1	8,69	8,88	---	250	min. 17	no fault

Note: The short-circuit current values are the values of the short-circuit currents in respective terminal of the tested transformer.

3. Table of test result: Short-circuit inductance measurement
Winding HV-MV

Admissible deviation: $\Delta\omega L_{max}$ = 2 %
File denomination: trfa11ia

Measured at 50 Hz			Calculated values			
Measurement after the test No.	Terminals	L (mH)	Phase	ωL (Ω)	ΔωL (%)	Tapping
before tests	R-S	395,7	R	62,06	---	min. 17
	S-T	395,5	S	62,24	---	
	T-R	394,9	T	61,99	---	
before tests	R-S	509,6	R	79,81	---	nom. 9b
	S-T	509,4	S	80,25	---	
	T-R	508,0	T	79,76	---	
before tests	R-S	652,9	R	102,1	---	max. 1
	S-T	652,9	S	103,0	---	
	T-R	649,9	T	102,1	---	
005	R-S	653,1	R	102,1	0,0	max. 1
	S-T	653,2	S	103,0	0,0	
	T-R	650,3	T	102,1	0,0	
006	R-S	653,6	R	102,2	0,1	max. 1
	S-T	653,3	S	103,1	0,1	
	T-R	650,6	T	102,1	0,0	
007	R-S	653,6	R	102,2	0,1	max. 1
	S-T	653,3	S	103,1	0,1	
	T-R	650,5	T	102,1	0,0	
009	R-S	509,9	R	79,90	0,1	nom. 9b
	S-T	509,8	S	80,26	0,0	
	T-R	508,6	T	79,86	0,1	
010	R-S	510,0	R	79,92	0,1	nom. 9b
	S-T	509,6	S	80,27	0,0	
	T-R	508,6	T	79,81	0,1	
011	R-S	509,9	R	79,89	0,1	nom. 9b
	S-T	509,8	S	80,26	0,0	
	T-R	508,6	T	79,86	0,1	
013	R-S	396,1	R	62,14	0,1	min. 17
	S-T	395,8	S	62,26	0,0	
	T-R	395,4	T	62,06	0,1	
014	R-S	396,1	R	62,14	0,1	min. 17
	S-T	395,8	S	62,27	0,0	
	T-R	395,4	T	62,06	0,1	
015	R-S	396,0	R	62,14	0,1	min. 17
	S-T	395,8	S	62,26	0,0	
	T-R	395,4	T	62,05	0,1	
after tests	R-S	510,0	R	79,93	0,2	nom. 9b
	S-T	509,7	S	80,25	0,0	
	T-R	508,7	T	79,85	0,1	
after tests	R-S	653,7	R	102,2	0,1	max. 1
	S-T	653,6	S	103,1	0,1	
	T-R	650,6	T	102,1	0,0	

4. Table of test result: Short-circuit inductance measurement
Tertiary winding HV-TW

Admissible deviation: $\Delta\omega L_{max}$ = 2 %
File denomination: trfa11ia

Measured at 50 Hz			Calculated values			
Measurement after the test No.	Terminals	L (mH)	Phase	ωL (Ω)	ΔωL (%)	Tapping
before tests	R-S	572,3	R	89,70	---	min. 17
	S-T	572,0	S	90,05	---	
	T-R	570,9	T	89,61	---	
before tests	R-S	727,9	R	114,0	---	nom. 9b
	S-T	727,6	S	114,7	---	
	T-R	725,4	T	113,9	---	
before tests	R-S	917,7	R	143,4	---	max. 1
	S-T	917,4	S	144,8	---	
	T-R	912,9	T	143,3	---	
018	R-S	919,1	R	143,8	0,3	max. 1
	S-T	919,0	S	144,9	0,1	
	T-R	915,4	T	143,7	0,3	
019	R-S	919,2	R	143,8	0,3	max. 1
	S-T	919,0	S	144,9	0,1	
	T-R	915,3	T	143,7	0,3	
020	R-S	919,2	R	143,8	0,3	max. 1
	S-T	919,0	S	144,9	0,1	
	T-R	915,5	T	143,7	0,3	
022	R-S	729,2	R	114,3	0,3	nom. 9b
	S-T	728,7	S	114,8	0,1	
	T-R	727,3	T	114,1	0,2	
023	R-S	729,6	R	114,4	0,4	nom. 9b
	S-T	728,7	S	114,8	0,1	
	T-R	727,3	T	114,1	0,2	
024	R-S	729,4	R	114,4	0,4	nom. 9b
	S-T	728,4	S	114,7	0,0	
	T-R	727,1	T	114,0	0,1	
026	R-S	573,4	R	90,03	0,4	min. 17
	S-T	572,5	S	90,08	0,0	
	T-R	572,3	T	89,73	0,1	
027	R-S	573,6	R	90,05	0,4	min. 17
	S-T	572,5	S	90,11	0,1	
	T-R	572,3	T	89,71	0,1	
028	R-S	573,5	R	89,93	0,3	min. 17
	S-T	573,2	S	90,21	0,2	
	T-R	572,3	T	89,84	0,3	
after tests	R-S	729,7	R	114,4	0,4	nom. 9b
	S-T	729,3	S	114,8	0,1	
	T-R	727,9	T	114,2	0,3	
after tests	R-S	919,6	R	144,0	0,4	max. 1
	S-T	919,6	S	144,9	0,1	
	T-R	916,6	T	144,0	0,5	

Assessment according to IEC 60076-5:2006 cl. 4.2.7.4

Conditions	Assessment
1) observation during the tests	**FULFILLED** The results of short-circuit tests and measurement and check performed during test did not reveal any condition of faults.
2) repeating of routine tests	**FULFILLED** The routine tests have been successfully repeated. *(Test Certificate – No. ŘJ 14/137 A from 19. 08. 2014 and No. ŘJ 14/168 A from 29.09. 2014 performed by ETD TRANSFORMÁTORY a.s., Plzeň, Czech Republic)*
3) inspection of active part of transformer	**FULFILLED** The visual inspection of the active part of the transformer after the short-circuit test did not reveal any defects.
4) detection of traces of internal electrical discharge	**FULFILLED** No traces of internal electrical discharge were found.
5) checking of short-circuit reactance	**FULFILLED** The change of the short-circuit reactance did not exceed the allowed tolerance 2 %.

Meteorological conditions

Test No.	Date (dd.mm.yy)	Time (hh:mm)	Temperature (^{o}C)	Relative humidity (%)	Atmospheric pressure (hPa)
005	11.9.2014	12:09	14,9	77	982
015	11.9.2014	15:15	17,6	65	982
018	11.9.2014	16:16	16,2	69	982
028	11.9.2014	17:40	14,8	84	982

Test circuit parameters

File denomination		trfa11ia
Test No.		005 - 028
Test circuit diagram		TSV122-A TSV122-B TSV122-C TSV122-A-T TSV122-B-T TSV122-C-T
Generator		S||J
Rated (phase to phase) voltage	(kV)	12,2
Phases connected		R, T
Inductance per phase	(mH)	0,143
Inductance of reactors per phase	(mH)	0
Resistance of resistors per phase	(Ω)	0
Supply transformer – Type		S_R, J_R, J_S, J_T
Connection		84+84+84+84
Transf. ratio		28
Inductance per phase	(mH)	0,008
Total inductance per phase of supply circuit	(mH)	0,151
Capacity in parallel	(μF)	---
Resistance in series	(Ω)	---
Neutral point of supply circuit		indirectly earthed R=200Ω
Short-circuit point		earthed
Load transformer – Type		---
Connection		---
Transf. ratio		---
Resistance of load resistors	(Ω)	---
Inductance of load reactors	(mH)	---
Capacity of load capacitors	(μF)	---
Neutral point of load circuit		---
Power factor / impedance of supply circuit	(- / %)	---
Power factor / impedance of load circuit	(- / %)	---
Power factor of test circuit	(-)	<0,2

Measuring devices used

Test circuit diagram: TSV122-A, TSV122-B, TSV122-C, TSV122-A-T, TSV122-B-T, TSV122-C-T
File denomination: trfa11ia.005 ÷ 028

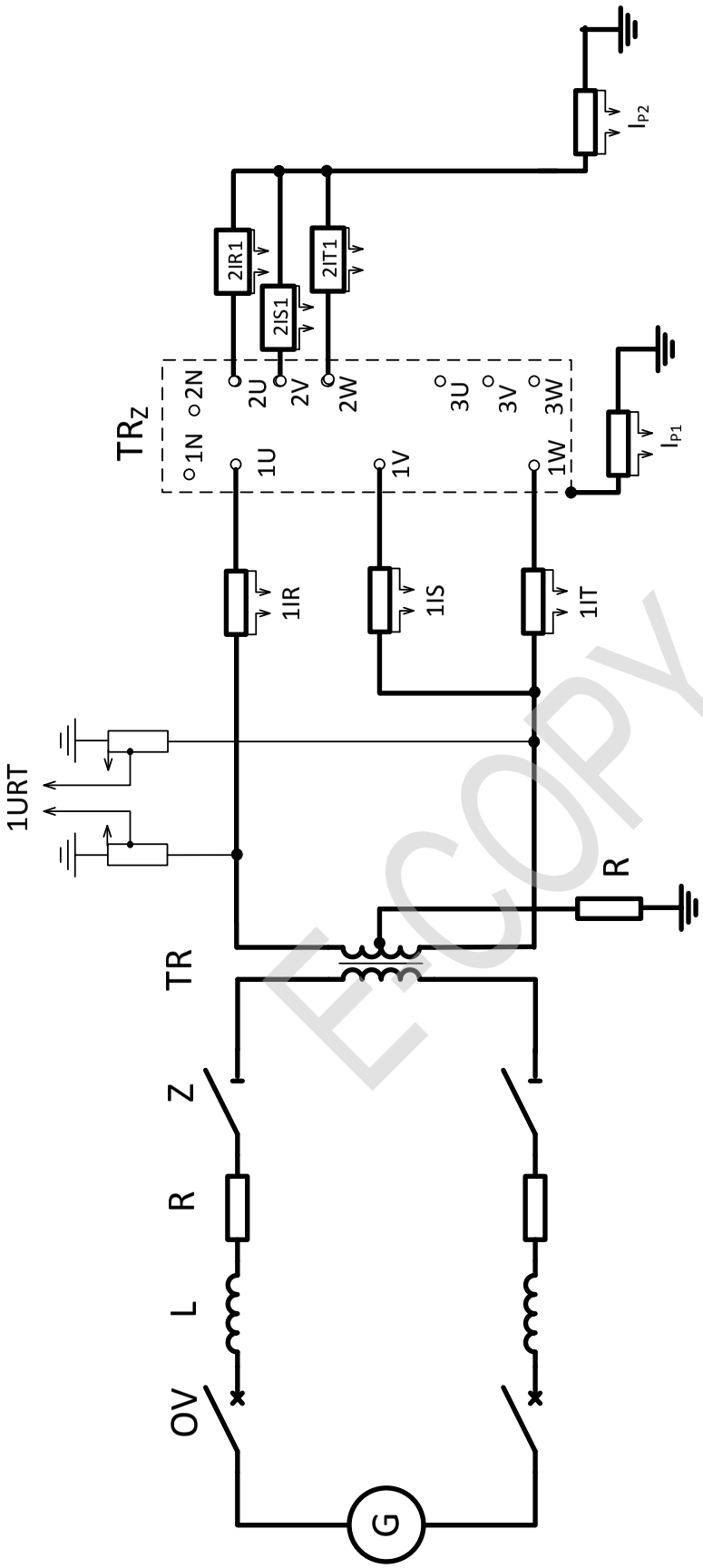
Measurand	Measuring sensor / device			Digital measuring system type DMS
	Type	Serial No.	Transfer constant	Input channel, Ser. No.
1IR	Cage shunt	001/95	10 kA / 2 V	100-10100-1
1IS	Cage shunt	002/95	10 kA / 2 V	100-10100-2
1IT	Cage shunt	003/95	10 kA / 2 V	100-10100-4
2IR1, 2IR2	Rogowski coil Integrative amplifier	FE 247 IZ 001/06	300 kA / 10 V	100-10100-14
2IS1, 2IS2	Rogowski coil Integrative amplifier	FE 248 IZ 002/06	300 kA / 10 V	100-10100-19
2IT1, 2IT2	Rogowski coil Integrative amplifier	FE 249 IZ 003/06	300 kA / 10 V	100-10100-24
1URT	Resistance voltage divider	DR 001/78	125 kV /150 V	100-10100-22
Ip1	Measuring current transformer	122419	1000 A / 5 A	100-10100-25
Ip2	Measuring current transformer	122516	1000 A / 5 A	100-10100-27
Buch	---	---	---	100-10100-16

Short-circuit inductance measurement

LCR HITESTER HIOKI, type 3532-50, serial No. 120510018

Meteorological conditions measurement

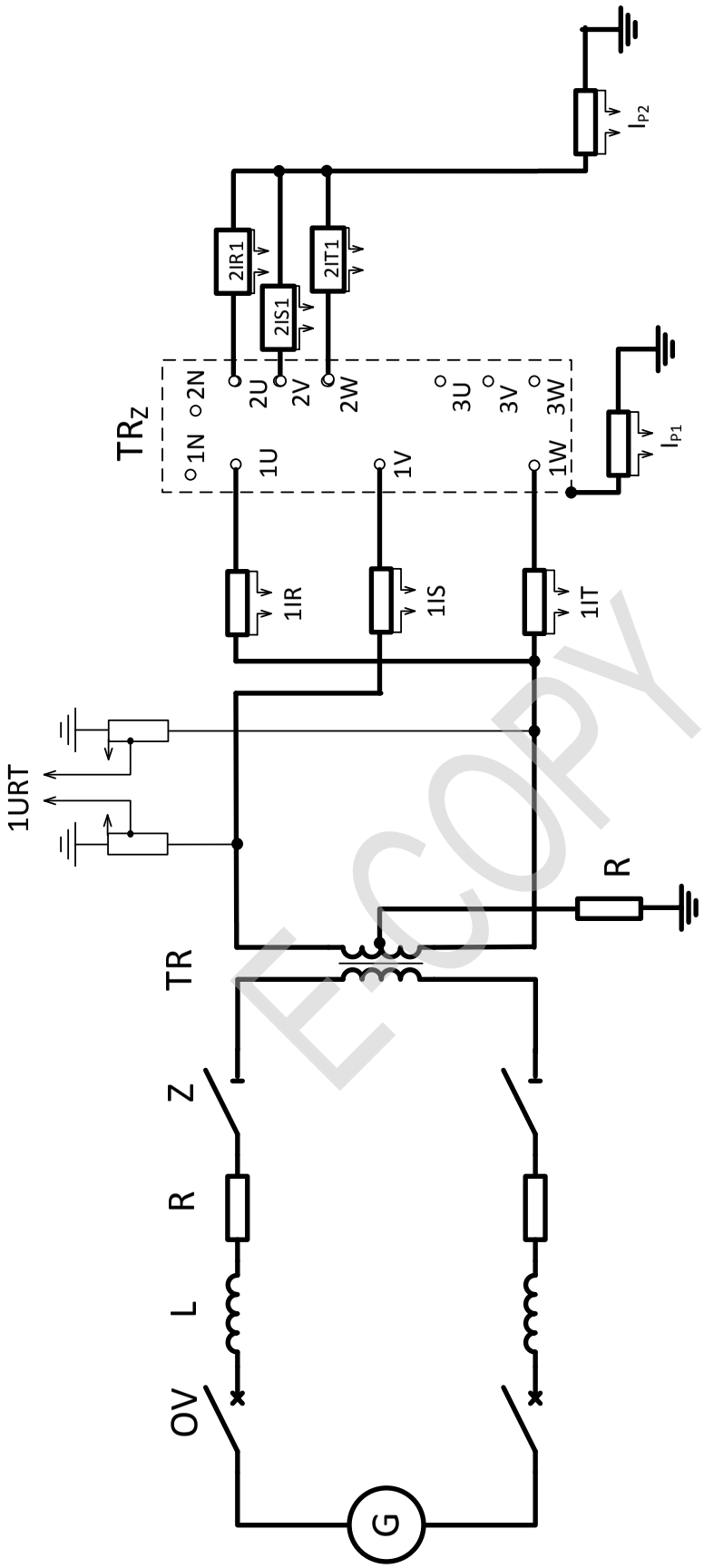
Meteorological station, type Vantage Pro 2, serial No. 3788A-6312



G - Short-circuit generator
OV - Master breaker
L, R - Reactors and resistors
Z - Make switch

TR - Short-circuit transformer
TR_Z - Transformer tested
I, U - Current and voltage measurement

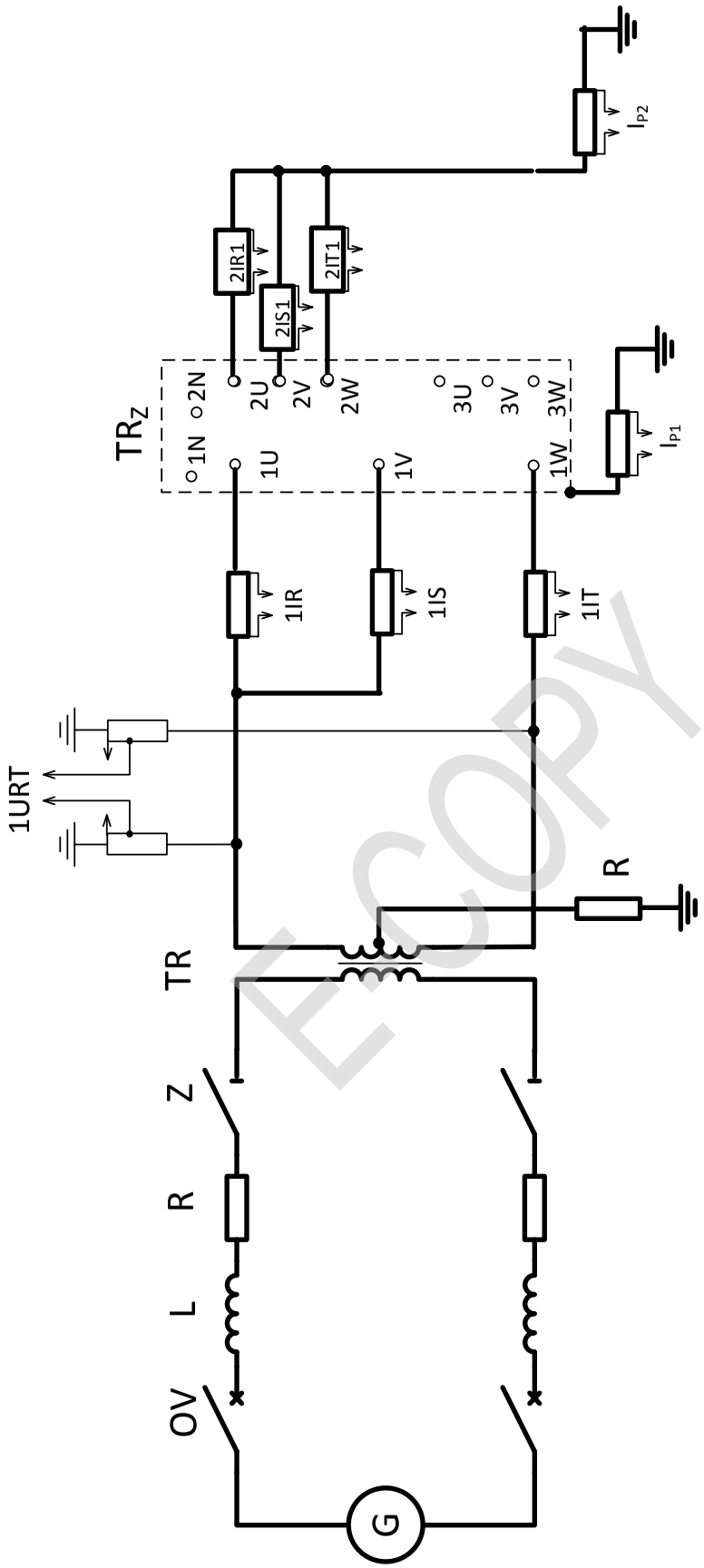
Test circuit diagram TSV122-A



G - Short-circuit generator
OV - Master breaker
L, R - Reactors and resistors
Z - Make switch

TR - Short-circuit transformer
TR_Z - Transformer tested
I, U - Current and voltage measurement

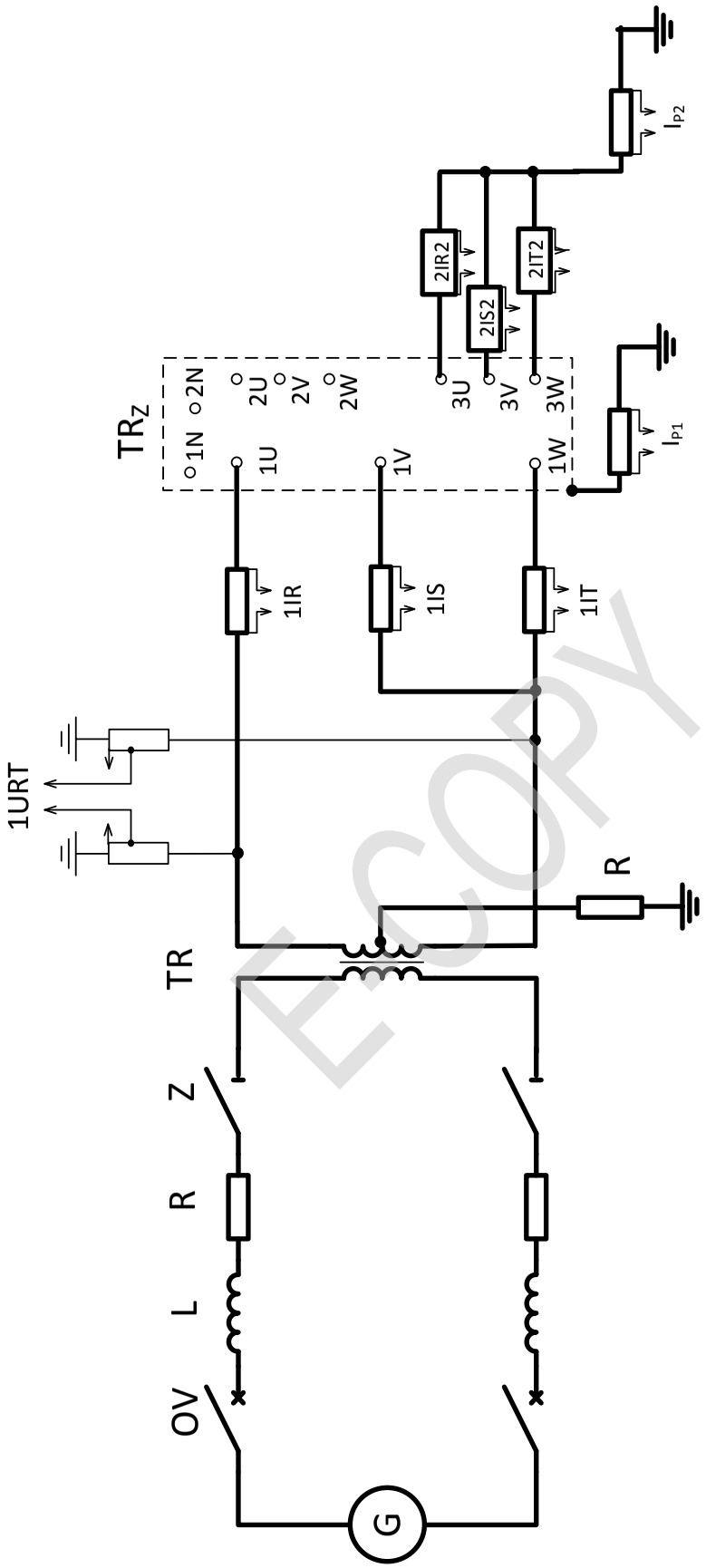
Test circuit diagram TSV122-B



G - Short-circuit generator
OV - Master breaker
L, R - Reactors and resistors
Z - Make switch

TR - Short-circuit transformer
TR_Z - Transformer tested
I, U - Current and voltage measurement

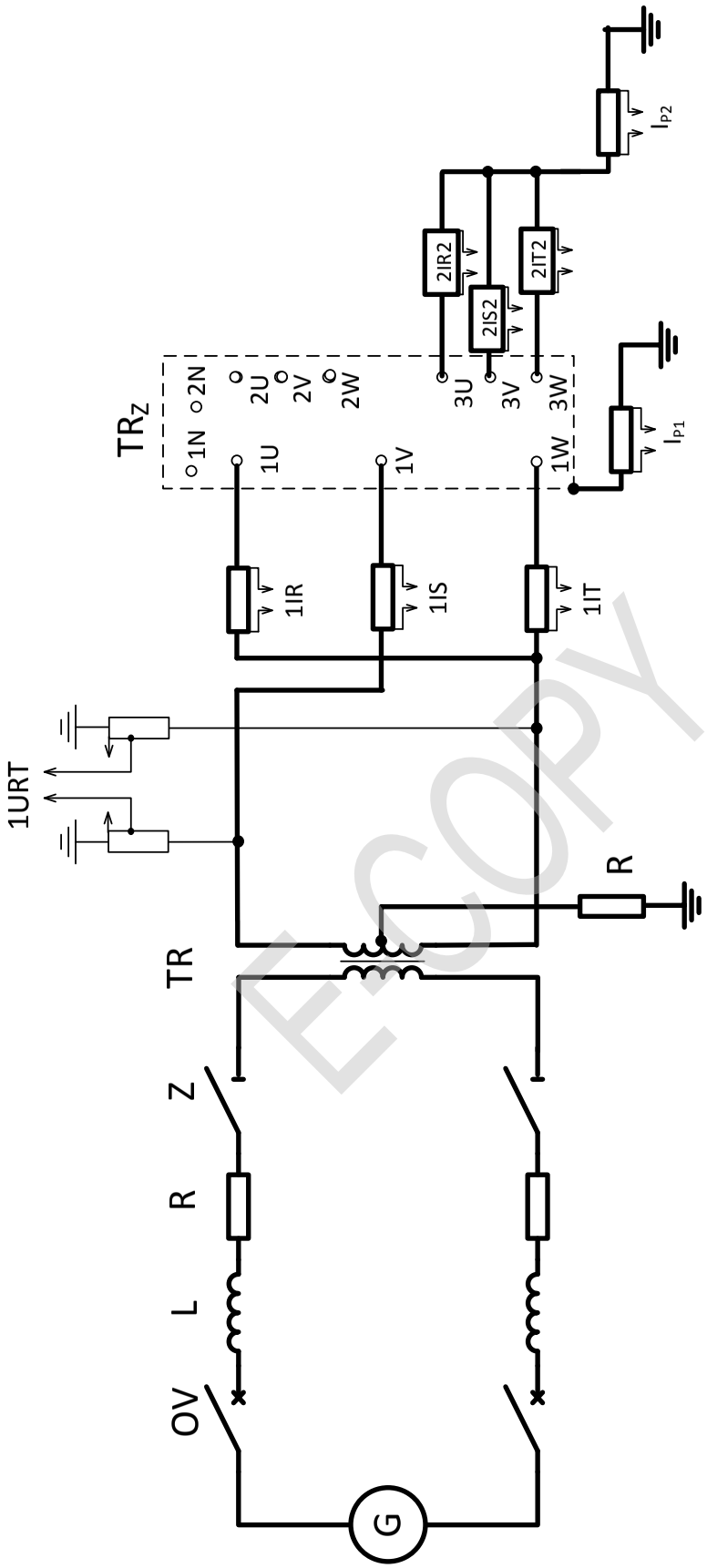
Test circuit diagram TSV122-C



Test circuit diagram TSV122-A-T

G - Short-circuit generator
OV - Master breaker
L, R - Reactors and resistors
Z - Make switch

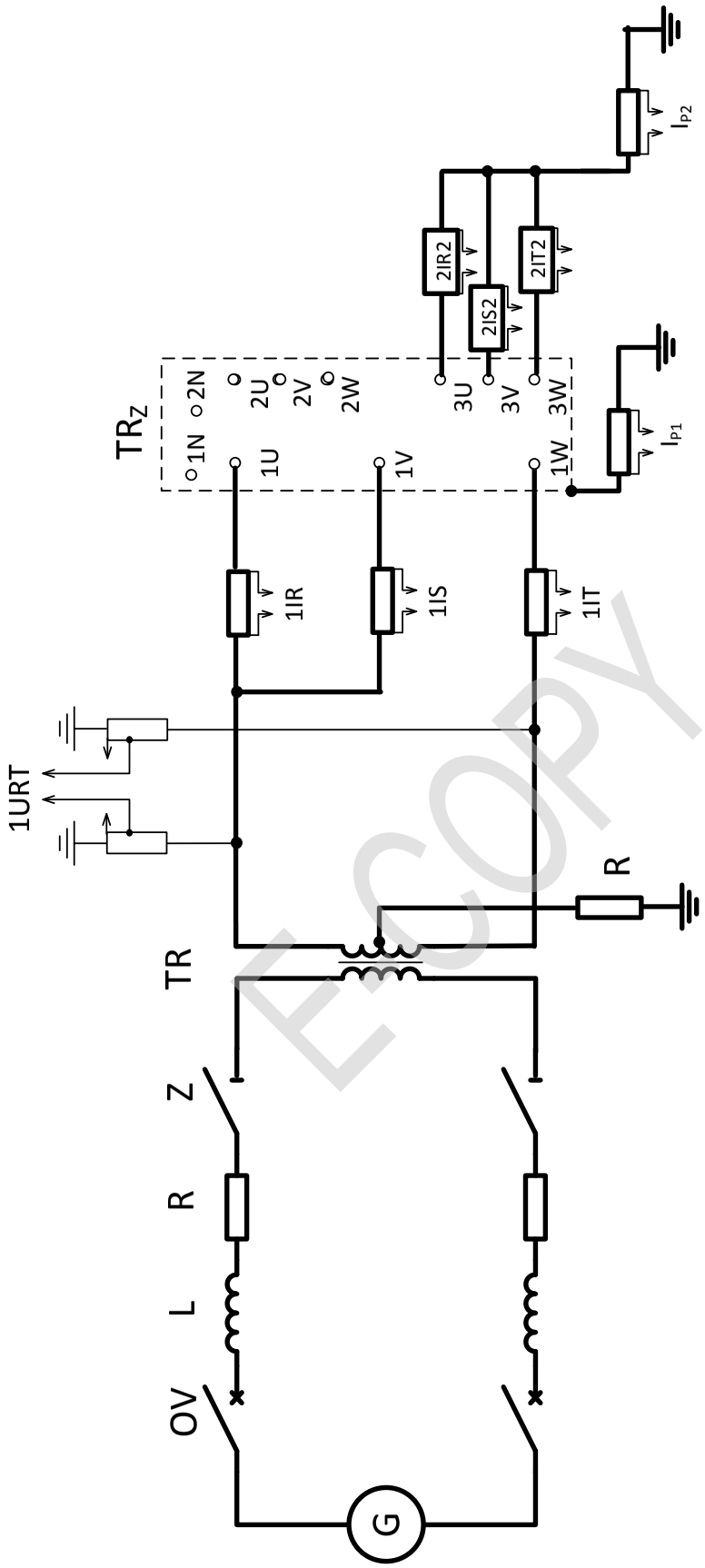
TR - Short-circuit transformer
TR_Z - Transformer tested
I, U - Current and voltage measurement



G - Short-circuit generator
OV - Master breaker
L, R - Reactors and resistors
Z - Make switch

TR - Short-circuit transformer
TR_Z - Transformer tested
I, U - Current and voltage measurement

Test circuit diagram TSV122-B-T



G - Short-circuit generator
OV - Master breaker
L, R - Reactors and resistors
Z - Make switch

TR - Short-circuit transformer
TR_Z - Transformer tested
I, U - Current and voltage measurement

Test circuit diagram TSV122-C-T

Fig. 1
Connection of the tested transformer to the test circuit – transformer before the tests

Fig. 2
Transformer after the tests

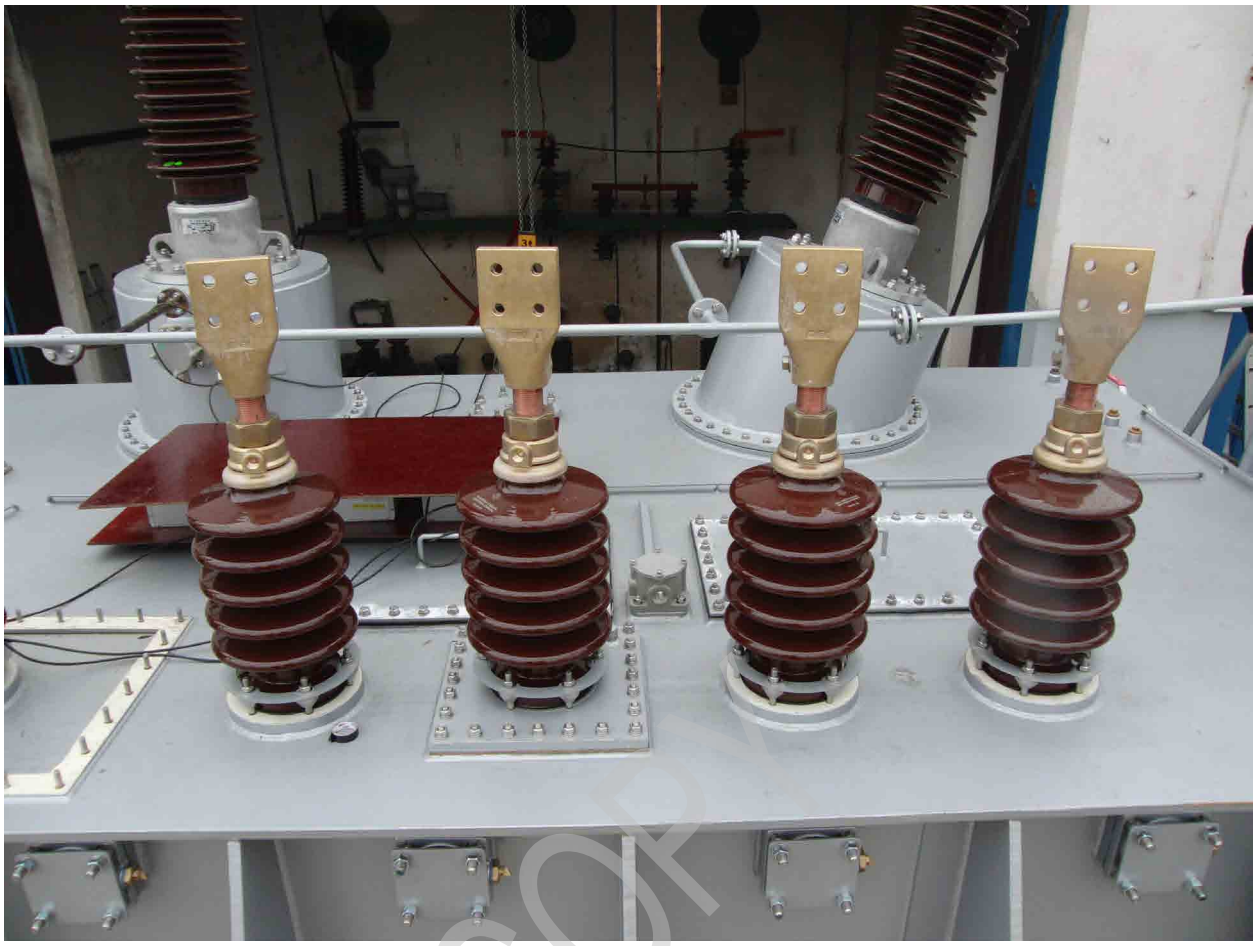


Fig. 3
Tested transformer after the short-circuit tests – bushings on the MV side

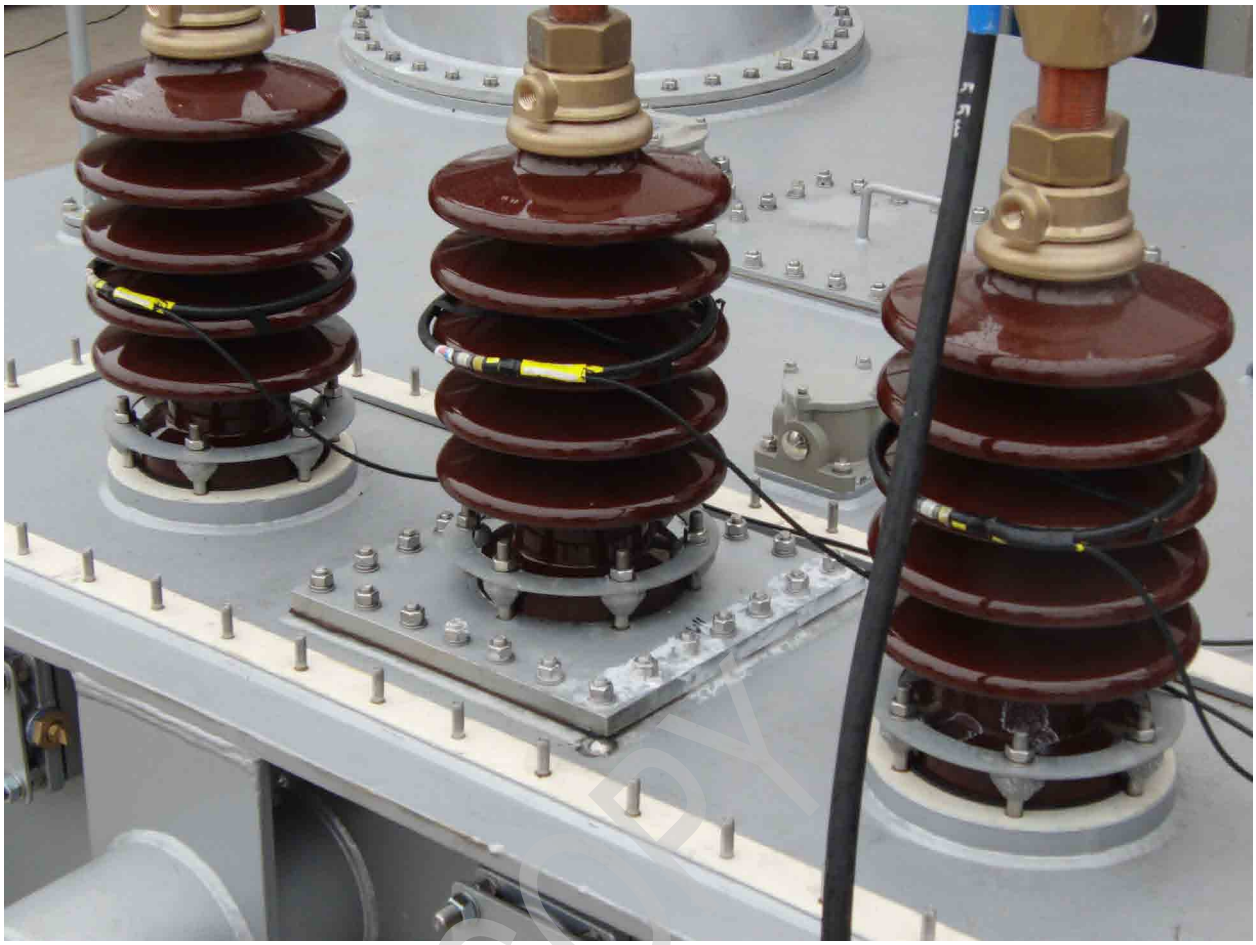


Fig. 4
Tested transformer after the short-circuit tests – bushings on the TW side

Fig. 5
Tested transformer after the short-circuit tests – bushings on the HV side

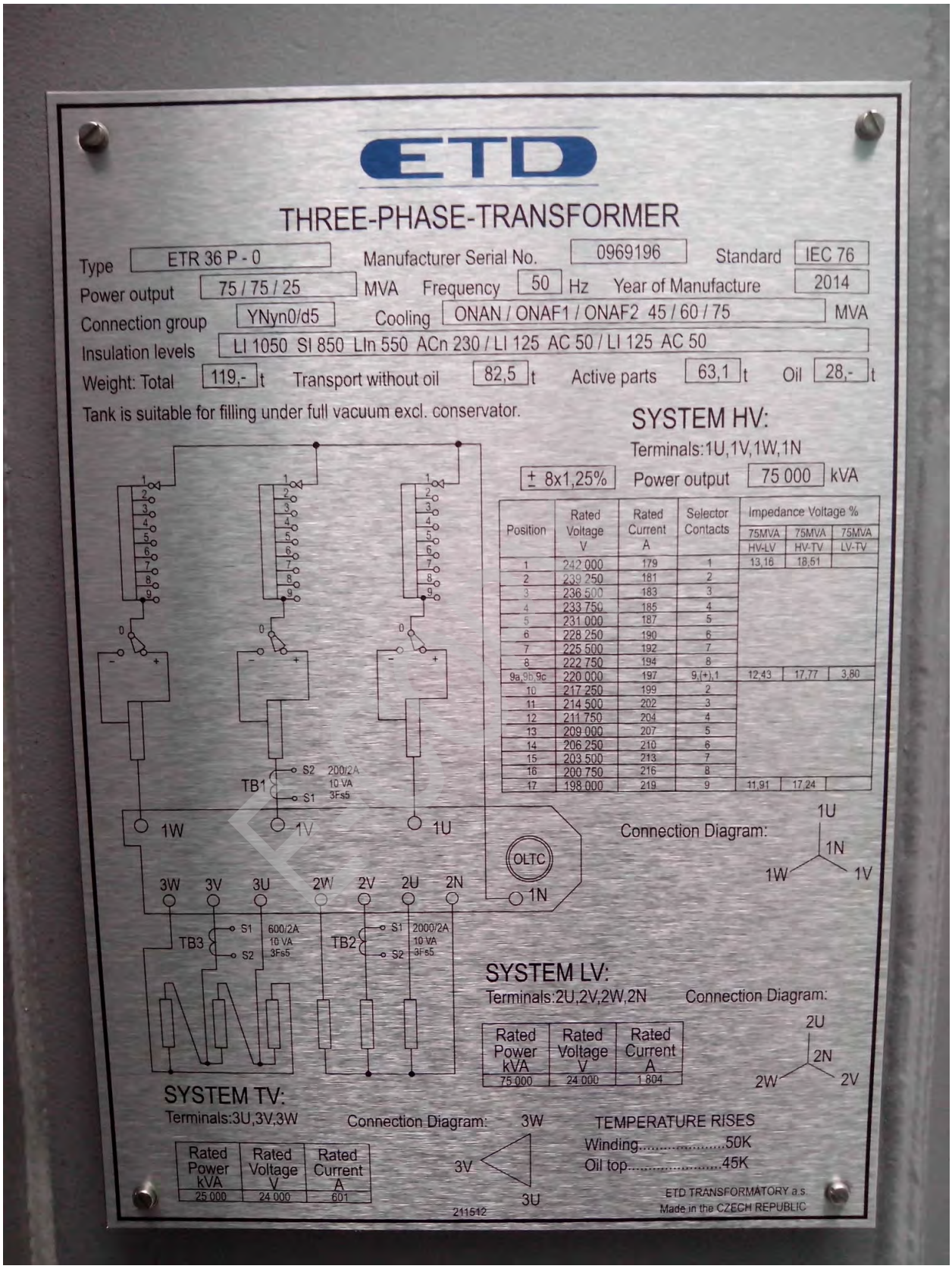
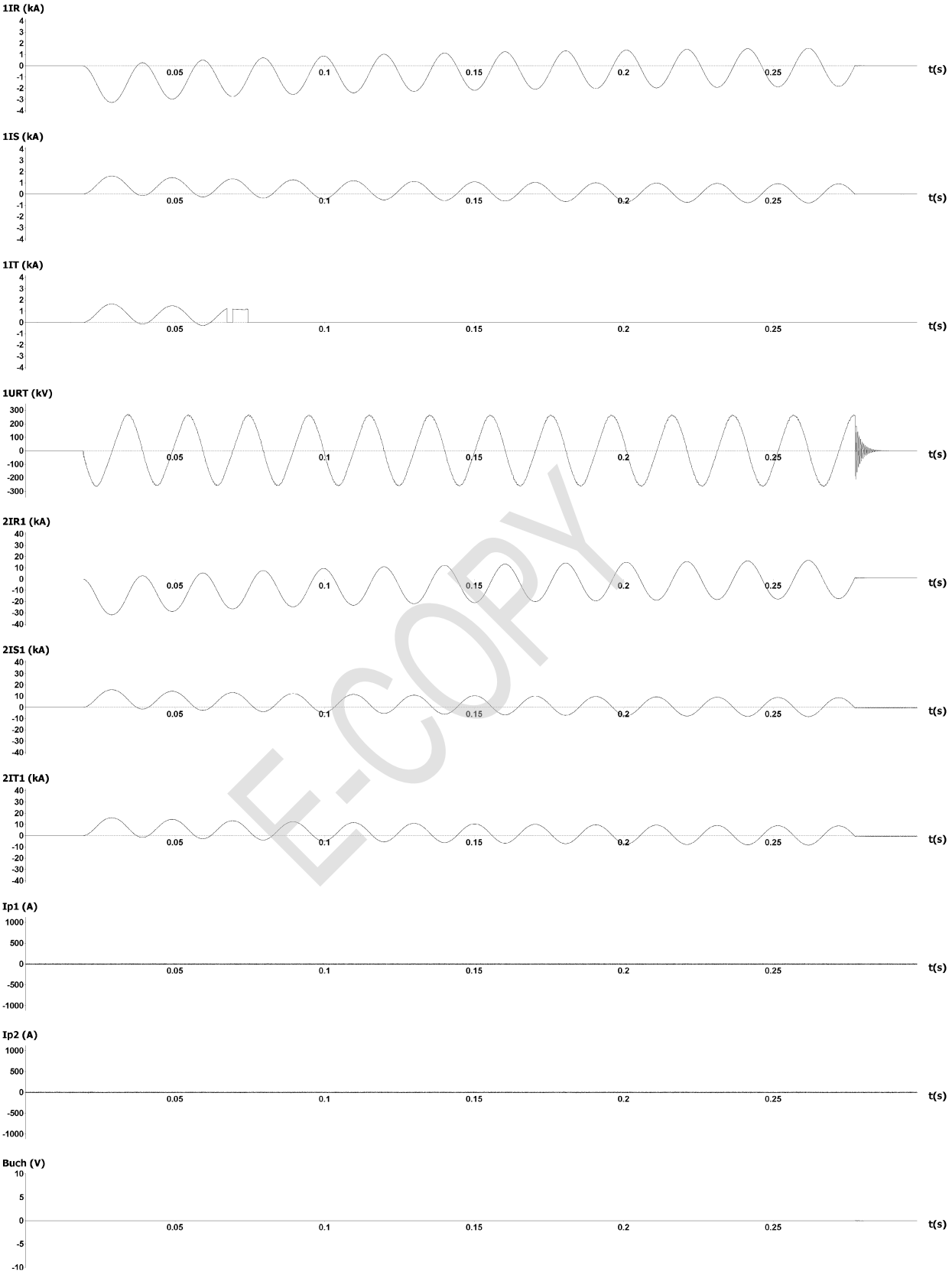


Fig. 6
Nameplate

trfa11ia.005



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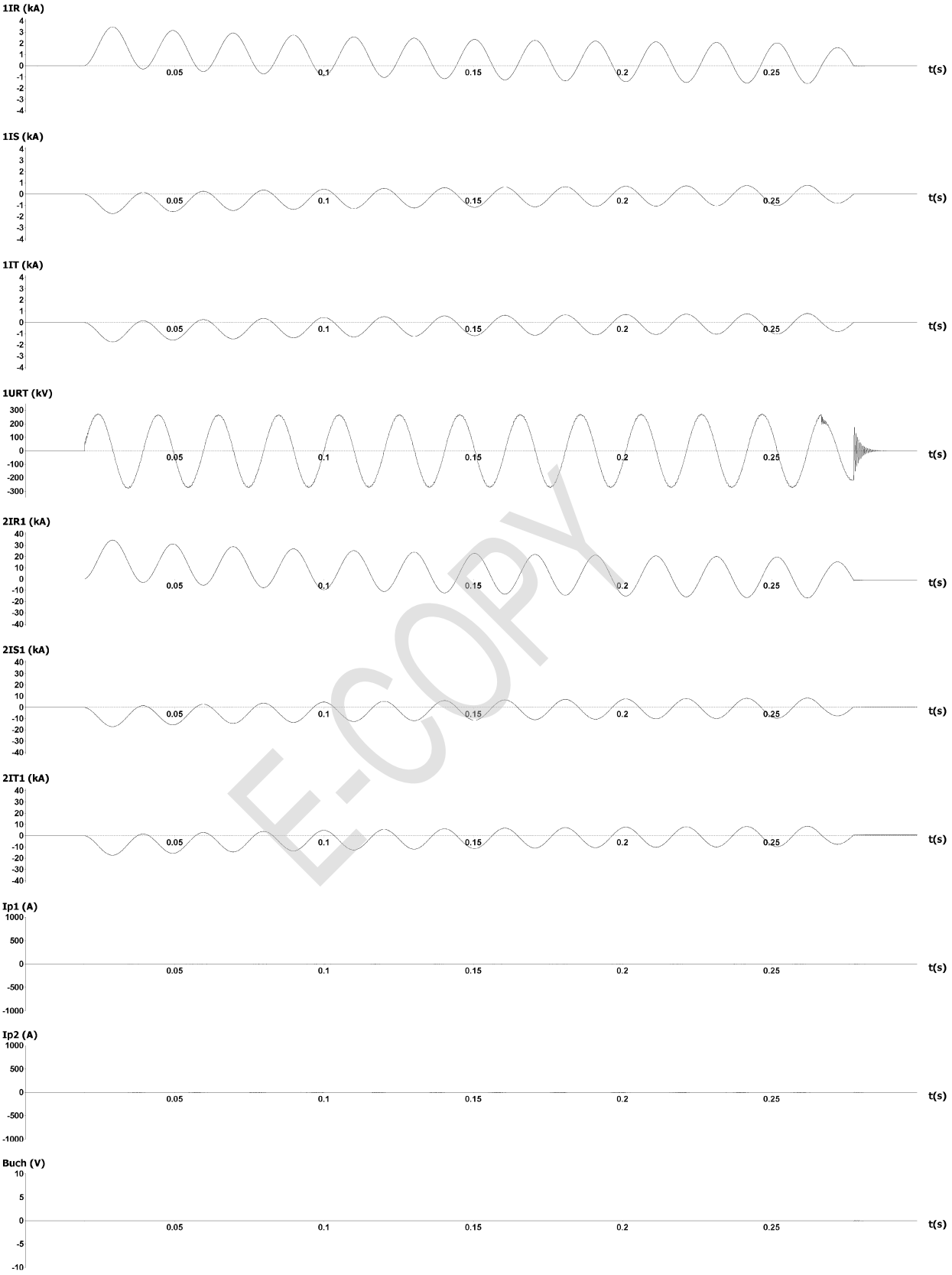

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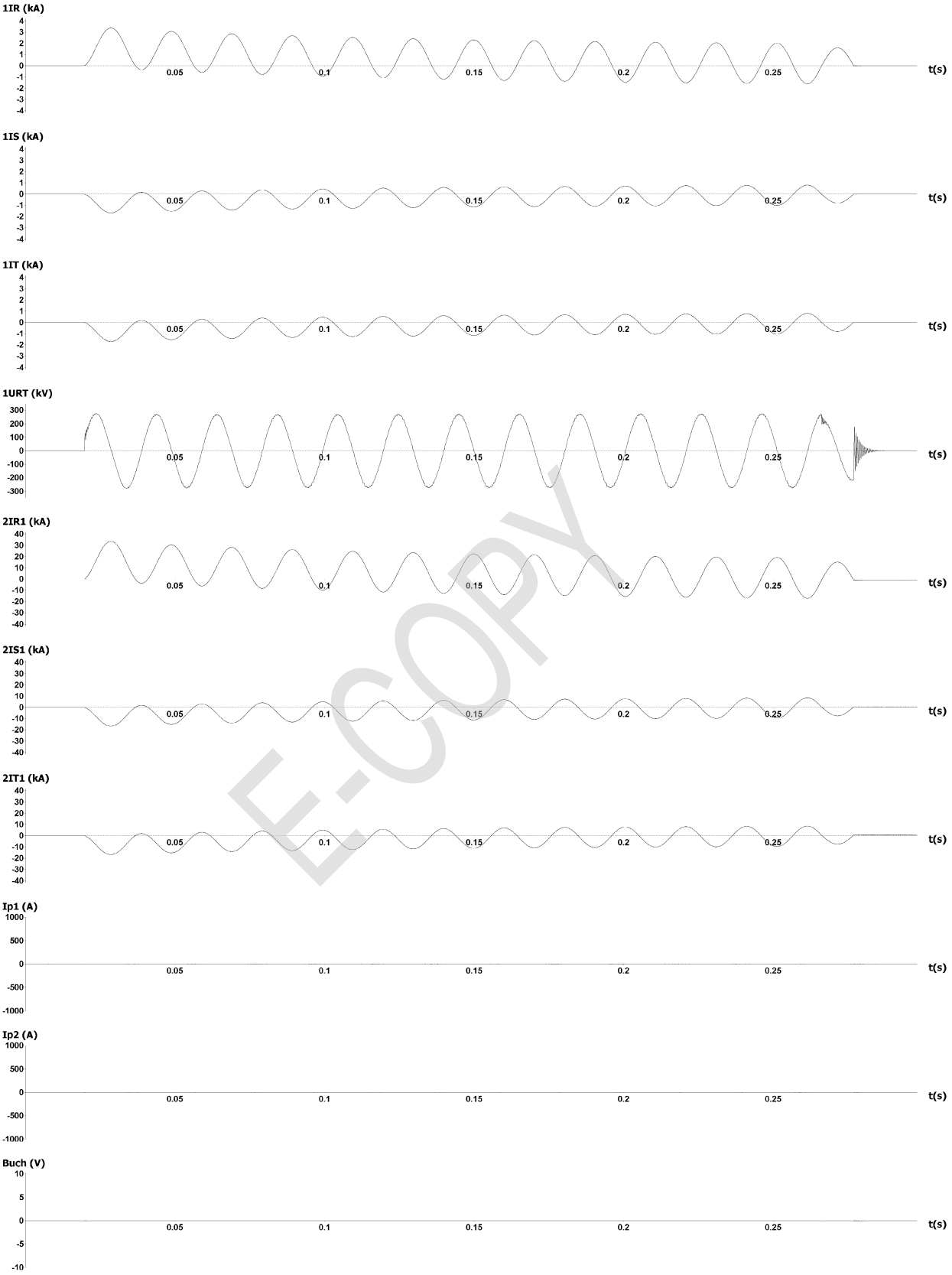

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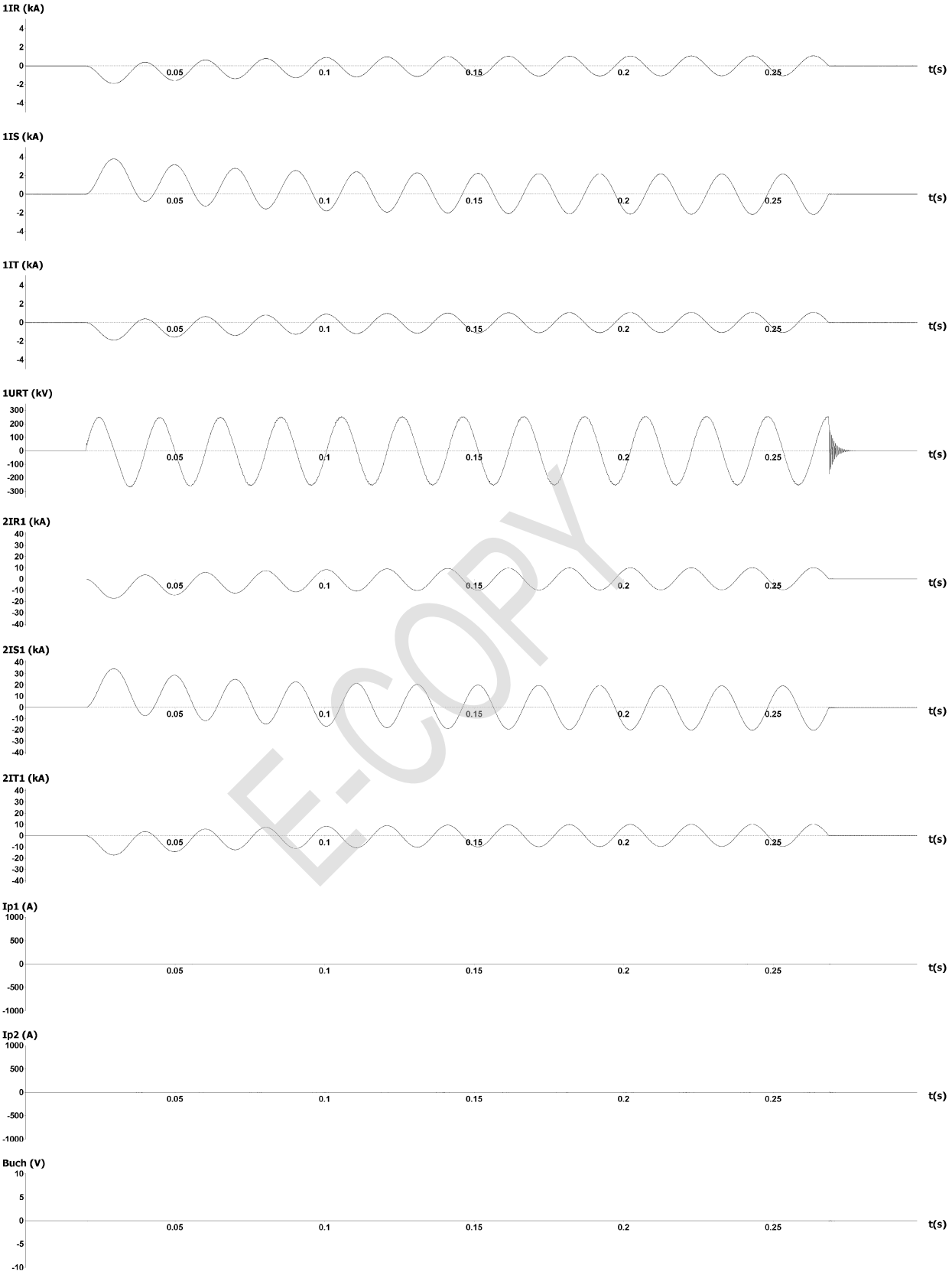

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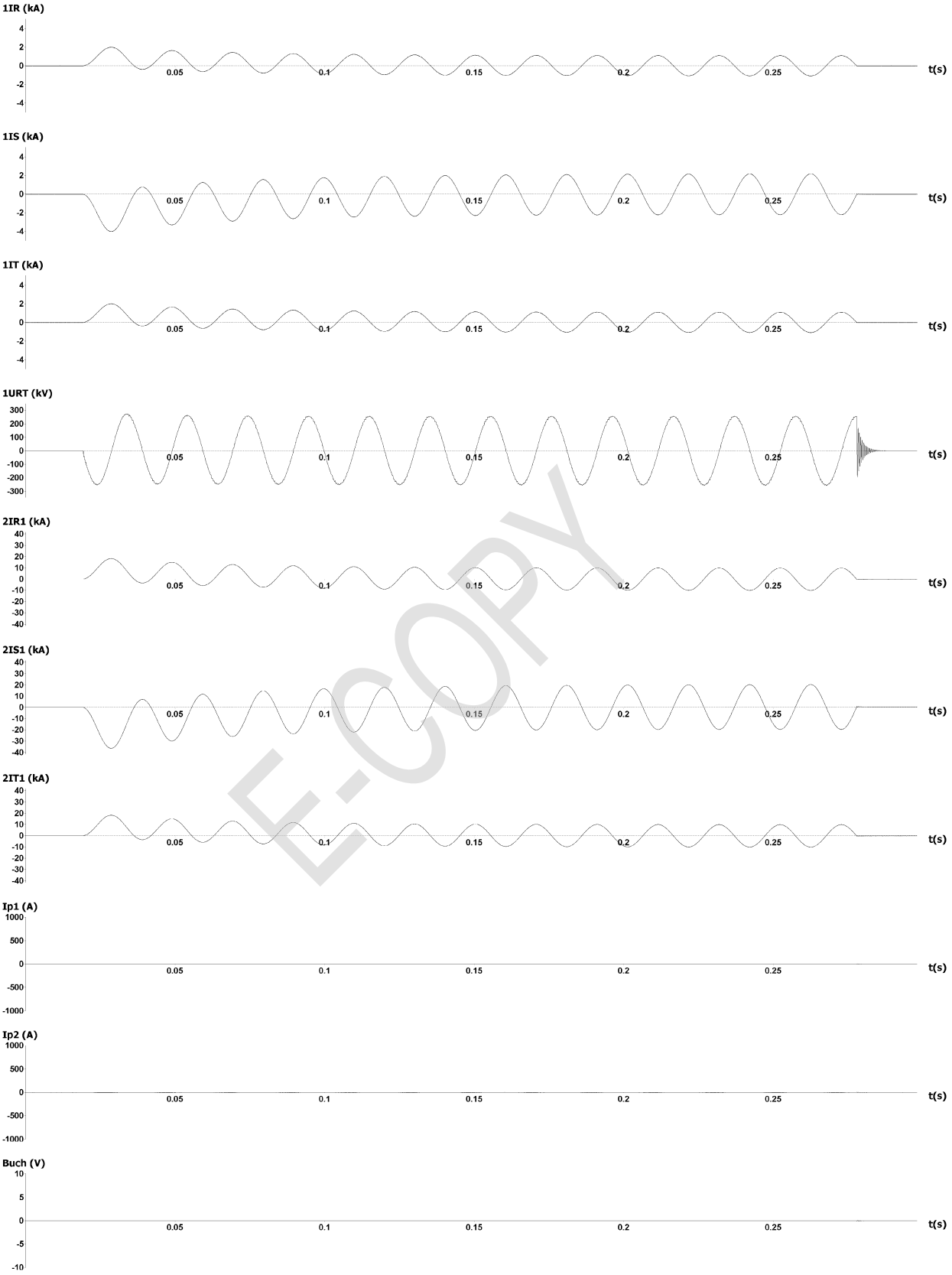

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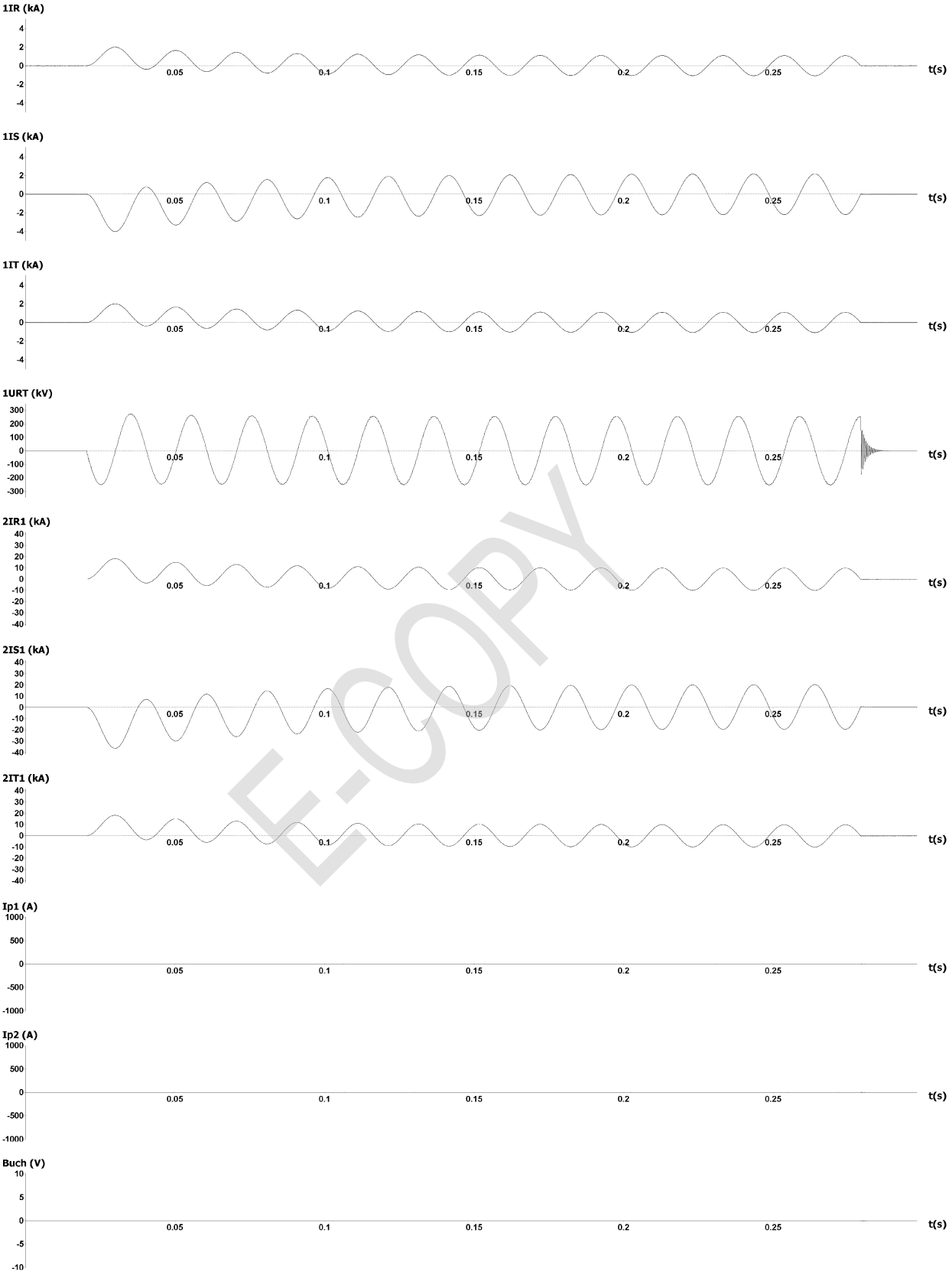

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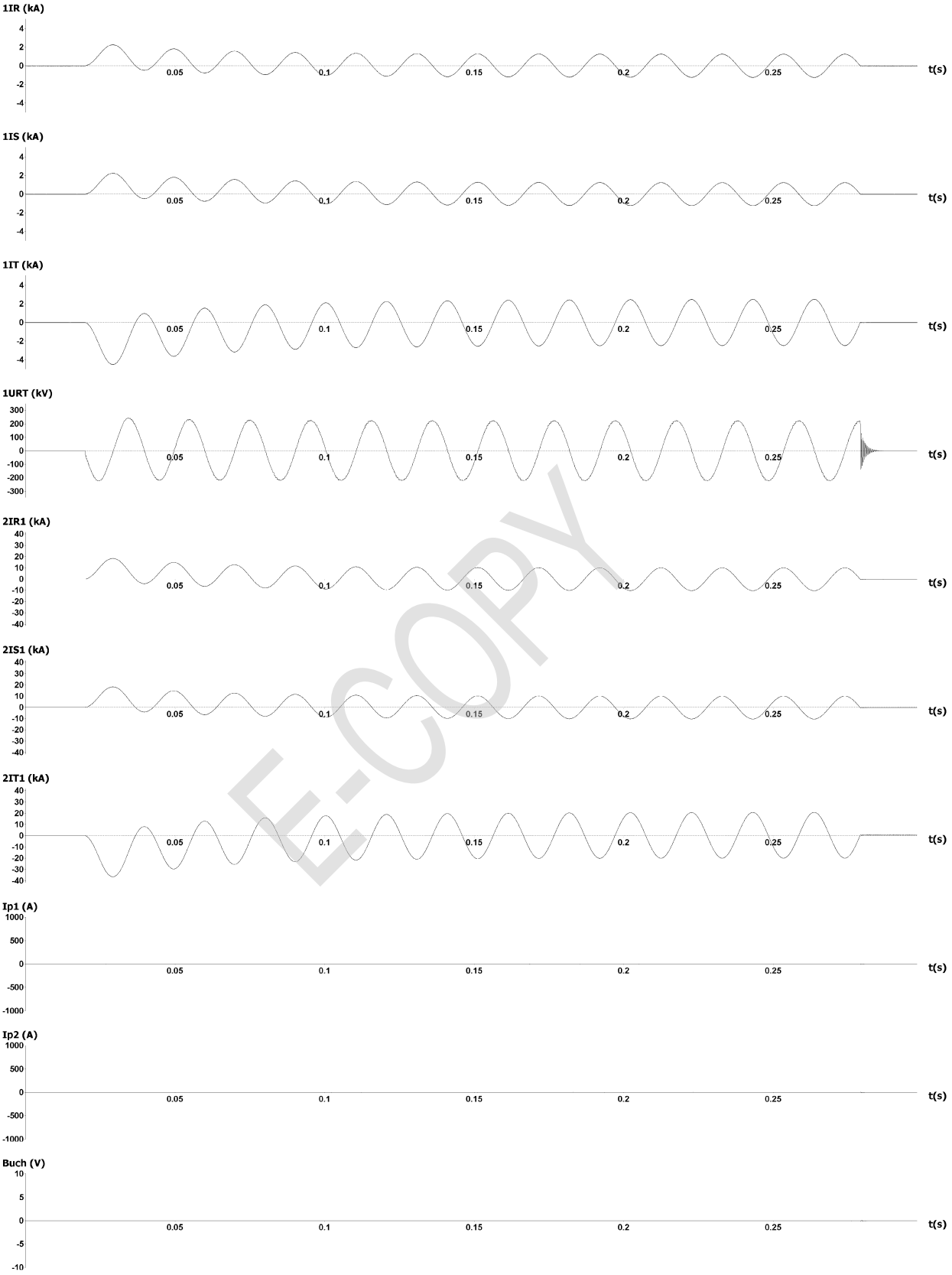

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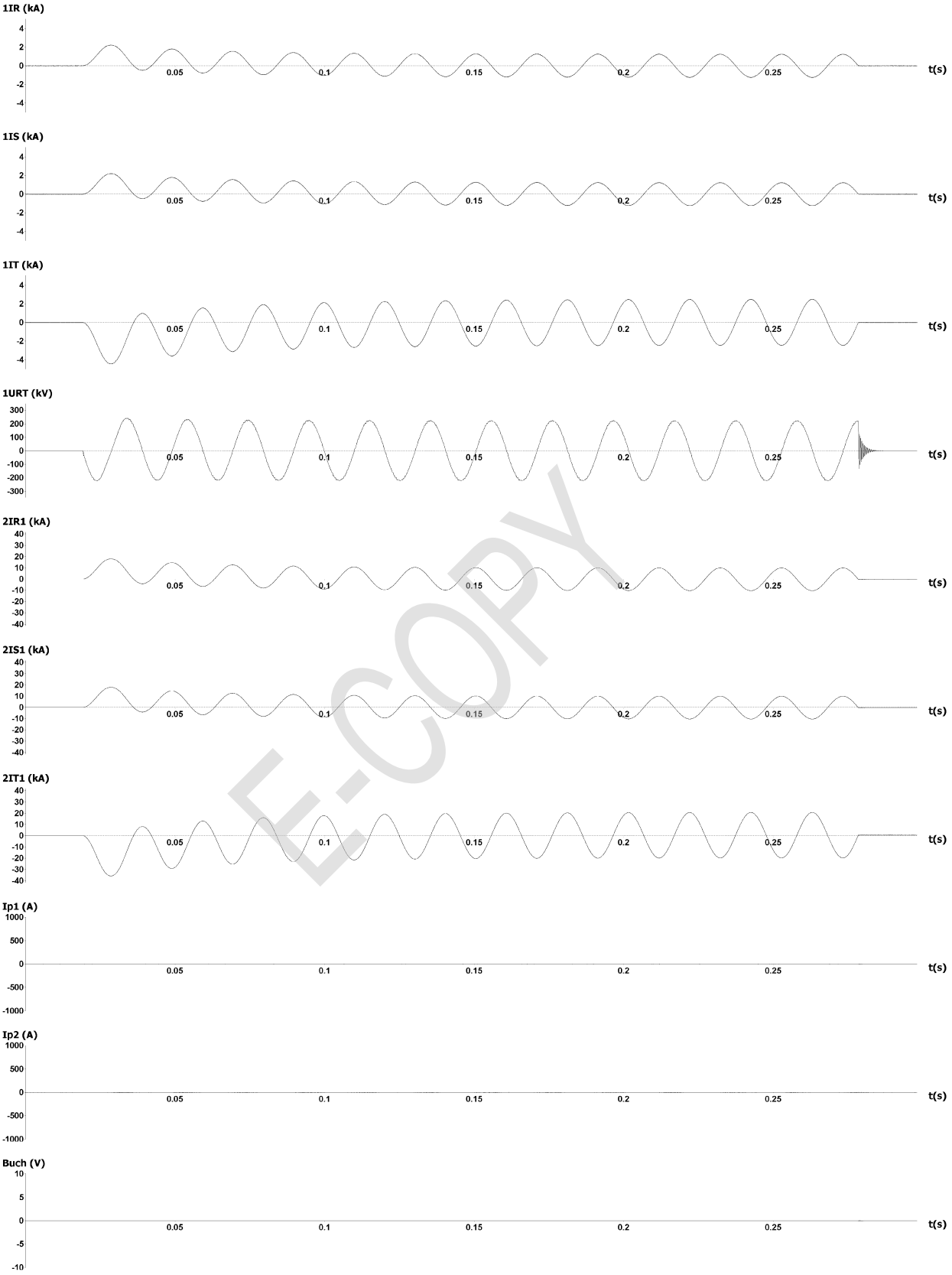

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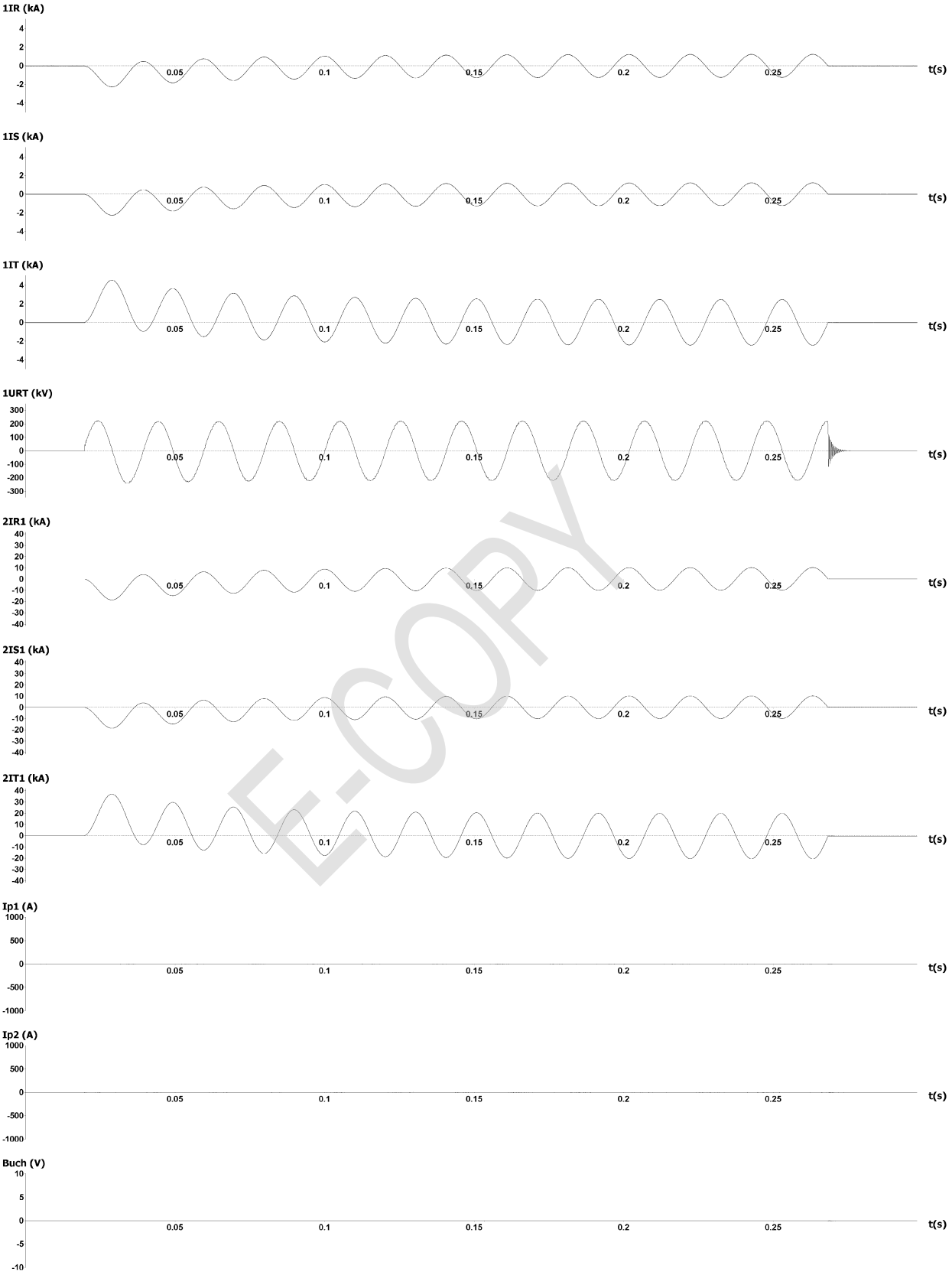

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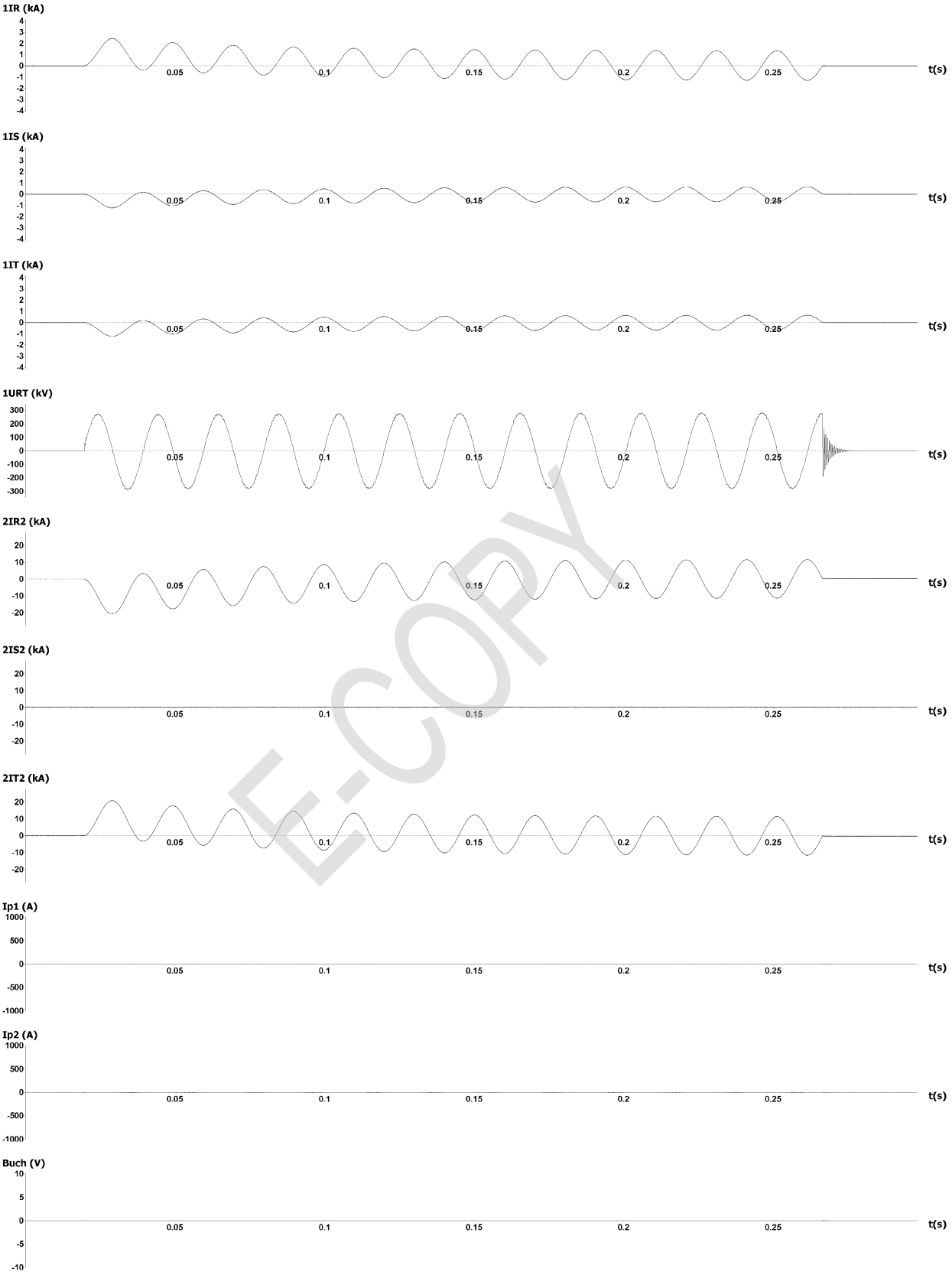
trfa11ia.020



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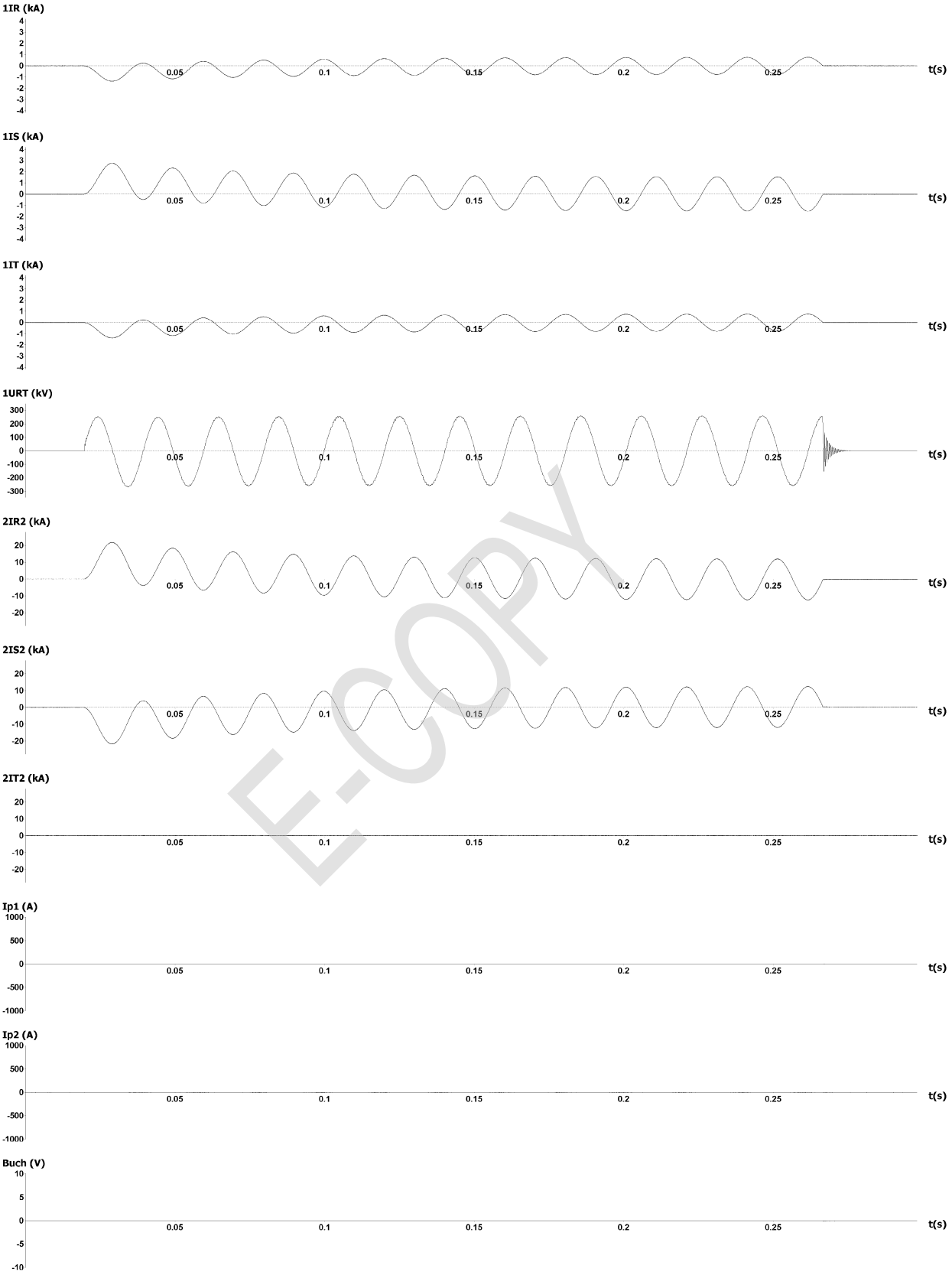

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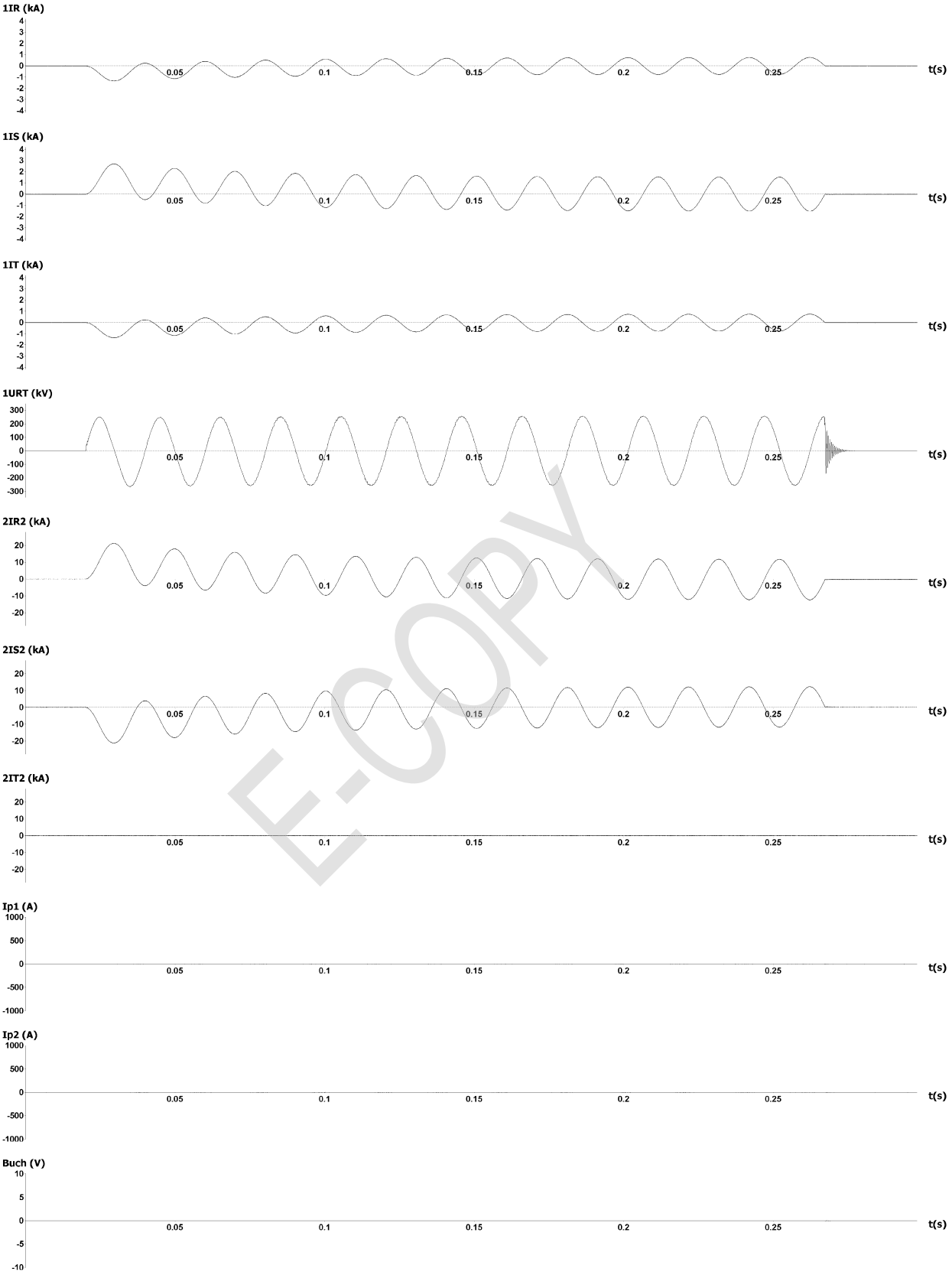

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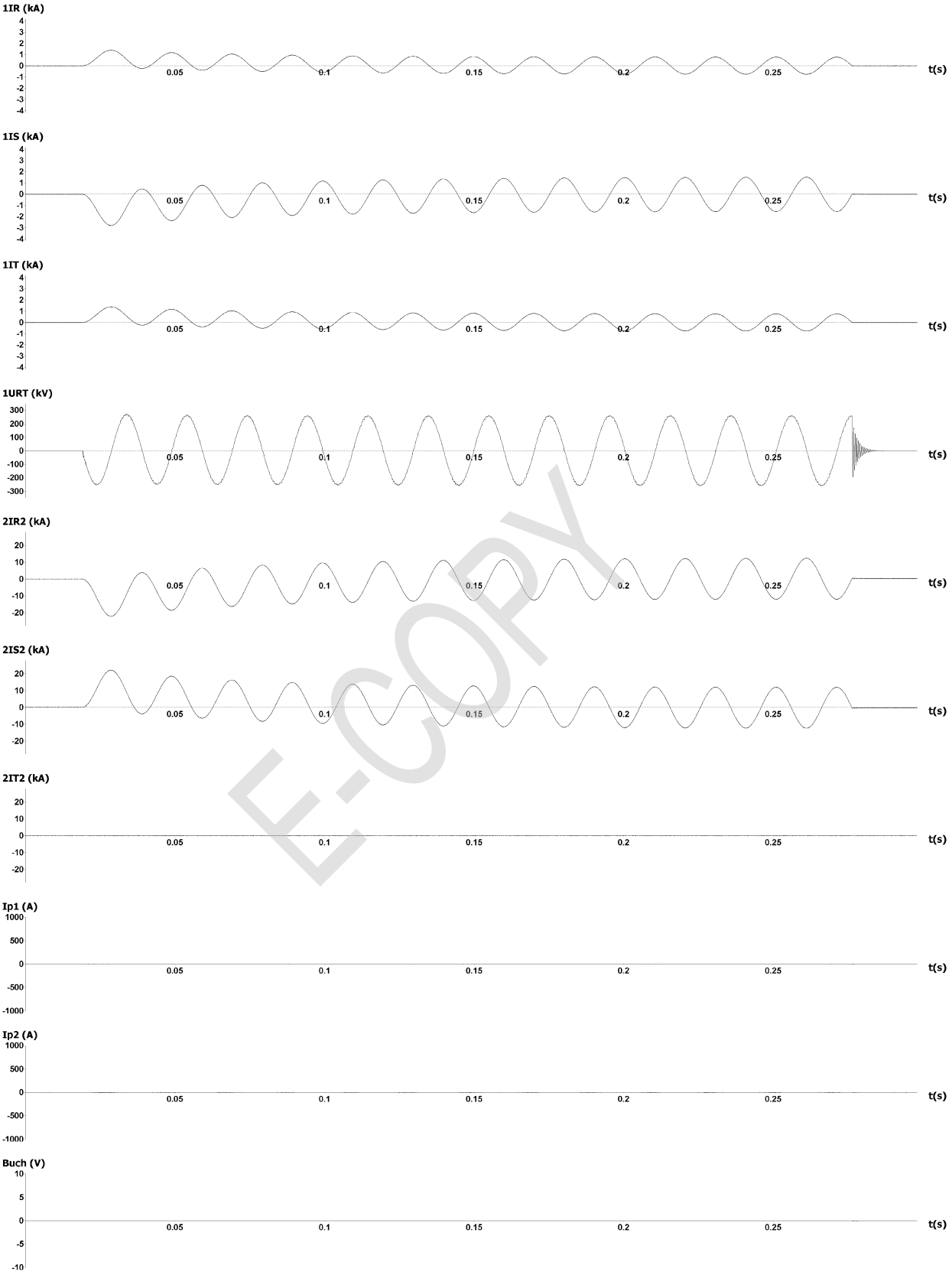

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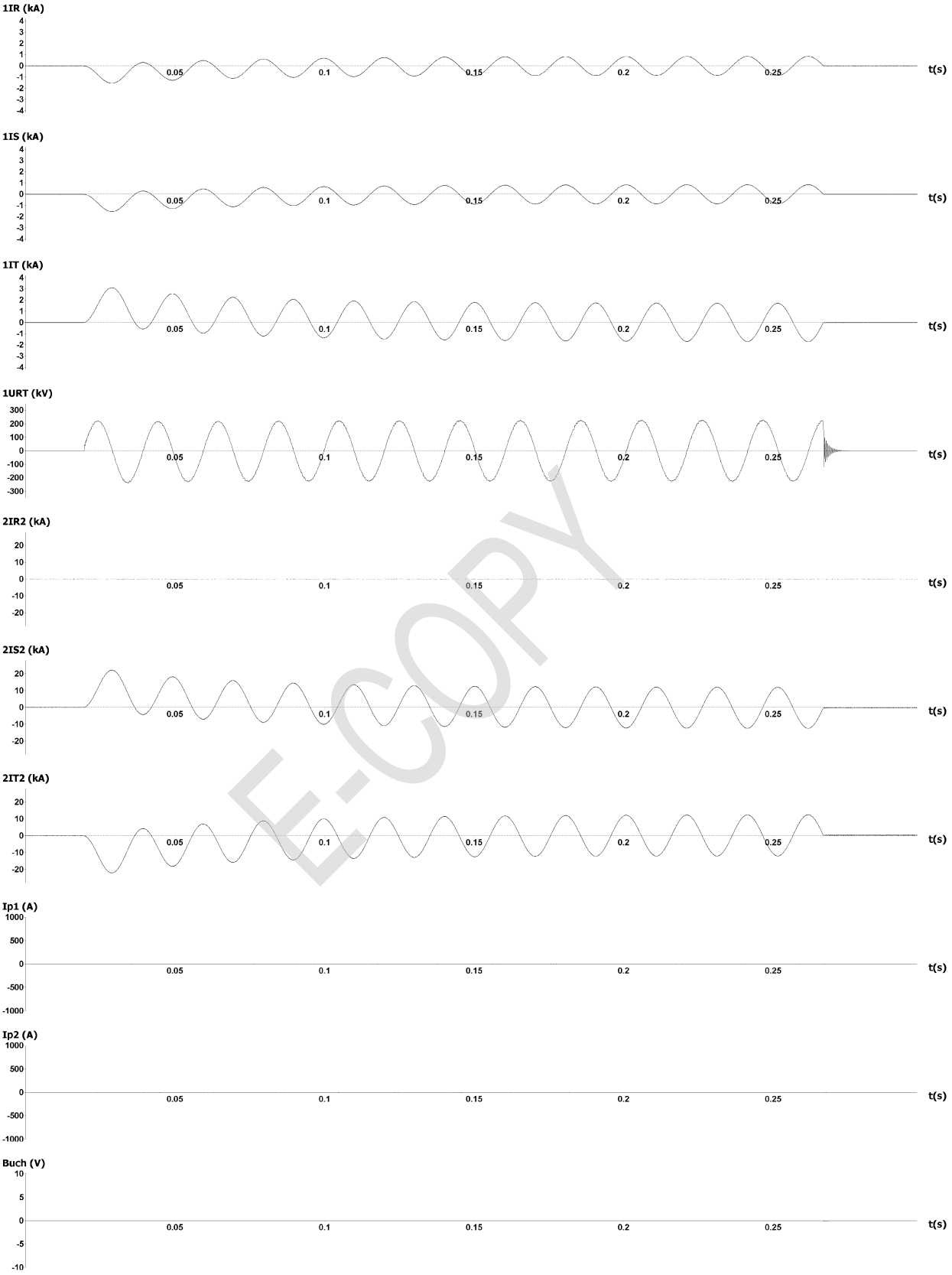

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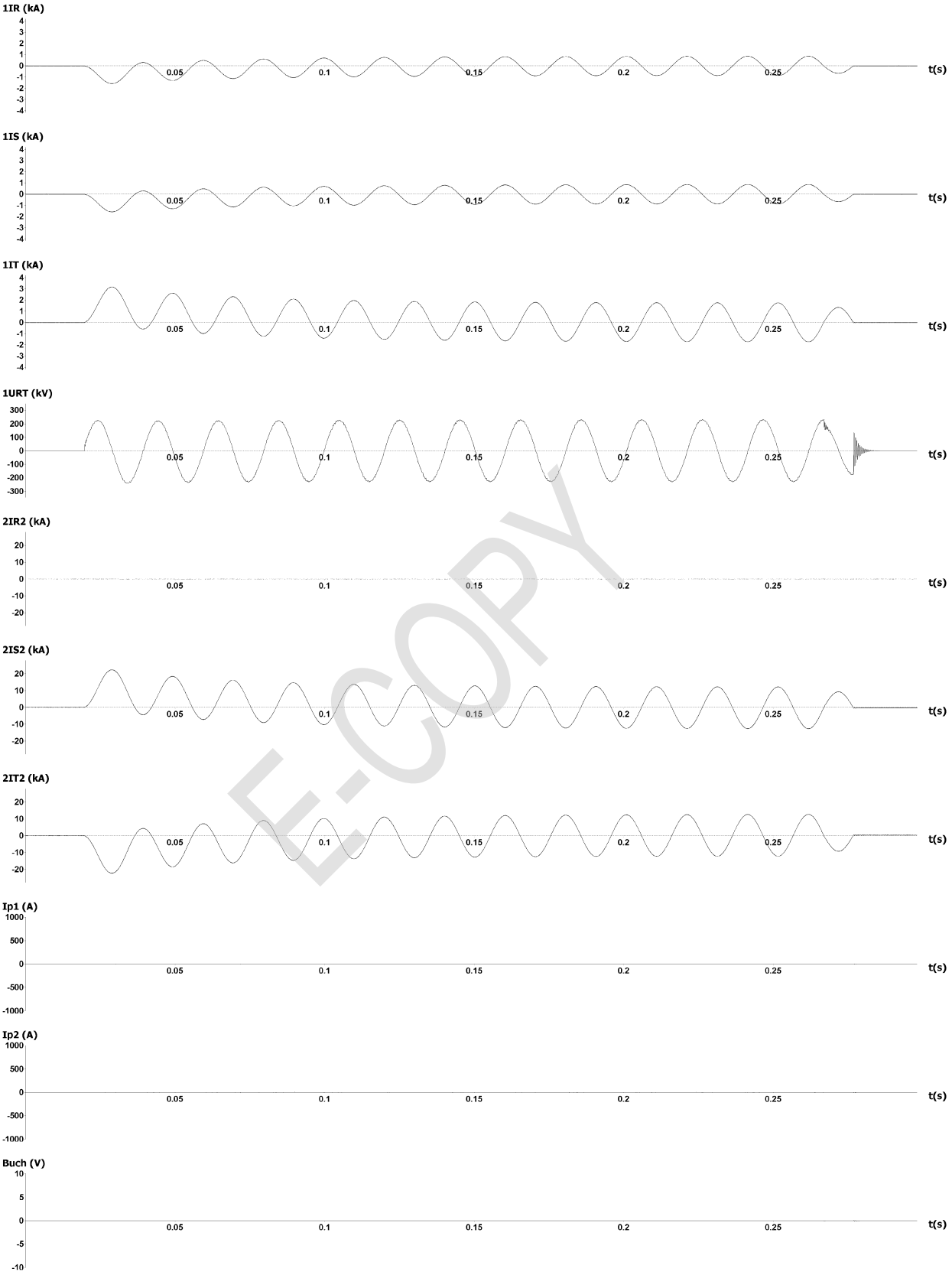

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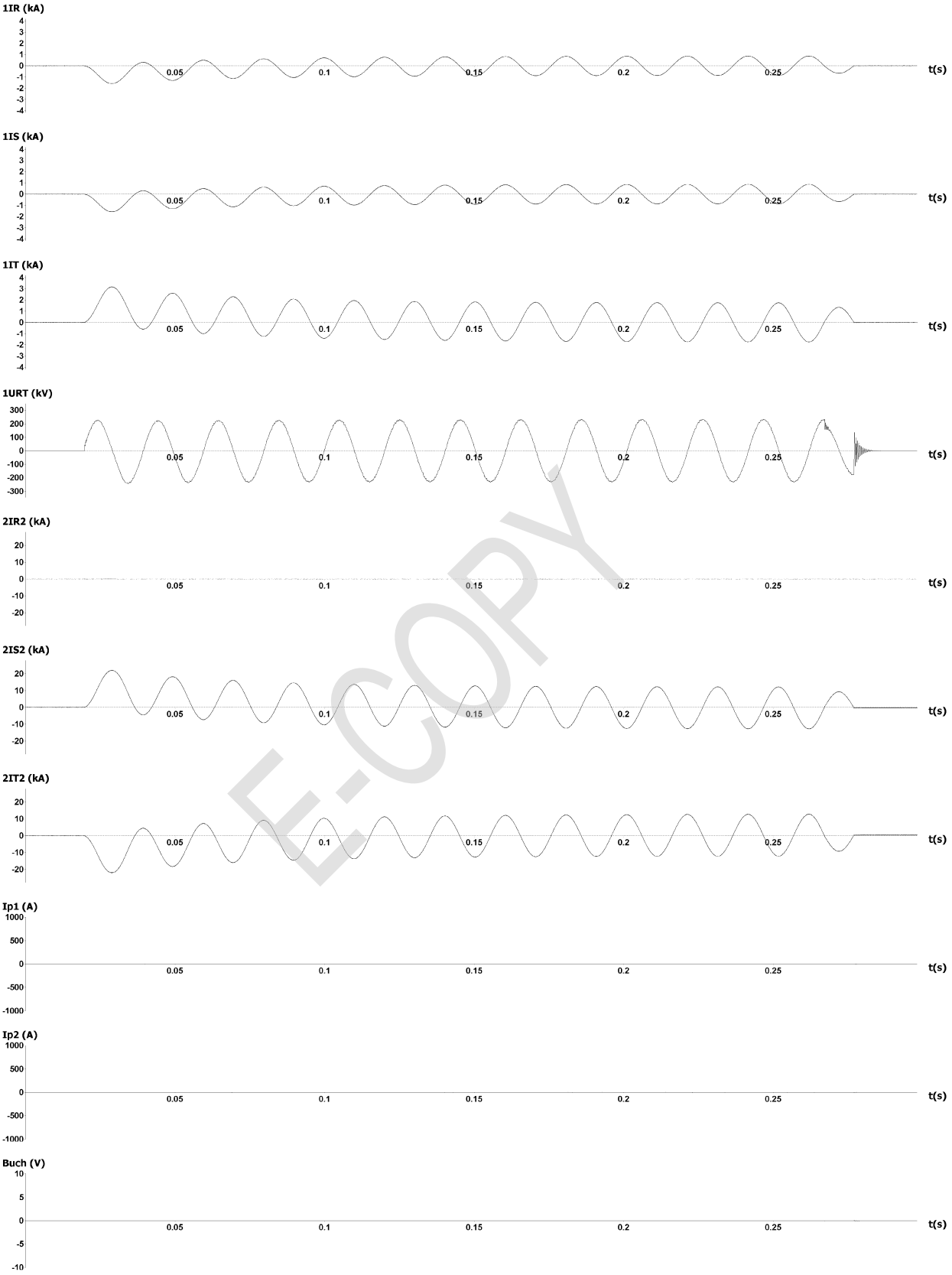
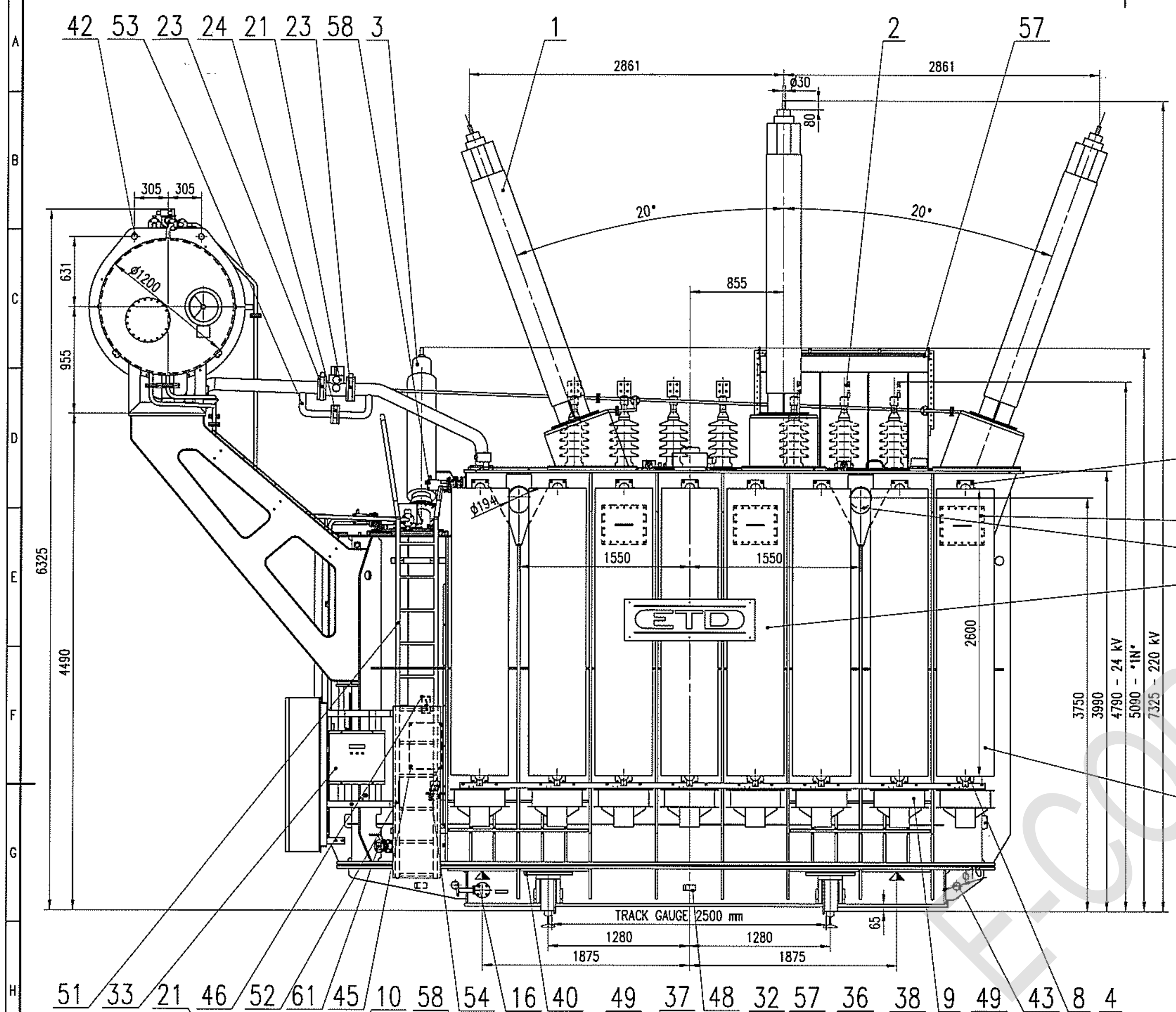
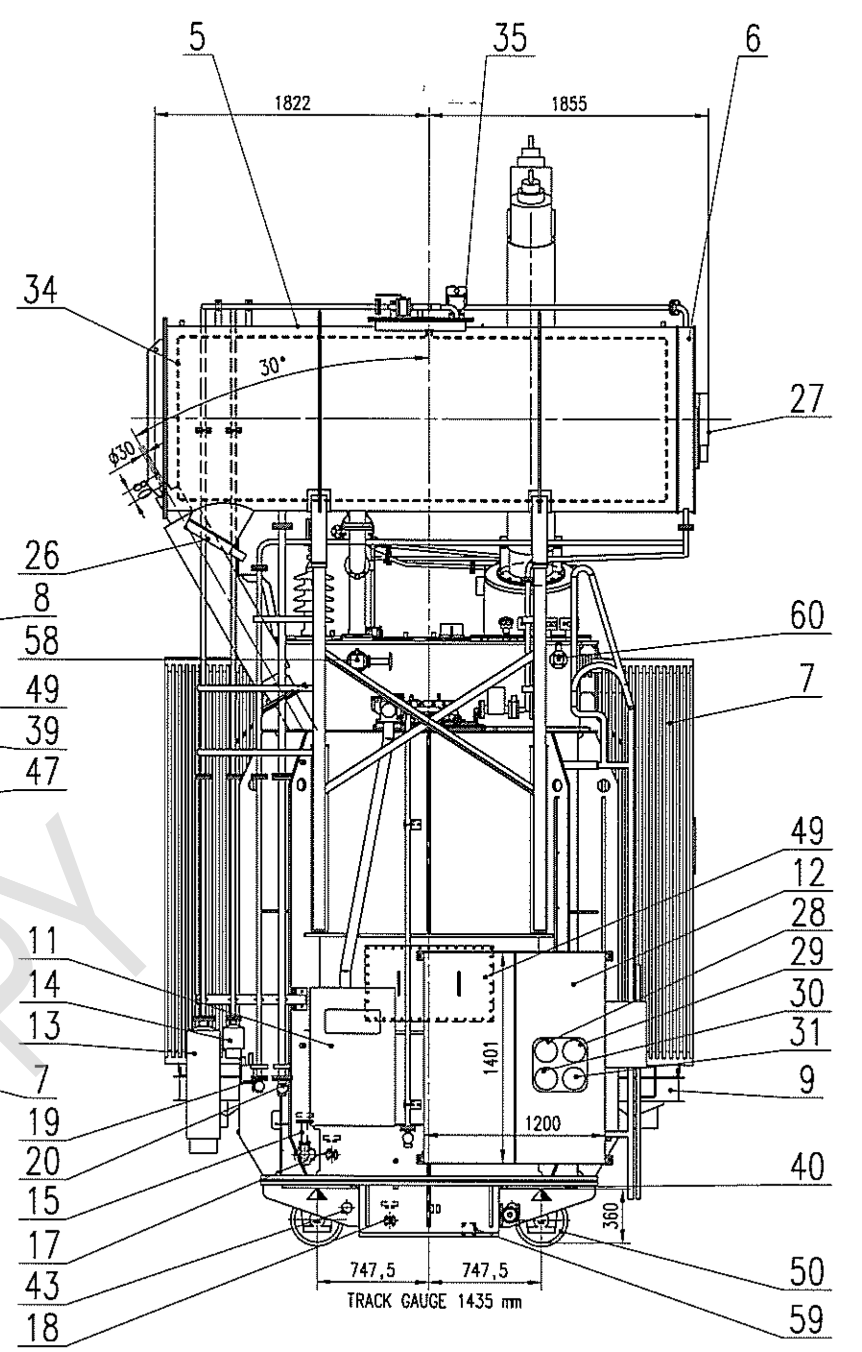
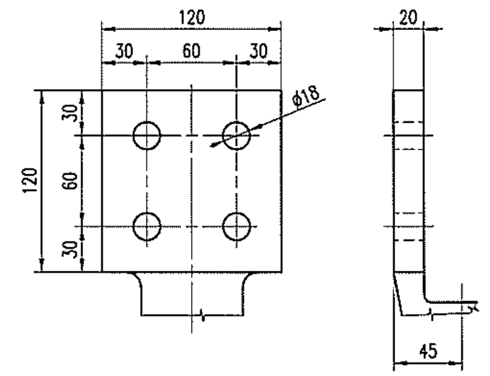


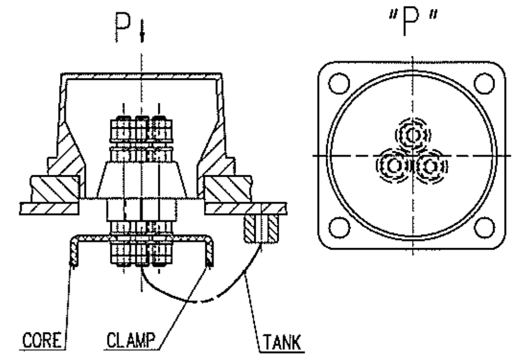




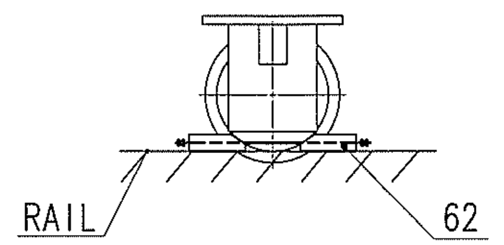
FLAG OF BUSHING 36/3150

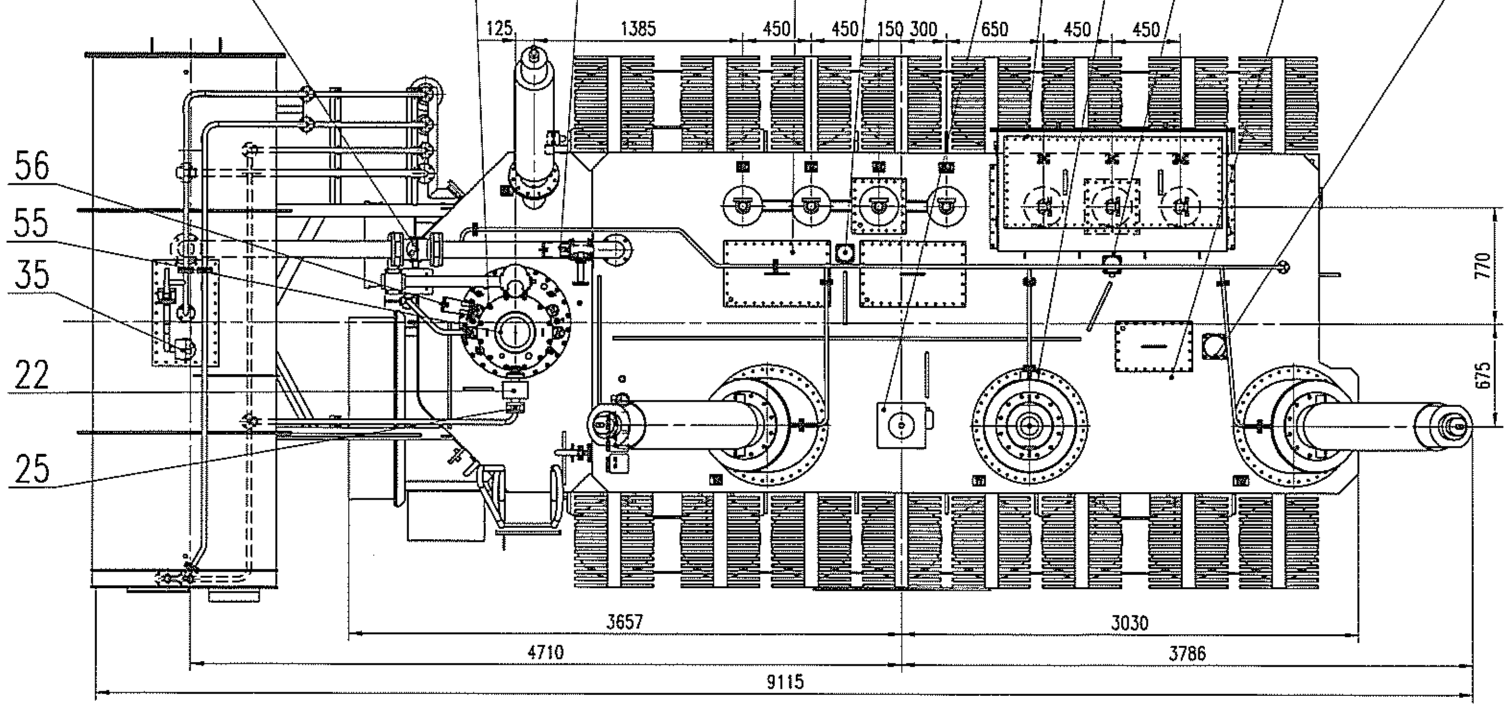


GROUNDING TERMINAL BOX



FIXING FOR RAIL WHEELS

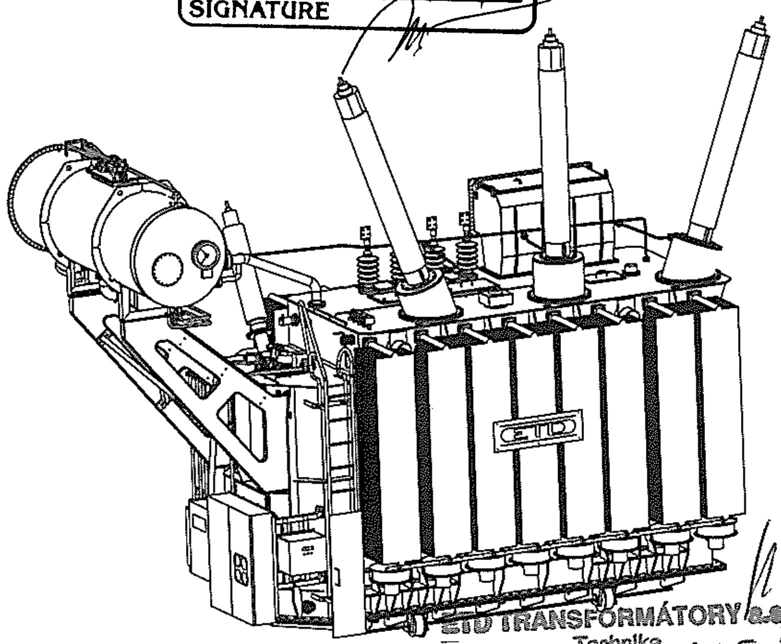




ZKU zkratovna
HIGH POWER LABORATORY
REPORT No. 14-174
SIGNATURE

COLOR: RAL 9006 (SILVER)

OUTPUT	VOLTAGE RATIO		CONNECTION
75/75/25 MVA	220 ± 8x1,25% / 24 / 24 kV	197 / 1804 / 601 A	YNyn0/d5



TRANSFORMER WEIGHT WITH OIL	119 000,- kg
OIL WEIGHT	28 000,- kg
WEIGHT OF ACTIVE PARTS	63 100,- kg
TRANSPORT WEIGHT WITHOUT OIL	82 500,- kg
TRANSPORT WEIGHT WITH OIL	105 000,- kg

LIST OF KOMPONENTS - Eh 9820 Z

VERSION: 27.5.2014

ŠEBESTA
1:25
4.4.2014

ETD TRANSFORMÁTORY a.s.
Technika
Konstrukce 29.5.2014

ETD

TRANSFORMER 75/75/25 MVA

EGYPT SUEZ GULF

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/137 A	Page No.: 1 / No. of pages: 8

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Purchaser:	ETD TRANSFORMÁTORY a.s.	Internal order No.:	765-271-3060

Technical data

Winding:	Output [kVA]:	Voltage [V]:	Current [A]:
1	75000	220000 ±8x1,25%	197
2	75000	24000	1804
3	25000	24000	601

Standard:	IEC 76				
Vector group:	YNyn0/d5	Type of cooling:	ONAN/ONAF$_1$/ONAF$_2$	Sort of loading:	S1
No. of phases:	3	Rated frequency:	50 Hz	Insulation class:	A

Contents:

Technical data 1
Enclosures 1
Tests evaluation 1
Measurement of voltage ratio on all taps 2
Checking of connection symbol 2
Applied voltage test (AV) 2
Switching impulse test 2
Measurement of winding resistance 3
Measurement of winding insulation resistance 4
Measurement of loss factor tg δ and capacitance C of the winding 4
Measurement of loss factor tg δ and capacitance C of the bushings 4
Induced voltage test with partial discharge measurement IVPD 5
Test of transformer oil 5
Test of oil tightness 5
Measurement of no-load loss and current 5
Measurement of load loss and impedance voltage, total loss 6
Measurement of load loss and impedance voltage, total loss 7
Tests on-load tap-changer (OLTC) 8
List of equipment 8

Enclosures

Enclosure to Test Certificate No. ŘJ 14/137 A – Switching impulse test

Tests evaluation

The transformer complied to all tests, carried on according to IEC 76.

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)
19.8.2014	Ing. Langer	Ing. Černý	

TR0008/03/ŘJ

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/137 A	Page No.: 2 / No. of pages: 8

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of voltage ratio on all taps

Checking of connection symbol

For voltage ratio:		220 ±8x1,25% kV (1) 24 kV (2)		220 ±8x1,25% kV (1) 24 kV (3)	
Connect. symbol corresponds:		YNyn0		YNd5	
No. of tap:	Winding [V]:	For voltage ratio:	Failing of ratio [%]:	For voltage ratio:	Failing of ratio [%]:
1	242000	10,083	-0,04	5,822	0,19
2	239250	9,969	-0,04	5,755	0,19
3	236500	9,854	-0,03	5,689	0,20
4	233750	9,740	-0,03	5,623	0,20
5	231000	9,625	-0,02	5,557	0,21
6	228250	9,510	-0,02	5,491	0,21
7	225500	9,396	-0,01	5,425	0,22
8	222750	9,281	-0,01	5,359	0,22
9a	220000	9,167	0,00	5,292	0,23
9b	220000	9,167	0,00	5,292	0,23
9c	220000	9,167	0,00	5,292	0,23
10	217250	9,052	0,01	5,226	0,24
11	214500	8,938	0,01	5,160	0,24
12	211750	8,823	0,02	5,094	0,25
13	209000	8,708	0,03	5,028	0,26
14	206250	8,594	0,03	4,962	0,26
15	203500	8,479	0,04	4,895	0,27
16	200750	8,365	0,05	4,829	0,28
17	198000	8,250	0,05	4,763	0,28

Applied voltage test (AV)

On the tested winding is applied the voltage $U_{test.}$ [kV] , f = 50 Hz , t = 60 s against the tank and other windings.

Tested winding:	220 kV(1)	24 kV (2)	24 kV (3)				
Testing voltage $U_{test.}$[kV]:	230	50	50				

Switching impulse test

Tested procedure: 1 ref. impulse (50% Utest) , 3 full impulses (100% Utest)

Tested windings:	220 kV		
Terminals:	1U, 1V, 1W		
Testing voltage U_{test} [kV]:	850		

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
19.8.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/137 A	Page No.: 3 / No. of pages: 8

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of winding resistance

Quoted value of winding resistance R [Ω] at temperature 20 °C

Winding: No. of tap:	1U-1N	1V-1N	1W-1N	Winding: No. of tap:	2U-2N	2V-2N	2W-2N
220 kV (1) / 1	0,858	0,860	0,858	24 kV(2) / -	0,00750	0,00748	0,00753
2	0,840	0,842	0,840				
3	0,823	0,824	0,823	24 kV(3) / -	3U-3V	3U-3W	3V-3W
4	0,805	0,806	0,805		0,0380	0,0381	0,0379
5	0,787	0,788	0,787				
6	0,769	0,770	0,769				
7	0,751	0,753	0,751				
8	0,733	0,735	0,733				
9a	0,715	0,715	0,713				
9b	0,714	0,715	0,713				
9c	0,751	0,751	0,751				
10	0,733	0,734	0,733				
11	0,715	0,716	0,715				
12	0,697	0,698	0,697				
13	0,679	0,680	0,679				
14	0,661	0,662	0,662				
15	0,644	0,644	0,644				
16	0,626	0,626	0,626				
17	0,607	0,607	0,606				

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
19.8.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/137 A	Page No.: 4 / No. of pages: 8

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of winding insulation resistance

Measurement of loss factor tg δ and capacitance C of the winding

Measured at winding temperature: 23 °C				Measured at winding temperature: 23 °C		
Connection at measurement:		$U_{test.}$ = 2500 V_{DC}			$U_{test.}$ = 10000 V/50 Hz	
* remaining windings connected to transf. tank		$R_{insulating}$ [MΩ]		Connection at measurement:	C [nF]	tg δ [%]
		15 s	60 s	(1) – (2) + (3) + tank	11,24	0,25
220 kV (1)	/ tank + *	3574	4640	(1) – (3) + tank	4,616	0,3
24 kV (2)	/ tank + *	1426	2225	(1) – (2)	6,629	0,21
24 kV (3)	/ tank + *	1141	2169	(2) – (1) + (3) + tank	27,99	0,22
(1) + (2)	/ tank + *	1644	2638	(2) – (1) + tank	7,857	0,25
(1) + (3)	/ tank + *	977	1655	(2) – (3)	20,13	0,21
(2) + (3)	/ tank + *	2131	3357	(3) – (1) + (2) + tank	36,95	0,24
(1) + (2) + (3)	/ tank + *	2399	3588	(3) – (2) + tank	36,81	0,24
core (U_{test}=1000 V_{DC})	/ tank + *	1569	2372	(3) – (1)	0,1368	0,55
frame (U_{test}=1000 V_{DC})	/ tank + *	2298	3055	(1) – tank	4,479	0,29
				(2) – tank	1,228	0,44
				(3) – tank	16,68	0,29

Measurement of loss factor tg δ and capacitance C of the bushings

Measured at winding temperature: 23 °C

Terminal / Serial No.		1U		1V		1W		1N	
Connection at measurement:	Utest	C_1[pF]	tg δ_1[%]	C_1[pF]	tg δ_1[%]	C_1[pF]	tg δ_1[%]	C_1[pF]	tg δ_1[%]
Terminal - Power factor tap	2 kV	327	0,22	330	0,22	330,6	0,23	253,1	0,23
	4 kV	327	0,22	330	0,22	330,6	0,23	253,1	0,23
	6 kV	327	0,22	330	0,22	330,6	0,23	253,1	0,23
	8 kV	327	0,22	330	0,22	330,6	0,23	253,1	0,23
	10 kV	327	0,22	330	0,22	330,6	0,23	253,1	0,23
Connection at measurement:	Utest	C_2[pF]	tg δ_2[%]	C_2[pF]	tg δ_2[%]	C_2[pF]	tg δ_2[%]	C_2[pF]	tg δ_2[%]
Power factor tap - tank	2 kV	633	0,33	601,2	0,23	610,2	0,28	454,2	0,3

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
19.8.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/137 A	Page No.: 5 / No. of pages: 8

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Induced voltage test with partial discharge measurement IVPD

Testing voltage $U_{TEST.}$ = 396 kV was induced between terminals of winding 220 kV at f = 125 Hz for time t = 48 sec.
(U_r = 220 kV, U_m = 245kV)

Three-phase test		Background noise	Testing voltage course: 1,2Ur/√3	1,58Ur/√3	1,8 Ur/√3	1,58 Ur/√3											1,2 Ur/√3	Background noise 0,4 Ur/√3
Testing voltage „phase – phase" $U_{TEST.}$ [kV]			264	347,6	396	347,6											264	
Voltage phase - earth at test U/√3[kV]			152,4	200,7	228,6	200,7											152,4	
Measured:	Test time t [s]		60	300	48	300	300	300	300	300	300	300	300	300	300	300	60	
1U	Apparent charge [pC]	14	110	100	150	150	250	300	200	200	170	160	145	145	145	150	130	25
1V	Apparent charge [pC]	35	60	60	100	10	100	12	13	0130	150	150	95	100	100	100	90	80	34
1W	Apparent charge [pC]	14	90	60	80	100	100	190	200	200	130	130	140	150	150	120	150	50	16

Test of transformer oil

Oil type:	SHELL DIALA S3 ZX-I		tg δ [%/90 °C]:	0,19	ρ_V [GΩm/90 °C]:	140,3	ε_r [-]:	2,14
Tr. tank:	Water content in oil[ppm]:	4	U_p [kV/2,5mm]:	78,2	s [kV/2,5mm]:	8,1	V [%]:	10,36
Tap changer:	Water content in oil[ppm]:	9	U_p [kV/2,5mm]:	70,5	s [kV/2,5mm]:	9,8	V [%]:	13,9

Test of oil tightness

The test carried out for 48 hours + 24 hours duration from last tigtness repair.

tank / external space .... with overpressure 40 kPa

Measurement of no-load loss and current

Measured values:					Guaranteed values:	
Energized winding 24 kV					tol.+30 %	tol.+15 %
U [V]	u [%]	I_0 [A]	i_0 [%]	ΔP_0 [kW]	i_0 [%]	ΔP_0 [kW]
26397	110	6,7	0,37	50,6		
25201	105	2,0	0,11	38,7		
24007	100	1,1	0,06	32,6	0,2	34
22813	95	0,8	0,05	28,3		
21599	90	0,7	0,04	24,8		

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
19.8.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

TR0008/03/ŘJ

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/137 A	Page No.: 6 / No. of pages: 8

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of load loss and impedance voltage, total loss

Values for winding temperature 95 °C

Measured values:								Guaranteed values:		
							$\Delta P_0+\Delta P_k$	tol.±7,5%	tol.+15%	tol.+10%
Energized winding:		Short-circ. winding:		For output:	u_k	ΔP_k	$\Sigma \Delta P$	u_k	ΔP_k	$\Sigma \Delta P$
	Tap No.:		Tap No.:	S [kVA]	[%]	[kW]	[kW]	[%]	[kW]	[kW]
(1)	1	(2)	-	75000	13,16	227,9				
	2				13,09	227,3				
	3				13,00	226,7				
	4				12,90	226,3				
	5				12,80	225,8				
	6				12,69	225,4				
	7				12,59	224,9				
	8				12,50	224,8				
	9a				12,43	224,5				
	9b				12,43	224,2	256,8	12,5	230	264
	9c				12,47	230,6				
	10				12,41	229,9				
	11				12,34	229,4				
	12				12,27	228,9				
	13				12,20	228,6				
	14				12,12	228,1				
	15				12,04	227,6				
	16				11,97	227,1				
	17				11,91	226,9				
Calculated load loss … 220 kV (1) / 24 kV (2) / 24 kV (3) … 75 / 50 /25 MVA According to IEC 60076-8 article 7.7.1.										
						202,0	234,6	-	210	244

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137
SIGNATURE

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19.8.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/137 A	Page No.: 7 / No. of pages: 8

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of load loss and impedance voltage, total loss

Values for winding temperature 95 °C

Measured values:								Guaranteed values:		
							$\Delta P_0+\Delta P_k$			
Energized winding:		Short-circ. winding:		For output:	* u_k	ΔP_k	$\sum \Delta P$	* u_k	ΔP_k	$\sum \Delta P$
	Tap No.:		Tap No.:	S [kVA]	[%]	[kW]	[kW]	[%]	[kW]	[kW]
(1)	1	(3)	-	25000	18,51	43,73				
	2				18,43	43,64				
	3				18,33	43,56				
	4				18,23	43,46				
	5				18,12	43,41				
	6				18,02	43,33				
	7				17,92	43,30				
	8				17,83	43,27				
	9a				17,77	43,28				
	9b				17,77	43,07	75,67	18 tol.±10%	-	-
	9c				17,81	43,95				
	10				17,74	43,82				
	11				17,67	43,73				
	12				17,59	43,64				
	13				17,51	43,59				
	14				17,43	43,52				
	15				17,35	43,47				
	16				17,29	43,44				
	17				17,24	43,39				
(2)	-	(3)	-	25000	3,80	38,3	70,9	3,5 tol.±15%	-	-

* uk … calculated for 75 MVA

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
19.8.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Tests on-load tap-changer (OLTC)

a) 8 complete operating cycles with transformer not energized;
b) 1 complete operating cycle with transformer not energized, with 85 % of the rated auxiliary supply voltage;
c) 1 complete operating cycle with the transformer energized at rated voltage and frequency at nop-load;
d) 10 tap-change operations with ±2 steps on either side of the principal tapping with as far as possible the rated current of the transformer, with one winding short – circuited.

List of equipment

Meters:	Fab. No.:	Date of calibration:	Date next calibration:	Pasport No.:
Current measurement transformer TETTEX 4874 sp.	A32370	04.02.2014	04.02.2015	ŘJ 14/012
Voltage measurement transformer EPRO NVOS 50	2/12/3738-3740	04.02.2014	04.02.2015	ŘJ 14/003
Power analyzer NORMA 5000-PP64	WO15590BA	23.12.2013	23.12.2014	3892/13/A
Multimeter AGILENT 34970A	MY44033442	25.01.2014	25.01.2015	158/14/A
Ratio and vector groupe NORMA	1788315	13.12.2013	13.12.2015	3895/13/A
Megaohmmeter C.A 6547	100927CAH	02.04.2013	02.04.2015	1153/13/A
Kilovoltmeter MU17+A2	884764	22.04.2014	22.04.2016	1647/14/A
Divider HIGHVOLT 250 kV - AC	884766, 884767	16.04.2014	16.04.2016	ŘJ 14/044
Calibrator PD TETTEX 3216WG	143595	04.11.2013	04.11.2014	ŘJ 13/247
Kilovoltmeter HAEFELY 2000 kV	12100015.60.1÷2 12100015.65.1	13.08.2012	13.08.2017	12100015.60.1-2 12100015.65.1
Measuring device HAEFELY HiAS 743	176632	17.02.2014	17.02.2016	1076/14/A
Capacitor HAEFELY 695 nF	12100015.90.1	27.08.2012	27.08.2017	12100015.90.1
Bridge TETTEX 2816/5284u	145663	06.02.2014	06.02.2016	42/14/S
Dieltest of oil BAUR DTA 100	952922008	10.10.2013	10.10.2015	ŘJ 13/232
Aquameter BAUR KFM 1000 S	959713011	21.04.2014	21.04.2016	ŘJ 14/066
Schering bridge TETTEX 2801	121510	16.06.2014	16.06.2017	2375/14/A
Teraohmmeter SEFELEC M1500 UFA	676	23.06.2014	23.06.2017	2384/14/A

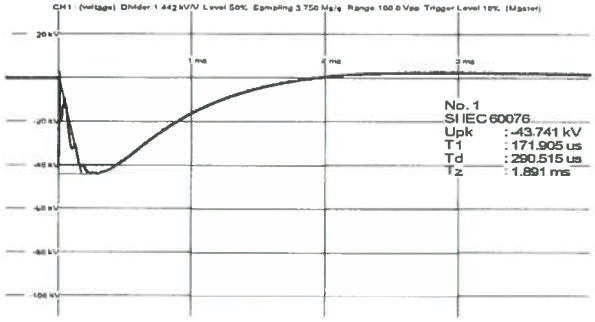
Date:	Testing engineer:	Head of laboratory:	
19.8.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

Enclosure to protocol No. ŘJ 14/137A
Switching impulse test

ETD TRANSFORMÁTORY a.s.

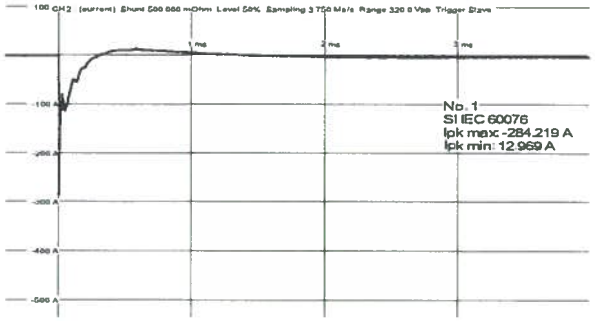
Work No.: 0969196 Temperature: 24 °C Pressure: 733,5 mmHg

1U,TAP NO.1 CH: 1



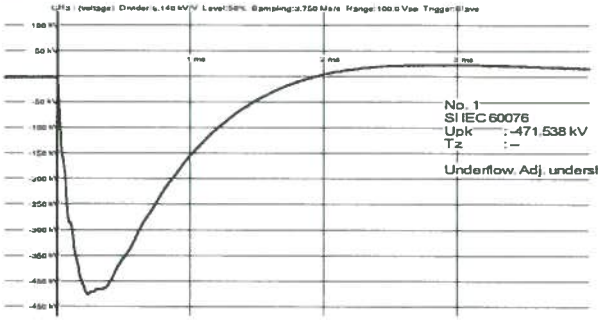
No. 1 SI IEC 60076 Upk: -43.741 kV T1: 171.905 us Td: 290.515 us Tz: 1.891

1U,TAP NO.1 CH: 2



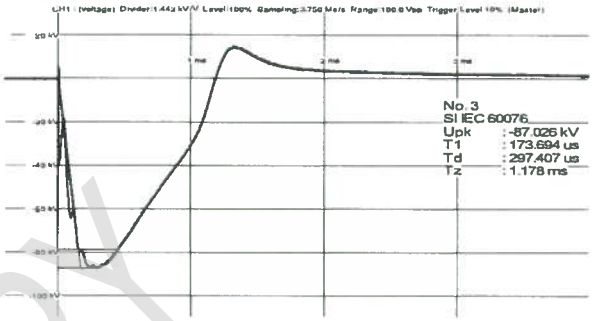
No. 1 SI IEC 60076 Ipk max: -284.219 A Ipk min: 12.969 A

1U,TAP NO.1 CH: 3



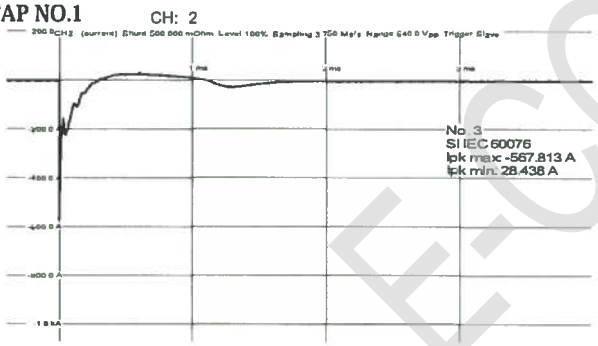
No. 1 SI IEC 60076 Upk: -471.538 kV Tz: -- Underflow. Adj. undershoot

1U,TAP NO.1 CH: 1



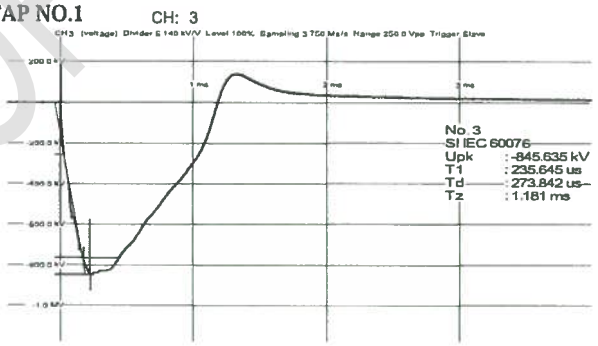
No. 3 SI IEC 60076 Upk: -87.026 kV T1: 173.694 us Td: 297.407 us Tz: 1.178

1U,TAP NO.1 CH: 2



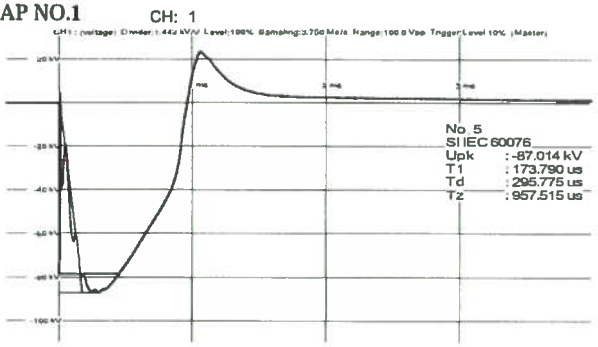
No. 3 SI IEC 60076 Ipk max: -567.813 A Ipk min: 28.438 A

1U,TAP NO.1 CH: 3



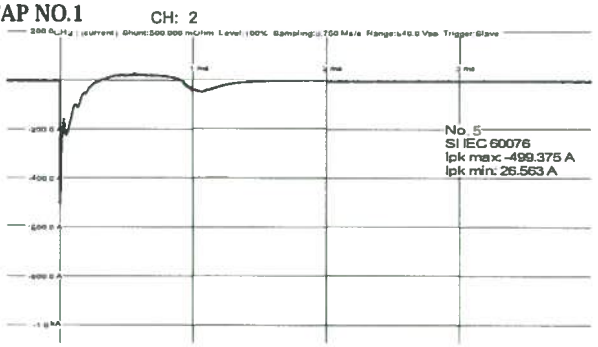
No. 3 SI IEC 60076 Upk: -845.635 kV T1: 235.645 us Td: 273.842 us Tz: 1.181

1U,TAP NO.1 CH: 1



No. 5 SI IEC 60076 Upk: -87.014 kV T1: 173.790 us Td: 295.775 us Tz: 957.51

1U,TAP NO.1 CH: 2



No. 5 SI IEC 60076 Ipk max: -499.375 A Ipk min: 26.563 A

Date:
13/08/14

ETD TRANSFORMÁTORY a.s.
Řízení jakosti
(2)

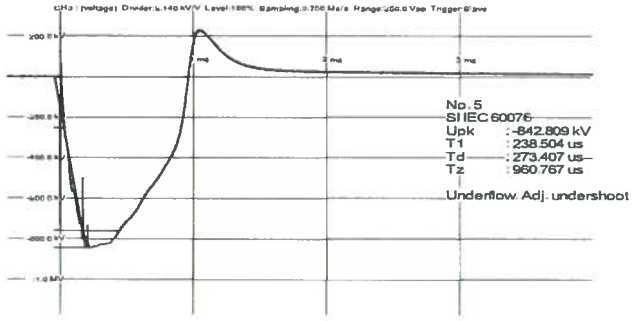
Testing engineer:
Ing.J.Langer

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137
SIGNATURE

Enclosure to protocol No. ŘJ 14/137A
Switching impulse test

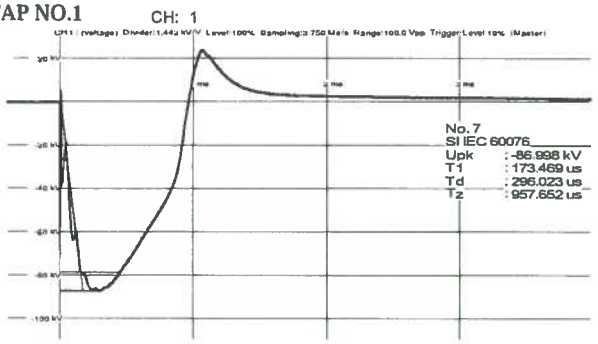
ETD TRANSFORMÁTORY a.s.

1U,TAP NO.1 CH: 3



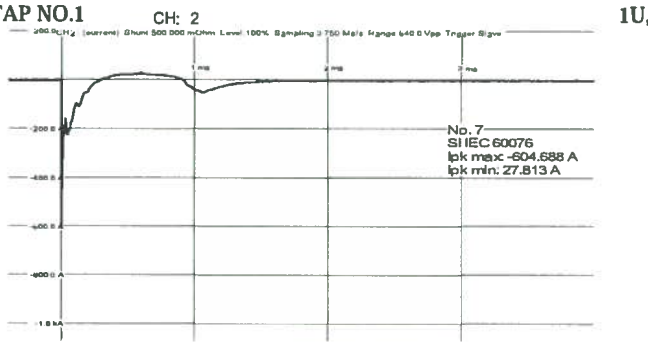
No. 5 SI IEC 60076 Upk: -842.809 kV T1: 238.504 us Td: 273.407 us Tz: 960.7

1U,TAP NO.1 CH: 1



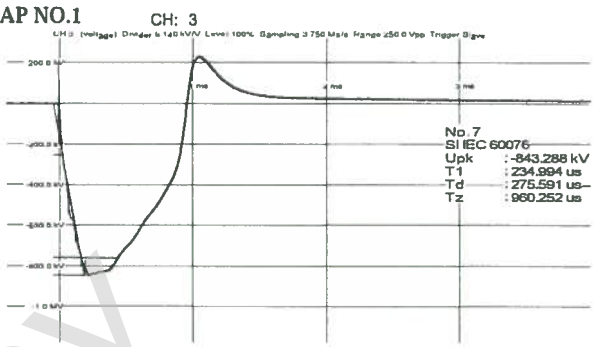
No. 7 SI IEC 60076 Upk: -86.998 kV T1: 173.469 us Td: 296.023 us Tz: 957.65

1U,TAP NO.1 CH: 2



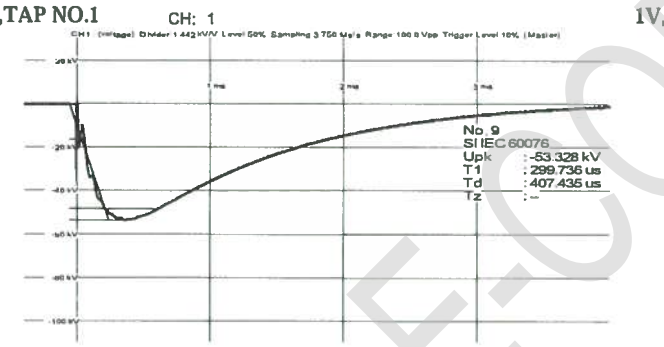
No. 7 SI IEC 60076 Ipk max: -604.688 A Ipk min: 27.813 A

1U,TAP NO.1 CH: 3



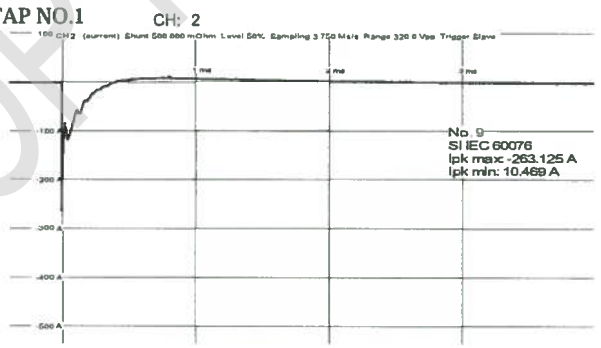
No. 7 SI IEC 60076 Upk: -843.288 kV T1: 234.994 us Td: 275.591 us Tz: 960.2

1V,TAP NO.1 CH: 1



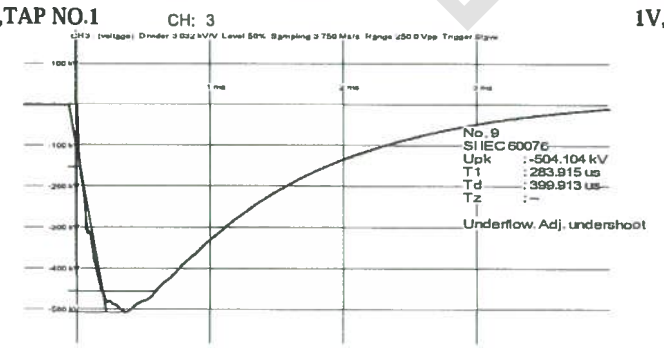
No. 9 SI IEC 60076 Upk: -53.328 kV T1: 299.736 us Td: 407.435 us Tz: --

1V,TAP NO.1 CH: 2



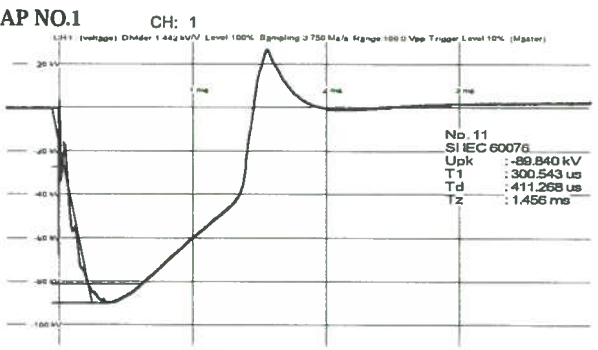
No. 9 SI IEC 60076 Ipk max: -263.125 A Ipk min: 10.469 A

1V,TAP NO.1 CH: 3



No. 9 SI IEC 60076 Upk: -504.104 kV T1: 283.915 us Td: 399.913 us Tz: -- U

1V,TAP NO.1 CH: 1



No. 11 SI IEC 60076 Upk: -89.840 kV T1: 300.543 us Td: 411.268 us Tz: 1.456

Date:
13/08/14

ETD TRANSFORMÁTORY a.s.
Řízení jakosti
(2)

Testing engineer:
Ing.J.Langer

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137A
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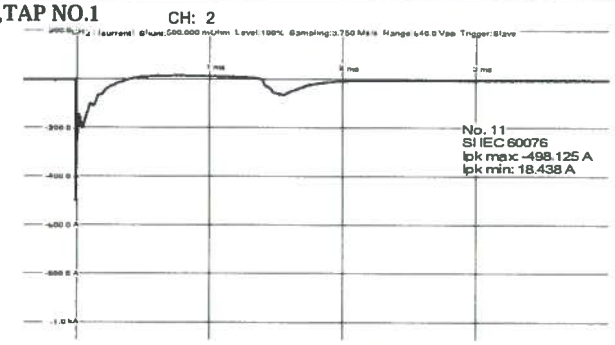
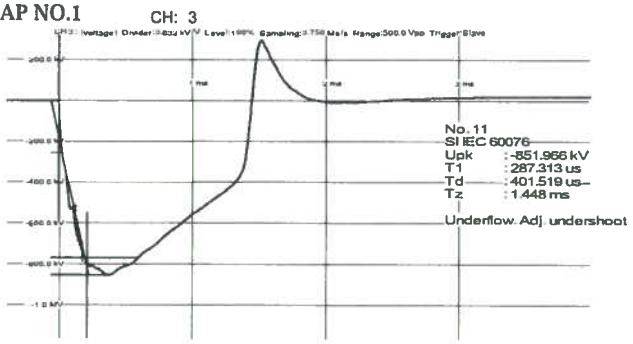
1V,TAP NO.1 CH: 2



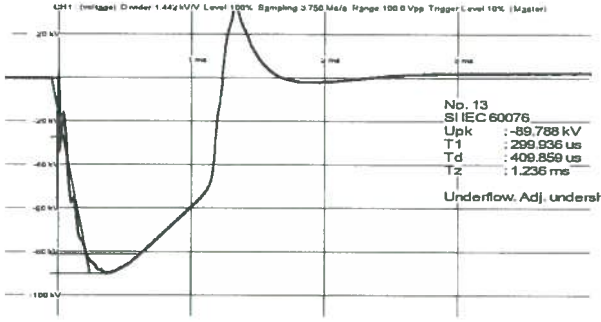
No. 11 SI IEC 60076 Ipk max: -498.125 A Ipk min: 18.438 A

1V,TAP NO.1 CH: 3



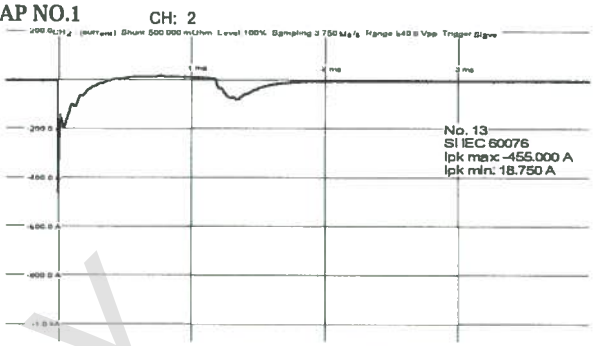
No. 11 SI IEC 60076 Upk: -851.966 kV T1: 287.313 us Td: 401.519 us Tz: 1.44

1V,TAP NO.1 CH: 1



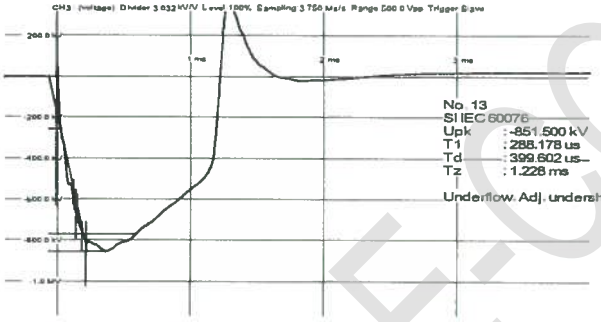
No. 13 SI IEC 60076 Upk: -89.788 kV T1: 299.936 us Td: 409.859 us Tz: 1.236

1V,TAP NO.1 CH: 2



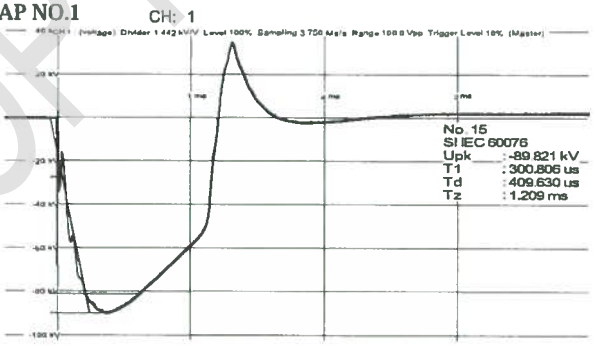
No. 13 SI IEC 60076 Ipk max: -455.000 A Ipk min: 18.750 A

1V,TAP NO.1 CH: 3



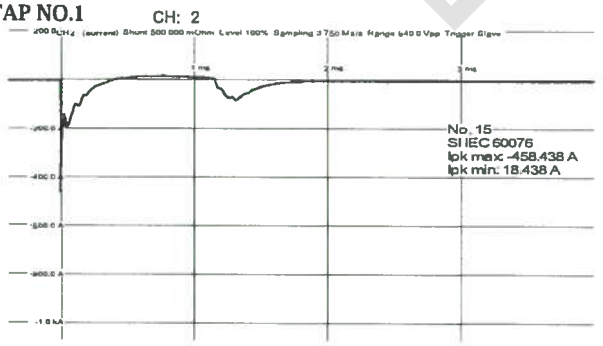
No. 13 SI IEC 60076 Upk: -851.500 kV T1: 288.178 us Td: 399.602 us Tz: 1.22

1V,TAP NO.1 CH: 1



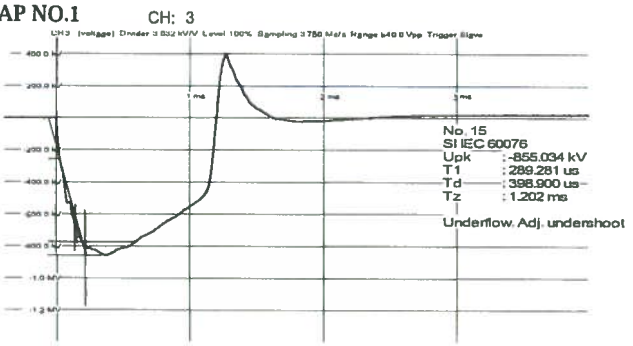
No. 15 SI IEC 60076 Upk: -89.821 kV T1: 300.806 us Td: 409.630 us Tz: 1.209

1V,TAP NO.1 CH: 2



No. 15 SI IEC 60076 Ipk max: -458.438 A Ipk min: 18.438 A

1V,TAP NO.1 CH: 3



No. 15 SI IEC 60076 Upk: -855.034 kV T1: 289.281 us Td: 398.900 us Tz: 1.20

Date:
13/08/14

ETD TRANSFORMÁTORY a.s.
Řízení jakosti
(2)

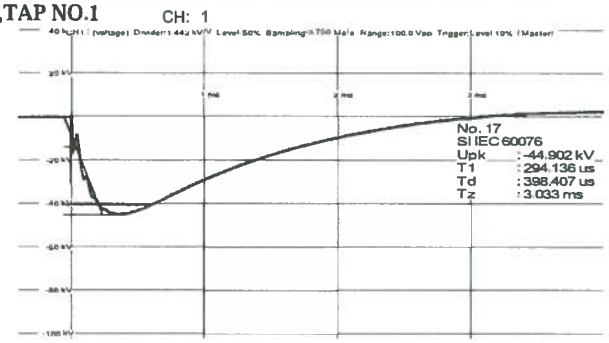
Testing engineer:
Ing.J.Langer

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137A
SIGNATURE

Enclosure to protocol No. ŘJ 14/137A
Switching impulse test

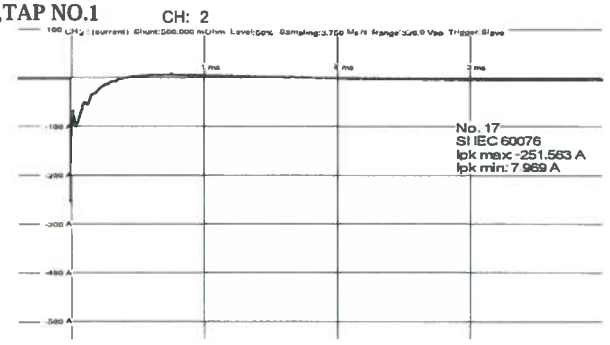
ETD TRANSFORMÁTORY a.s.

1W,TAP NO.1 CH: 1



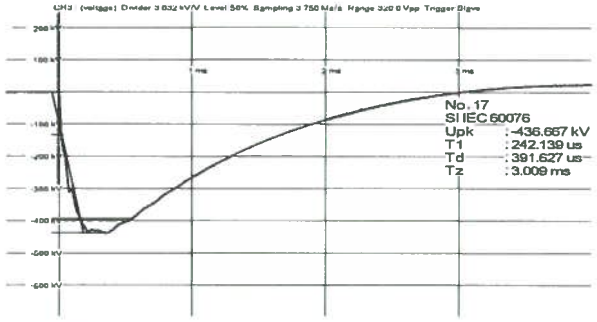
No. 17 SI IEC 60076 Upk: -44.902 kV T1: 294.136 us Td: 398.407 us Tz: 3.033

1W,TAP NO.1 CH: 2



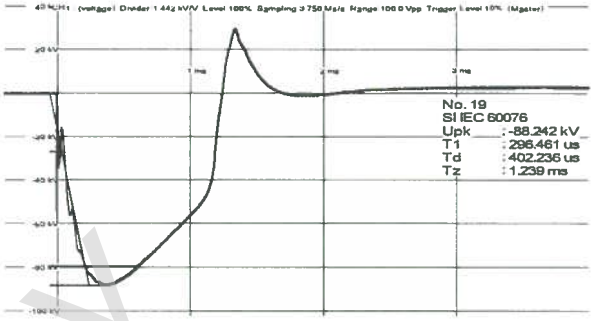
No. 17 SI IEC 60076 Ipk max: -251.563 A Ipk min: 7.969 A

1W,TAP NO.1 CH: 3



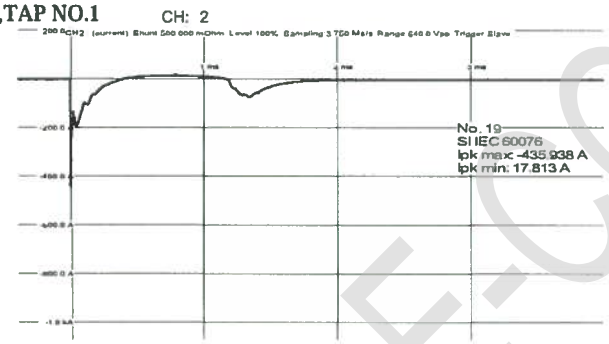
No. 17 SI IEC 60076 Upk: -436.657 kV T1: 242.139 us Td: 391.627 us Tz: 3.00

1W,TAP NO.1 CH: 1



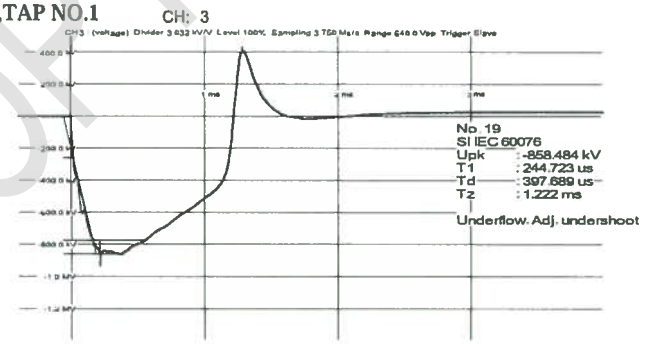
No. 19 SI IEC 60076 Upk: -88.242 kV T1: 296.461 us Td: 402.236 us Tz: 1.239

1W,TAP NO.1 CH: 2



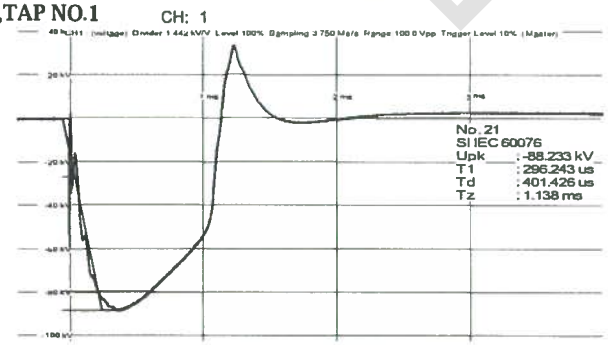
No. 19 SI IEC 60076 Ipk max: -435.938 A Ipk min: 17.813 A

1W,TAP NO.1 CH: 3



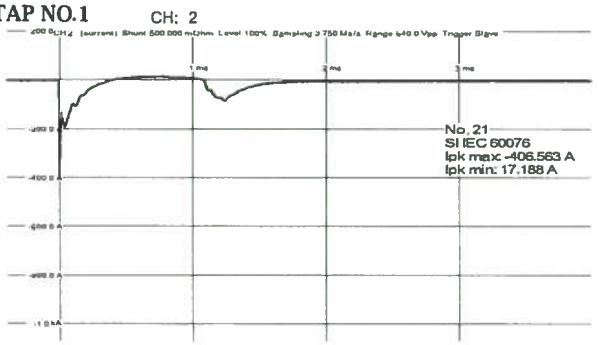
No. 19 SI IEC 60076 Upk: -858.484 kV T1: 244.723 us Td: 397.689 us Tz: 1.22

1W,TAP NO.1 CH: 1



No. 21 SI IEC 60076 Upk: -88.233 kV T1: 296.243 us Td: 401.426 us Tz: 1.138

1W,TAP NO.1 CH: 2



No. 21 SI IEC 60076 Ipk max: -406.563 A Ipk min: 17.188 A

Date:
13/08/14

ETD TRANSFORMÁTORY a.s.
Řízení jakosti
(2)

Testing engineer:
Ing.J.Langer

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
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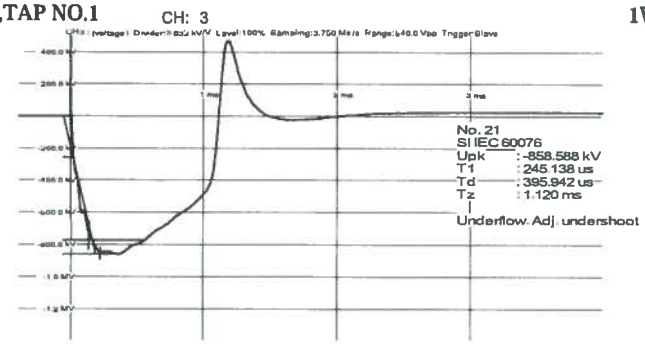
Enclosure to protocol No. ŘJ 14/137A
Switching impulse test

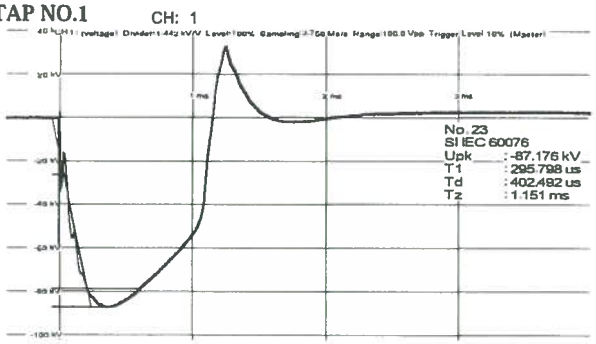
ETD TRANSFORMÁTORY a.s.

1W,TAP NO.1 CH: 3



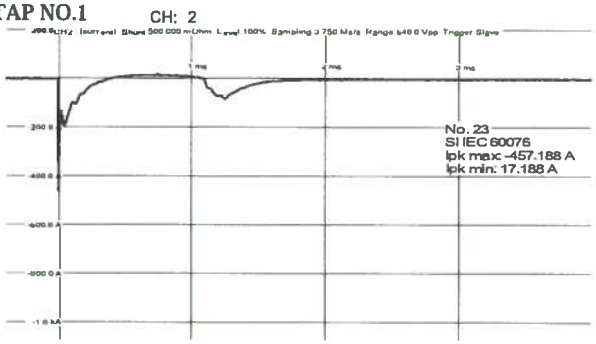
No. 21 SI IEC 60076 Upk: -858.588 kV T1: 245.138 us Td: 395.942 us Tz: 1.12

1W,TAP NO.1 CH: 1



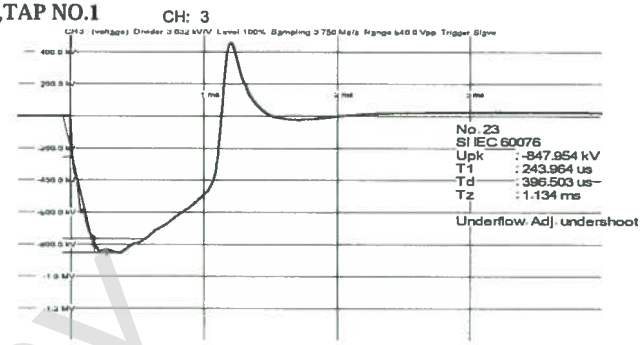
No. 23 SI IEC 60076 Upk: -87.176 kV T1: 295.798 us Td: 402.492 us Tz: 1.151

1W,TAP NO.1 CH: 2



No. 23 SI IEC 60076 Ipk max: -457.188 A Ipk min: 17.188 A

1W,TAP NO.1 CH: 3



No. 23 SI IEC 60076 Upk: -847.954 kV T1: 243.964 us Td: 396.503 us Tz: 1.13

Date:
13/08/14

ETD TRANSFORMÁTORY a.s.
Řízení jakosti
(2)

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-137
SIGNATURE

Testing engineer:
Ing.J.Langer

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/168 A	Page No.: 1 / No. of pages: 9

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Purchaser:	ETD TRANSFORMÁTORY a.s.	Internal order No.:	765-271-3060

Technical data

Winding:	Output [kVA]:	Voltage [V]:	Current [A]:
1	75000	220000 ±8x1,25%	197
2	75000	24000	1804
3	25000	24000	601

Standard:	IEC 76				
Vector group:	YNyn0/d5	Type of cooling:	ONAN/ONAF$_1$/ONAF$_2$	Sort of loading:	S1
No. of phases:	3	Rated frequency:	50 Hz	Insulation class:	A

Contents:

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Tests evaluation 1
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Enclosures

Enclosure to Test Certificate No. ŘJ 14/168 A – Lightning impulse test
Enclosure to Test Certificate No. ŘJ 14/168 A – Switching impulse test

Tests evaluation

The transformer complied to all tests, carried on according to IEC 76.

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)
29.9.2014	v.z. Ing. Langer	Ing. Černý	

TR0008/03/ŘJ

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of voltage ratio on all taps

Checking of connection symbol

For voltage ratio:		220 ±8x1,25% kV (1) 24 kV (2)		220 ±8x1,25% kV (1) 24 kV (3)	
Connect. symbol corresponds:		YNyn0		YNd5	
No. of tap:	Winding [V]:	For voltage ratio:	Failing of ratio [%]:	For voltage ratio:	Failing of ratio [%]:
1	242000	10,083	-0,04	5,822	0,19
2	239250	9,969	-0,04	5,755	0,19
3	236500	9,854	-0,03	5,689	0,20
4	233750	9,740	-0,03	5,623	0,20
5	231000	9,625	-0,02	5,557	0,21
6	228250	9,510	-0,02	5,491	0,21
7	225500	9,396	-0,01	5,425	0,22
8	222750	9,281	-0,01	5,359	0,22
9a	220000	9,167	0,00	5,292	0,23
9b	220000	9,167	0,00	5,292	0,23
9c	220000	9,167	0,00	5,292	0,23
10	217250	9,052	0,01	5,226	0,24
11	214500	8,938	0,01	5,160	0,24
12	211750	8,823	0,02	5,094	0,25
13	209000	8,708	0,03	5,028	0,26
14	206250	8,594	0,03	4,962	0,26
15	203500	8,479	0,04	4,895	0,27
16	200750	8,365	0,05	4,829	0,28
17	198000	8,250	0,05	4,763	0,28

Applied voltage test (AV)

On the tested winding is applied the voltage $U_{test.}$ [kV] , f = 50 Hz , t = 60 s against the tank and other windings.

Tested winding:	220 kV(1)	24 kV (2)	24 kV (3)				
Testing voltage $U_{test.}$[kV]:	230	50	50				

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REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
29.9.2014	v.z. Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Lightning impulse test

On the test winding terminals apply 3 pulses of negative polarity 1,2 / 50 μs.

Tested windings:	220 kV(1)	24 kV (2)	24 kV (3)	
Terminals:	1U, 1V, 1W	2U, 2V, 2W	3U, 3V, 3W	
Testing voltage U_{test} [kV]:	1050	125	125	

Switching impulse test

Tested procedure: 1 ref. impulse (50% Utest) , 3 full impulses (100% Utest)

Tested windings:	220 kV			
Terminals:	1U, 1V, 1W			
Testing voltage U_{test} [kV]:	850			

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
29.9.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of winding resistance

Quoted value of winding resistance R [Ω] at temperature 20 °C

Winding: No. of tap:	1U-1N	1V-1N	1W-1N	Winding: No. of tap:	2U-2N	2V-2N	2W-2N
220 kV (1) / 1	0,851	0,852	0,850	24 kV(2) / -	0,00744	0,00743	0,00747
2	0,833	0,834	0,833				
3	0,815	0,816	0,815	24 kV(3) / -	3U-3V	3U-3W	3V-3W
4	0,797	0,799	0,797		0,0377	0,0378	0,0376
5	0,780	0,781	0,780				
6	0,762	0,763	0,762				
7	0,744	0,746	0,744				
8	0,727	0,728	0,726				
9a	0,708	0,709	0,706				
9b	0,708	0,709	0,706				
9c	0,744	0,745	0,744				
10	0,726	0,727	0,726				
11	0,709	0,709	0,709				
12	0,691	0,692	0,691				
13	0,673	0,674	0,673				
14	0,655	0,656	0,656				
15	0,638	0,639	0,638				
16	0,620	0,621	0,620				
17	0,602	0,602	0,600				

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-134
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
29.9.2014	v. z. Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/168 A	Page No.: 5 / No. of pages: 9

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of winding insulation resistance

Measurement of loss factor tg δ and capacitance C of the winding

Measured at winding temperature: 18 °C

Measured at winding temperature: 18 °C

Connection at measurement: * remaining windings connected to transf. tank		$U_{test.}$ = 2500 V_{DC} $R_{insulating}$ [MΩ]		Connection at measurement:	$U_{test.}$ = 10000 V/50 Hz C [nF]	tg δ [%]
		15 s	60 s	(1) – (2) + (3) + tank	11,24	0,26
220 kV (1)	/ tank + *	5410	6550	(1) – (3) + tank	4,602	0,31
24 kV (2)	/ tank + *	2296	3167	(1) – (2)	6,638	0,22
24 kV (3)	/ tank + *	1544	2892	(2) – (1) + (3) + tank	28,08	0,22
(1) + (2)	/ tank + *	1897	3640	(2) – (1) + tank	7,974	0,26
(1) + (3)	/ tank + *	1340	2259	(2) – (3)	20,16	0,22
(2) + (3)	/ tank + *	3442	5000	(3) – (1) + (2) + tank	37,03	0,25
(1) + (2) + (3)	/ tank + *	4180	5780	(3) – (2) + tank	36,9	0,25
core (U_{test}=1000 V_{DC})	/ tank + *	2144	3460	(3) – (1)	0,136	0,53
frame (U_{test}=1000 V_{DC})	/ tank + *	3444	4450	(1) – tank	4,465	0,3
				(2) – tank	1,236	0,42
				(3) – tank	16,73	0,28

Measurement of loss factor tg δ and capacitance C of the bushings

Measured at winding temperature: 18 °C

Terminal / Serial No.		1U		1V		1W		1N	
Connection at measurement:	Utest	C_1[pF]	tg δ_1[%]	C_1[pF]	tg δ_1[%]	C_1[pF]	tg δ_1[%]	C_1[pF]	tg δ_1[%]
Terminal - Power factor tap	2 kV	326,4	0,20	327,8	0,18	332,5	0,24	254,6	0,23
	4 kV	326,4	0,20	327,8	0,18	332,5	0,24	254,6	0,23
	6 kV	326,4	0,20	327,8	0,18	332,5	0,24	254,6	0,23
	8 kV	326,4	0,20	327,8	0,18	332,5	0,24	254,6	0,23
	10 kV	326,4	0,20	327,8	0,18	332,5	0,24	254,6	0,23
Connection at measurement:	Utest	C_2[pF]	tg δ_2[%]	C_2[pF]	tg δ_2[%]	C_2[pF]	tg δ_2[%]	C_2[pF]	tg δ_2[%]
Power factor tap - tank	2 kV	636,0	0,34	602,4	0,22	612,0	0,26	455,8	0,30

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
29.9.2014	v.z. Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/168 A	Page No.: 6 / No. of pages: 9

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Induced voltage test with partial discharge measurement IVPD

Testing voltage $U_{TEST.}$ = 396 kV was induced between terminals of winding 220 kV at f = 125 Hz for time t = 48 sec.
(U_r = 220 kV, U_m = 245kV)

Three-phase test		Background noise	Testing voltage course: 1,2Ur/√3	1,58Ur/√3	1,8 Ur/√3	1,58 Ur/√3											1,2 Ur/√3	Background noise 0,4 Ur/√3
Testing voltage „phase – phase“ $U_{TEST.}$ [kV]			264	347,6	396	347,6											264	
Voltage phase - earth at test U/√3[kV]			152,4	200,7	228,6	200,7											152,4	
Measured:	Test time t [s]		60	300	48	300	300	300	300	300	300	300	300	300	300	300	60	
1U	Apparent charge [pC]	10	80	115		120	110	110	110	120	110	110	118	110	110	120	115	82	15
1V	Apparent charge [pC]	7	20	36		65	65	85	75	70	65	65	65	60	60	65	65	60	10
1W	Apparent charge [pC]	8	45	75		60	60	55	60	60	50	50	50	50	50	55	55	40	10

Test of transformer oil

Oil type:	SHELL DIALA S3 ZX-I							
Tr. tank:	Water content in oil[ppm]:	4	U_p [kV/2,5mm]:	78,5	s [kV/2,5mm]:	7,1	V [%]:	9,0
Tap changer:	Water content in oil[ppm]:	11	U_p [kV/2,5mm]:	79,6	s [kV/2,5mm]:	4,9	V [%]:	6,1

Test of oil tightness

The test carried out for 48 hours + 24 hours duration from last tigtness repair.

tank / external space .... with overpressure 40 kPa

Measurement of no-load loss and current

Measured values:					Guaranteed values:	
Energized winding 24 kV					tol.+30 %	tol.+15 %
U [V]	u [%]	I_0 [A]	i_0 [%]	ΔP_0 [kW]	i_0 [%]	ΔP_0 [kW]
26398	110	6,3	0,35	49,6		
25204	105	2,1	0,12	38,2		
23998	100	1,2	0,07	32,2	0,2	34
22806	95	0,9	0,05	28,1		
21600	90	0,7	0,04	24,6		

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-424
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
29.9.2014	v.z. Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

TR0008/03/ŘJ

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/168 A	Page No.: 7 / No. of pages: 9

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of load loss and impedance voltage, total loss

Values for winding temperature 95 °C

Measured values:								Guaranteed values:		
							$\Delta P_0+\Delta P_k$	tol.±7,5%	tol.+15%	tol.+10%
Energized winding:		Short-circ. winding:		For output:	u_k	ΔP_k	$\Sigma \Delta P$	u_k	ΔP_k	$\Sigma \Delta P$
	Tap No.:		Tap No.:	S [kVA]	[%]	[kW]	[kW]	[%]	[kW]	[kW]
(1)	1	(2)	-	75000	13,17	227,6				
	2				13,09	227,2				
	3				13,00	226,6				
	4				12,91	226,3				
	5				12,80	225,7				
	6				12,70	225,2				
	7				12,59	225,4				
	8				12,50	224,9				
	9a				12,43	224,4				
	9b				12,43	224,0	256,2	12,5	230	264
	9c				12,48	230,9				
	10				12,41	230,1				
	11				12,35	229,4				
	12				12,27	229,0				
	13				12,20	229,1				
	14				12,12	228,3				
	15				12,04	227,9				
	16				11,97	227,1				
	17				11,92	226,3				
Calculated load loss … 220 kV (1) / 24 kV (2) / 24 kV (3) … 75 / 50 /25 MVA According to IEC 60076-8 article 7.7.1.										
						201,2	233,4	-	210	244

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
SIGNATURE

Date:	Testing engineer:	Head of laboratory:	
29.9.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

ETD	ETD TRANSFORMÁTORY a.s.	Certificate No.: ŘJ 14/168 A	Page No.: 8 / No. of pages: 9

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Measurement of load loss and impedance voltage, total loss

Values for winding temperature 95 °C

Measured values:								Guaranteed values:		
							$\Delta P_0+\Delta P_k$			
Energized winding:		Short-circ. winding:		For output:	* u_k	ΔP_k	$\Sigma \Delta P$	* u_k	ΔP_k	$\Sigma \Delta P$
	Tap No.:		Tap No.:	S [kVA]	[%]	[kW]	[kW]	[%]	[kW]	[kW]
(1)	1	(3)	-	25000	18,55	43,37				
	2				18,46	43,24				
	3				18,36	43,15				
	4				18,26	43,06				
	5				18,15	42,98				
	6				18,05	42,92				
	7				17,94	42,87				
	8				17,86	42,86				
	9a				17,80	42,87				
	9b				17,80	42,74	74,94	18 tol.±10%	-	-
	9c				17,84	43,51				
	10				17,77	43,40				
	11				17,70	43,27				
	12				17,62	43,19				
	13				17,54	43,12				
	14				17,46	43,06				
	15				17,38	43,00				
	16				17,31	42,95				
	17				17,27	42,97				
(2)	-	(3)	-	25000	3,78	38,2	70,4	3,5 tol.±15%	-	-

* uk … calculated for 75 MVA

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29.9.2014	Ing. Langer	Ing. Černý	ETD TRANSFORMÁTORY a.s. Řízení jakosti (2)

Test Certificate
Transformer tests

Work No.: 0969196	Type: ETR 36 P-0	Manufacturer: ETD TRANSFORMÁTORY a.s.

Tests on-load tap-changer (OLTC)

a) 8 complete operating cycles with transformer not energized;
b) 1 complete operating cycle with transformer not energized, with 85 % of the rated auxiliary supply voltage;
c) 1 complete operating cycle with the transformer energized at rated voltage and frequency at nop-load;
d) 10 tap-change operations with ±2 steps on either side of the principal tapping with as far as possible the rated current of the transformer, with one winding short – circuited.

List of equipment

Meters:	Fab. No.:	Date of calibration:	Date next calibration:	Pasport No.:
Current measurement transformer TETTEX 4874 sp.	A32370	04.02.2014	04.02.2015	ŘJ 14/012
Voltage measurement transformer EPRO NVOS 50	2/12/3738-3740	04.02.2014	04.02.2015	ŘJ 14/003
Power analyzer NORMA 5000-PP64	WO15590BA	23.12.2013	23.12.2014	3892/13/A
Multimeter AGILENT 34970A	MY44033442	25.01.2014	25.01.2015	158/14/A
Ratio and vector groupe NORMA	1788315	13.12.2013	13.12.2015	3895/13/A
Megaohmmeter C.A 6547	100927CAH	02.04.2013	02.04.2015	1153/13/A
Kilovoltmeter MU17+A2	884764	22.04.2014	22.04.2016	1647/14/A
Divider HIGHVOLT 250 kV - AC	884766, 884767	16.04.2014	16.04.2016	ŘJ 14/044
Calibrator PD TETTEX 3216WG	143595	04.11.2013	04.11.2014	ŘJ 13/247
Kilovoltmeter HAEFELY 2000 kV	12100015.60.1÷2 12100015.65.1	13.08.2012	13.08.2017	12100015.60.1-2 12100015.65.1
Measuring device HAEFELY HiAS 743	176632	17.02.2014	17.02.2016	1076/14/A
Capacitor HAEFELY 695 nF	12100015.90.1	27.08.2012	27.08.2017	12100015.90.1
Bridge TETTEX 2816/5284u	145663	06.02.2014	06.02.2016	42/14/S
Dieltest of oil BAUR DTA 100	952922008	10.10.2013	10.10.2015	ŘJ 13/232
Aquameter BAUR KFM 1000 S	959713011	21.04.2014	21.04.2016	ŘJ 14/066
Schering bridge TETTEX 2801	121510	16.06.2014	16.06.2017	2375/14/A
Teraohmmeter SEFELEC M1500 UFA	676	23.06.2014	23.06.2017	2384/14/A

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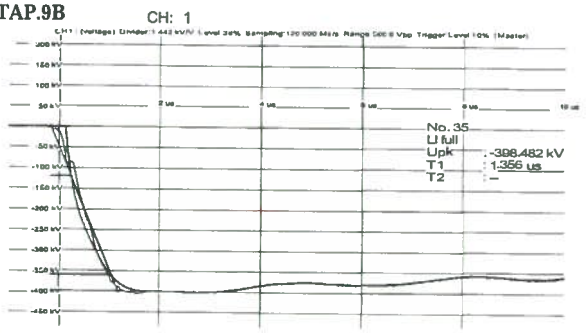
Enclosure to protocol No. ŘJ 14/168A

Lighting impulse test

ETD TRANSFORMÁTORY a.s.

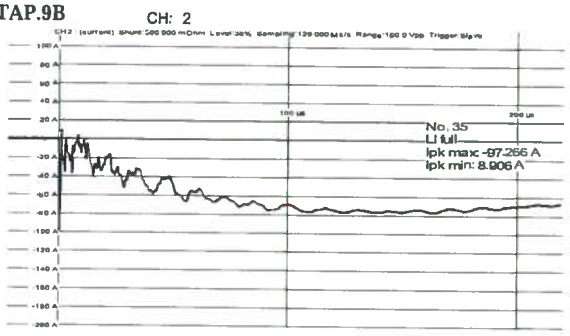
Work No.: 0969196 Temperature: 20,5 Pressure: 733mmHg

1U_TAP.9B CH: 1



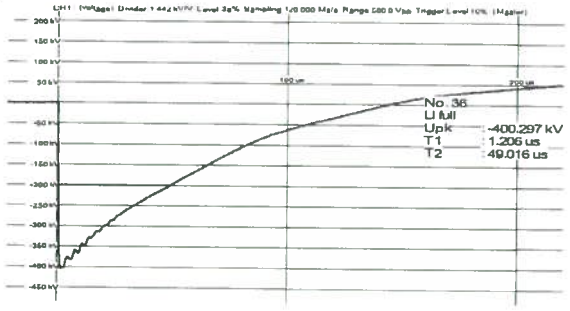
No. 35 LI full Upk: -398.482 kV T1: 1.356 us T2: --

1U_TAP.9B CH: 2



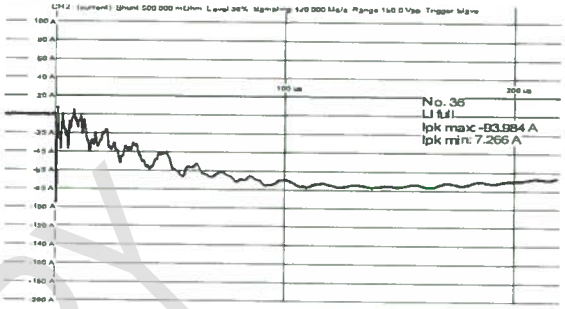
No. 35 LI full Ipk max: -97.266 A Ipk min: 8.906 A

1U_TAP.9B CH: 1



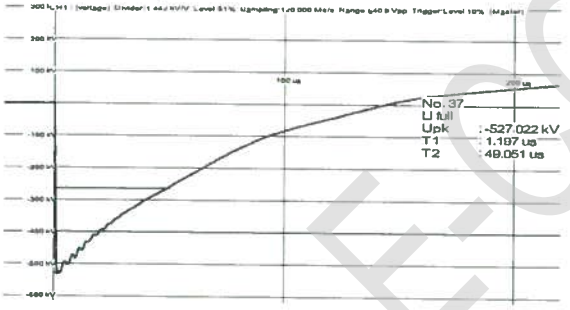
No. 36 LI full Upk: -400.297 kV T1: 1.206 us T2: 49.016 us

1U_TAP.9B CH: 2



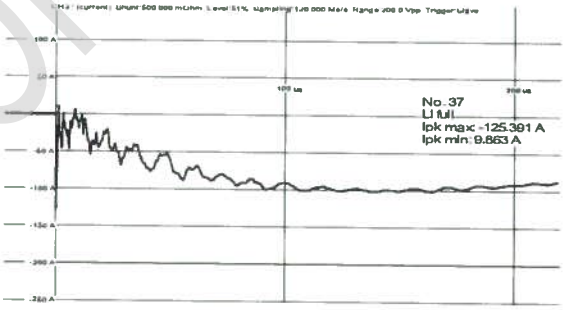
No. 36 LI full Ipk max: -93.984 A Ipk min: 7.266 A

1U_TAP.9B CH: 1



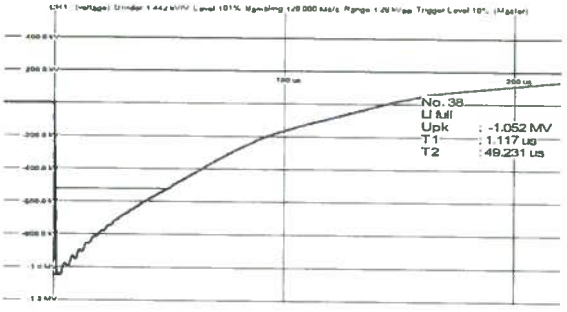
No. 37 LI full Upk: -527.022 kV T1: 1.197 us T2: 49.051 us

1U_TAP.9B CH: 2



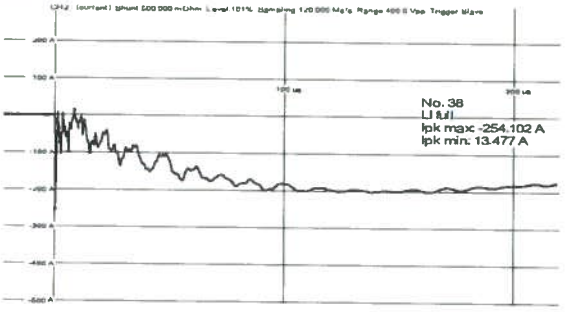
No. 37 LI full Ipk max: -125.391 A Ipk min: 9.863 A

1U_TAP.9B CH: 1



No. 38 LI full Upk: -1.052 MV T1: 1.117 us T2: 49.231 us

1U_TAP.9B CH: 2



No. 38 LI full Ipk max: -254.102 A Ipk min: 13.477 A

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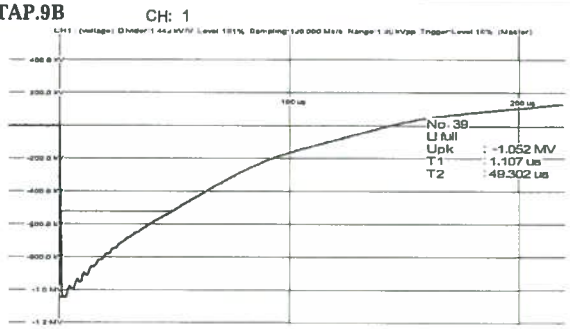
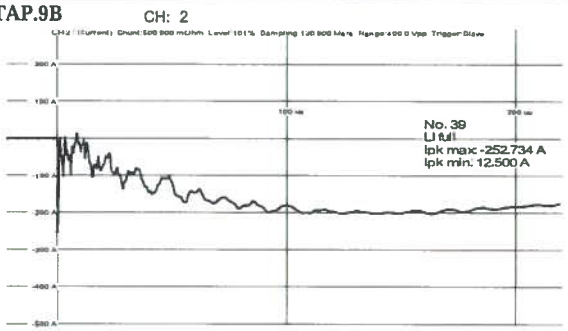
1U_TAP.9B CH: 1



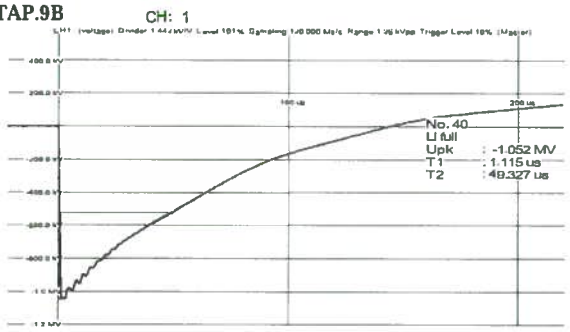
No. 39 LI full Upk: -1.052 MV T1: 1.107 us T2: 49.302 us

1U_TAP.9B CH: 2



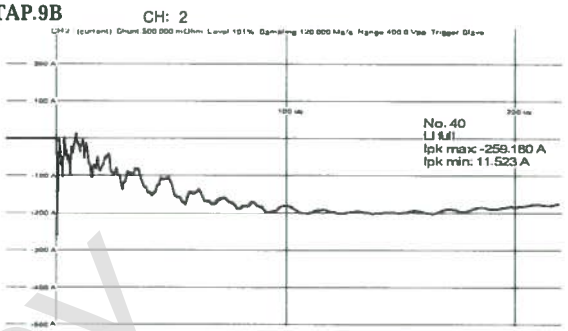
No. 39 LI full Ipk max: -252.734 A Ipk min: 12.500 A

1U_TAP.9B CH: 1



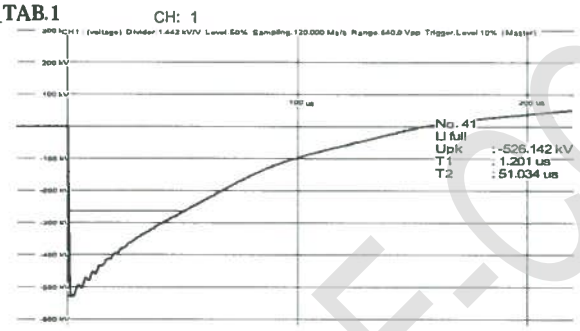
No. 40 LI full Upk: -1.052 MV T1: 1.115 us T2: 49.327 us

1U_TAP.9B CH: 2



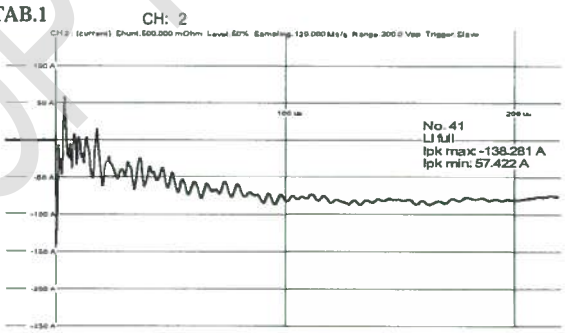
No. 40 LI full Ipk max: -259.180 A Ipk min: 11.523 A

1V_TAB.1 CH: 1



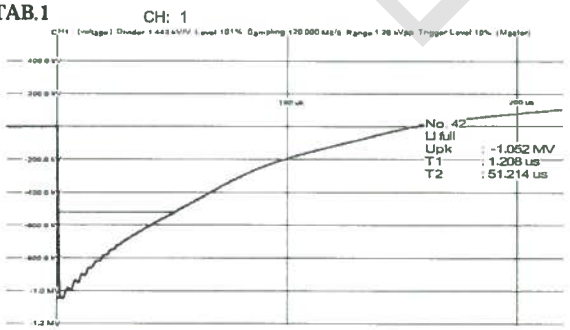
No. 41 LI full Upk: -526.142 kV T1: 1.201 us T2: 51.034 us

1V_TAB.1 CH: 2



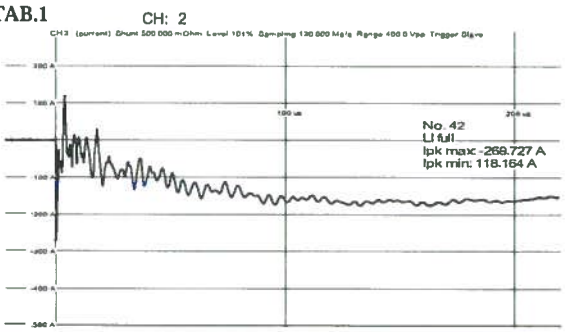
No. 41 LI full Ipk max: -138.281 A Ipk min: 57.422 A

1V_TAB.1 CH: 1



No. 42 LI full Upk: -1.052 MV T1: 1.208 us T2: 51.214 us

1V_TAB.1 CH: 2



No. 42 LI full Ipk max: -269.727 A Ipk min: 118.164 A

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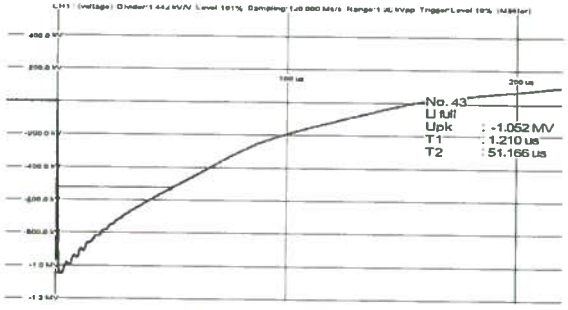
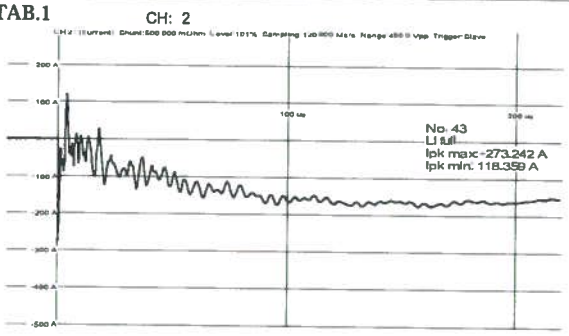
1V_TAB.1 CH: 1



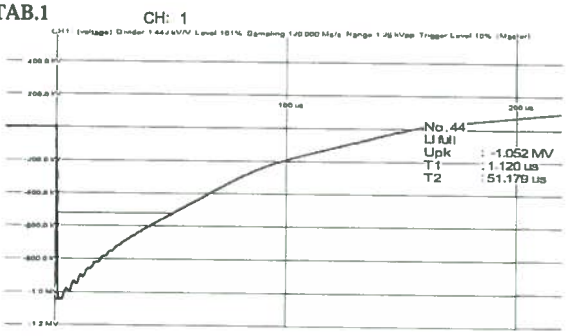
No. 43 LI full Upk: -1.052 MV T1: 1.210 us T2: 51.166 us

1V_TAB.1 CH: 2



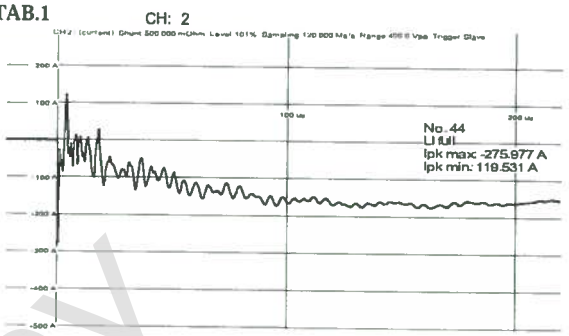
No. 43 LI full Ipk max: -273.242 A Ipk min: 118.359 A

1V_TAB.1 CH: 1



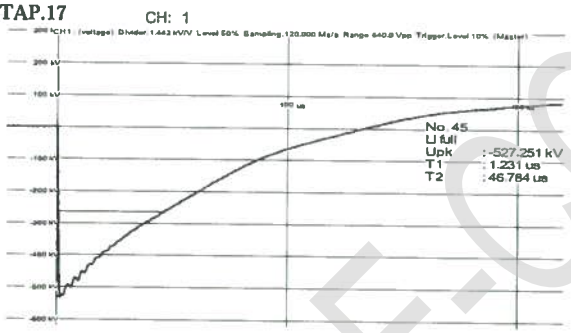
No. 44 LI full Upk: -1.052 MV T1: 1.120 us T2: 51.179 us

1V_TAB.1 CH: 2



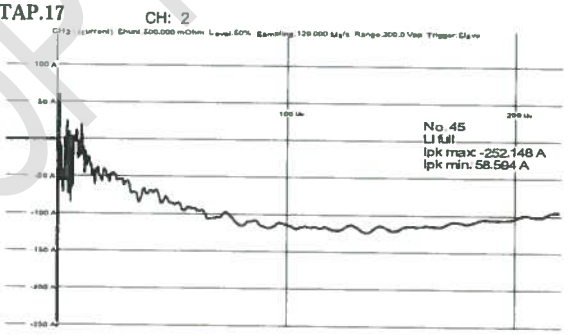
No. 44 LI full Ipk max: -275.977 A Ipk min: 119.531 A

1W_TAP.17 CH: 1



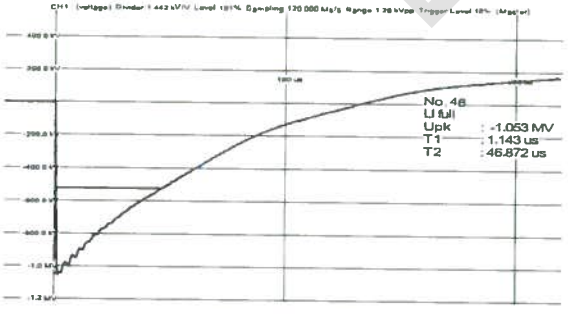
No. 45 LI full Upk: -527.251 kV T1: 1.231 us T2: 46.784 us

1W_TAP.17 CH: 2



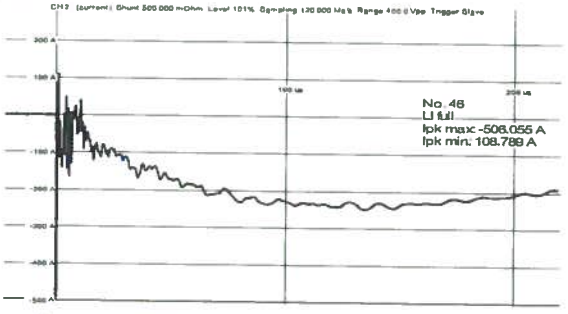
No. 45 LI full Ipk max: -252.148 A Ipk min: 58.594 A

1W_TAP.17 CH: 1



No. 46 LI full Upk: -1.053 MV T1: 1.143 us T2: 46.872 us

1W_TAP.17 CH: 2



No. 46 LI full Ipk max: -506.055 A Ipk min: 108.789 A

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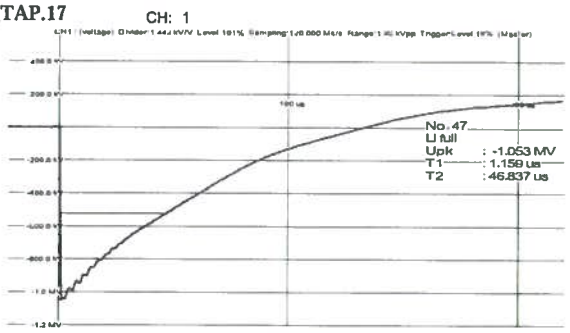
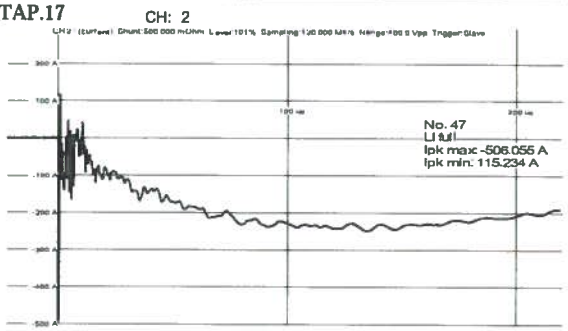
1W_TAP.17 CH: 1



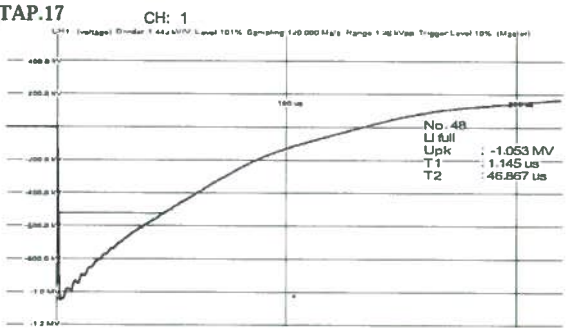
No. 47 LI full Upk: -1.053 MV T1: 1.159 us T2: 46.837 us

1W_TAP.17 CH: 2



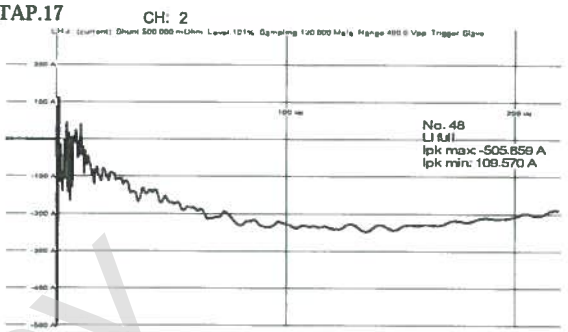
No. 47 LI full Ipk max: -506.055 A Ipk min: 115.234 A

1W_TAP.17 CH: 1



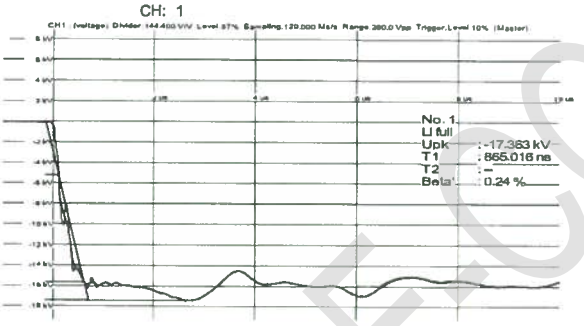
No. 48 LI full Upk: -1.053 MV T1: 1.145 us T2: 46.867 us

1W_TAP.17 CH: 2



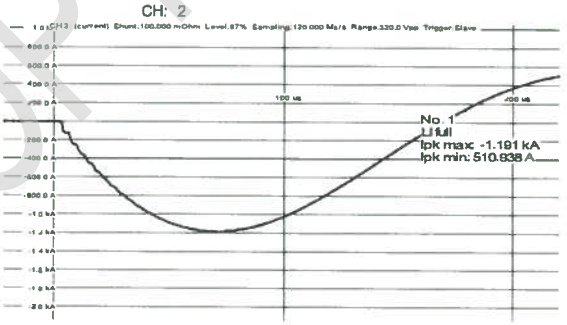
No. 48 LI full Ipk max: -505.859 A Ipk min: 109.570 A

2U CH: 1



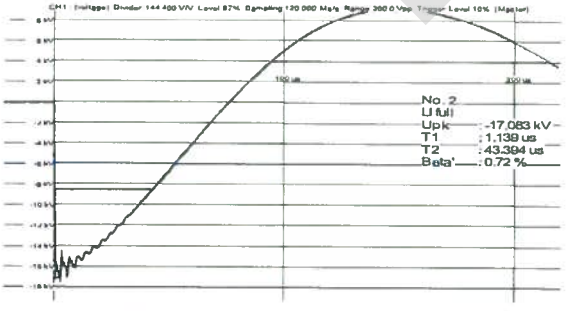
No. 1 LI full Upk: -17.363 kV T1: 865.016 ns T2: -- Beta': 0.24 %

2U CH: 2



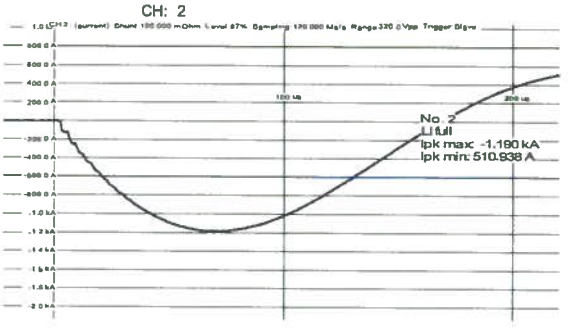
No. 1 LI full Ipk max: -1.191 kA Ipk min: 510.938 A

2U CH: 1



No. 2 LI full Upk: -17.083 kV T1: 1.139 us T2: 43.394 us Beta': 0.72 %

2U CH: 2



No. 2 LI full Ipk max: -1.190 kA Ipk min: 510.938 A

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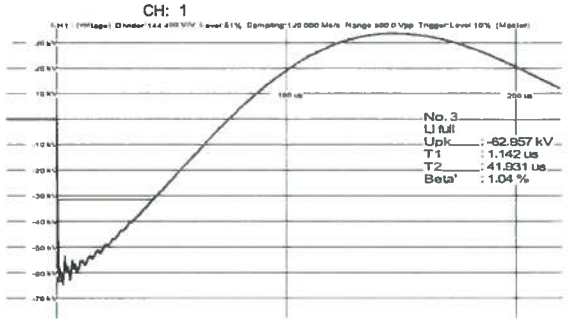
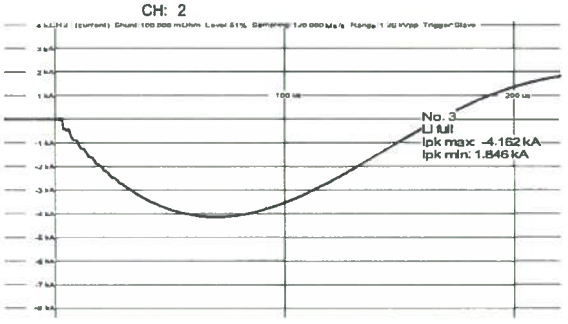
2U CH: 1



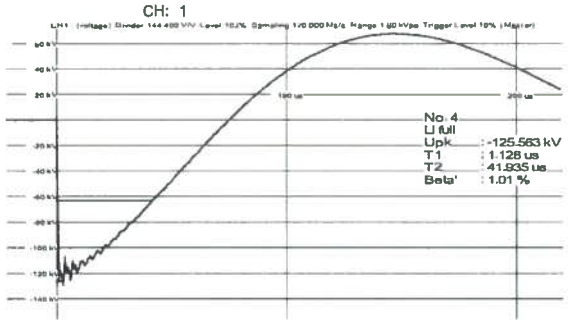
No. 3 LI full Upk: -62.957 kV T1: 1.142 us T2: 41.931 us Beta': 1.04 %

2U CH: 2



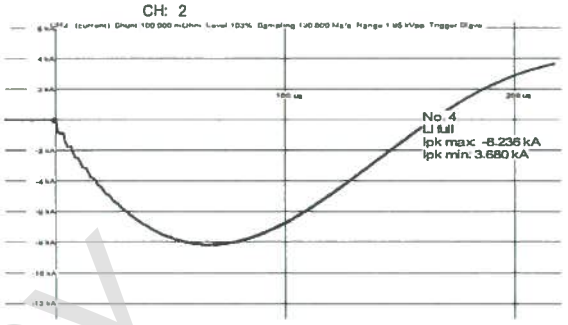
No. 3 LI full Ipk max: -4.162 kA Ipk min: 1.846 kA

2U CH: 1



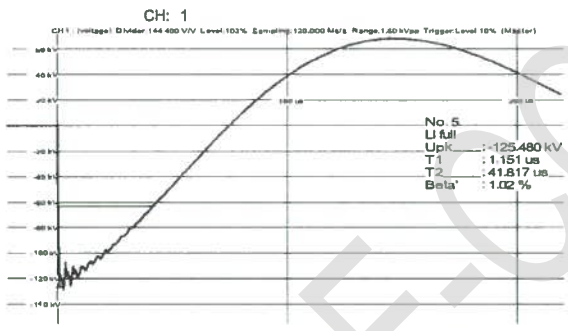
No. 4 LI full Upk: -125.563 kV T1: 1.128 us T2: 41.935 us Beta': 1.01 %

2U CH: 2



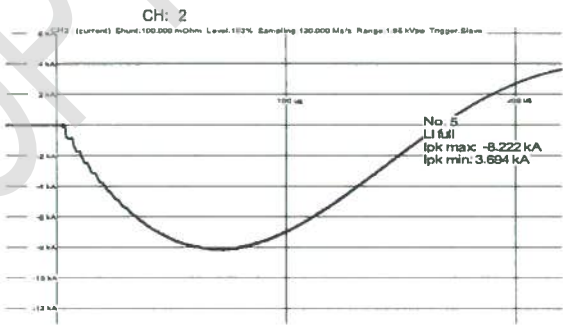
No. 4 LI full Ipk max: -8.236 kA Ipk min: 3.680 kA

2U CH: 1



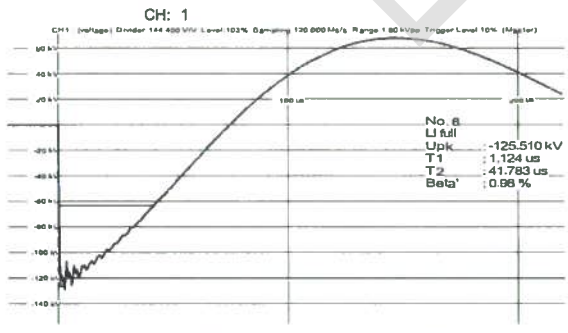
No. 5 LI full Upk: -125.480 kV T1: 1.151 us T2: 41.817 us Beta': 1.02 %

2U CH: 2



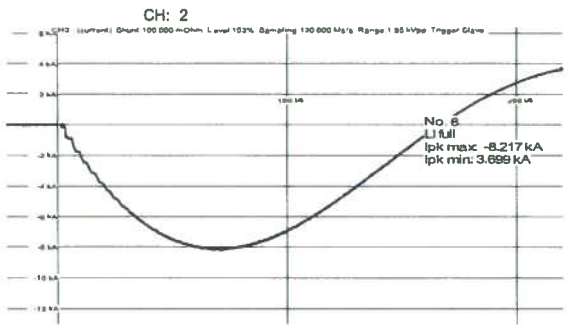
No. 5 LI full Ipk max: -8.222 kA Ipk min: 3.694 kA

2U CH: 1



No. 6 LI full Upk: -125.510 kV T1: 1.124 us T2: 41.783 us Beta': 0.98 %

2U CH: 2



No. 6 LI full Ipk max: -8.217 kA Ipk min: 3.699 kA

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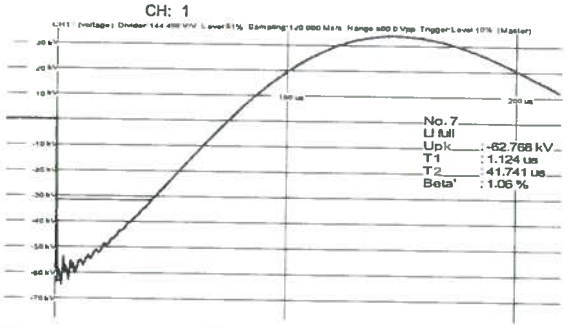
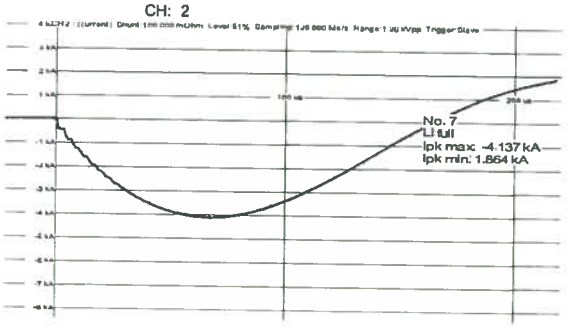
2V CH: 1



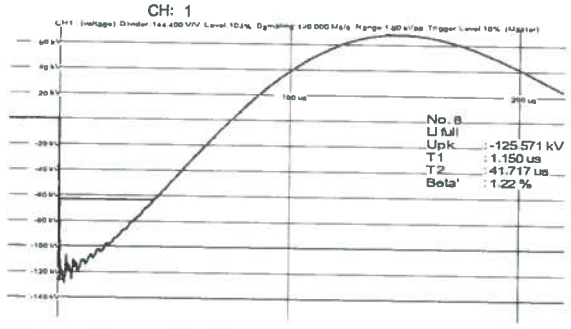
No. 7 LI full Upk: -62.768 kV T1: 1.124 us T2: 41.741 us Beta': 1.06 %

2V CH: 2



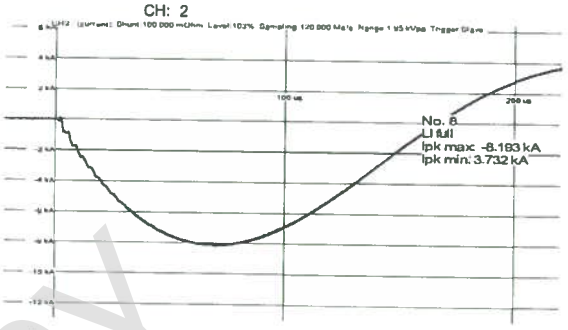
No. 7 LI full Ipk max: -4.137 kA Ipk min: 1.864 kA

2V CH: 1



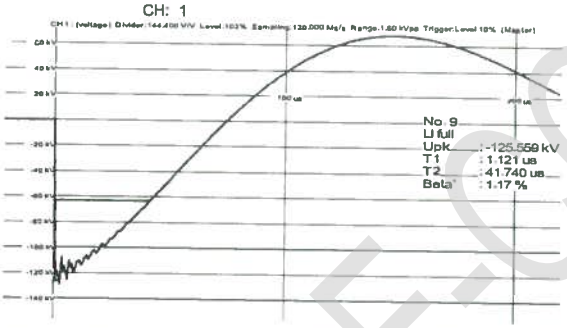
No. 8 LI full Upk: -125.571 kV T1: 1.150 us T2: 41.717 us Beta': 1.22 %

2V CH: 2



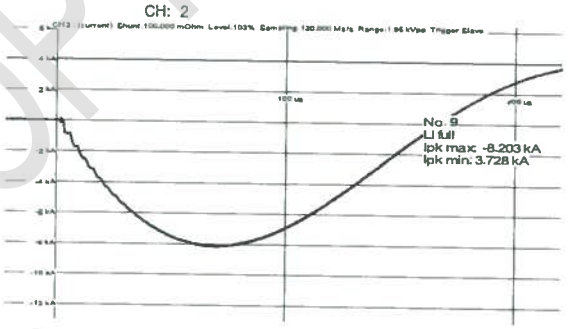
No. 8 LI full Ipk max: -8.193 kA Ipk min: 3.732 kA

2V CH: 1



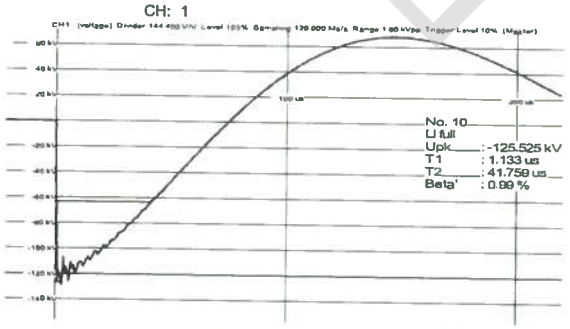
No. 9 LI full Upk: -125.559 kV T1: 1.121 us T2: 41.740 us Beta': 1.17 %

2V CH: 2



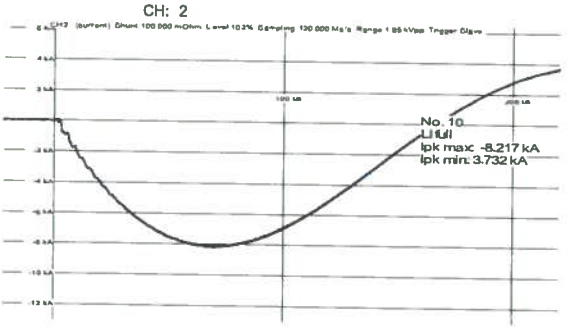
No. 9 LI full Ipk max: -8.203 kA Ipk min: 3.728 kA

2V CH: 1



No. 10 LI full Upk: -125.525 kV T1: 1.133 us T2: 41.759 us Beta': 0.99 %

2V CH: 2



No. 10 LI full Ipk max: -8.217 kA Ipk min: 3.732 kA

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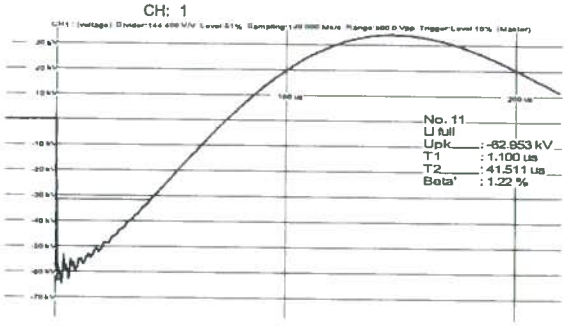
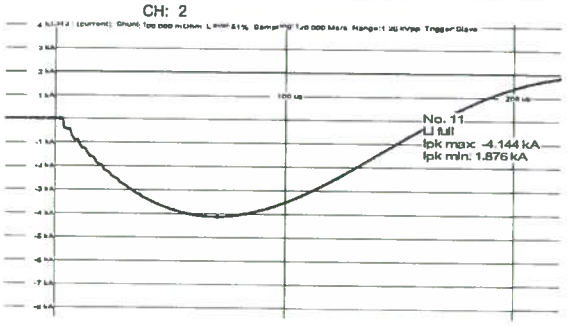
2W CH: 1



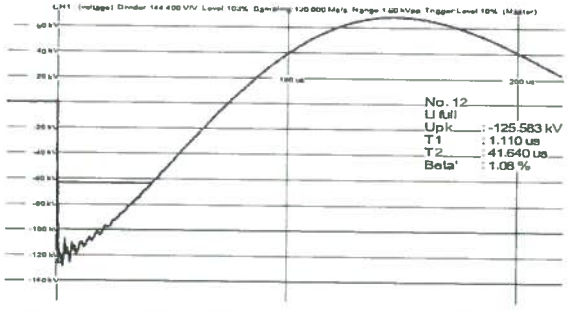
No. 11 LI full Upk: -62.953 kV T1: 1.100 us T2: 41.511 us Beta': 1.22 %

2W CH: 2



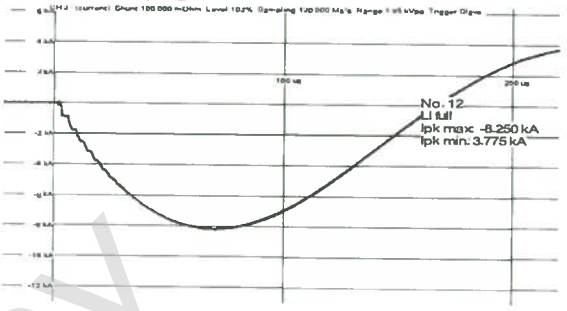
No. 11 LI full Ipk max: -4.144 kA Ipk min: 1.876 kA

2W CH: 1



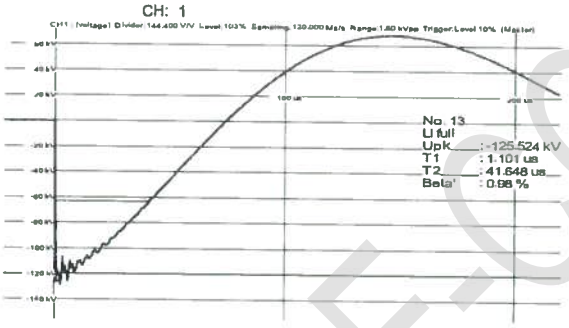
No. 12 LI full Upk: -125.583 kV T1: 1.110 us T2: 41.640 us Beta': 1.08 %

2W CH: 2



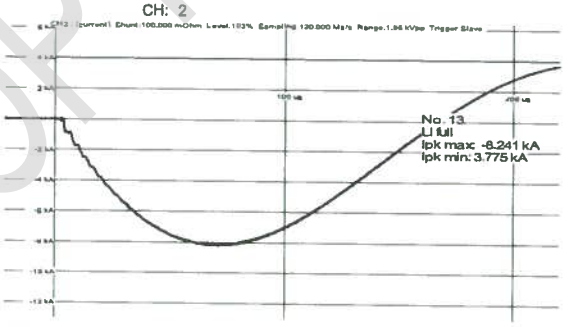
No. 12 LI full Ipk max: -8.250 kA Ipk min: 3.775 kA

2W CH: 1



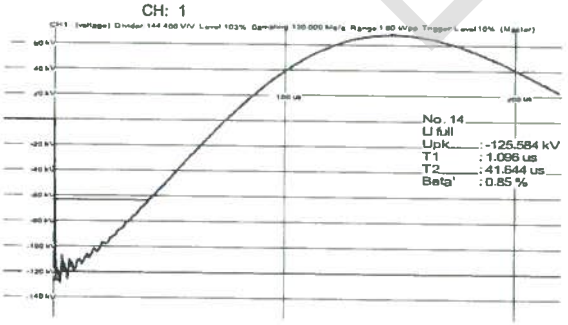
No. 13 LI full Upk: -125.524 kV T1: 1.101 us T2: 41.648 us Beta': 0.98 %

2W CH: 2



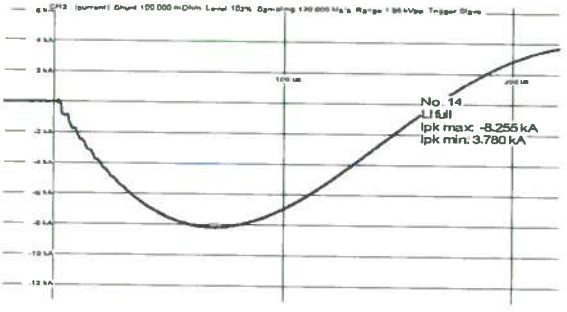
No. 13 LI full Ipk max: -8.241 kA Ipk min: 3.775 kA

2W CH: 1



No. 14 LI full Upk: -125.584 kV T1: 1.096 us T2: 41.644 us Beta': 0.85 %

2W CH: 2



No. 14 LI full Ipk max: -8.255 kA Ipk min: 3.780 kA

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Enclosure to protocol No. ŘJ 14/168A
Lighting impulse test

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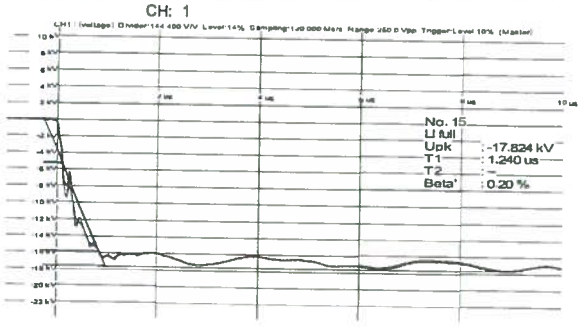
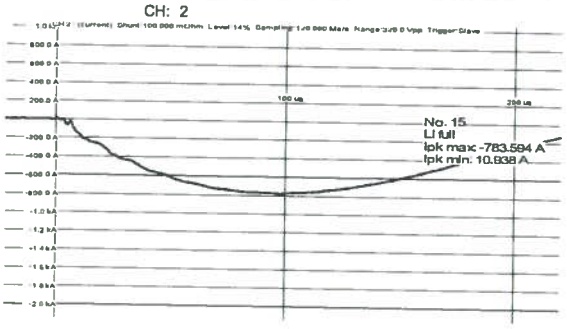
3U CH: 1



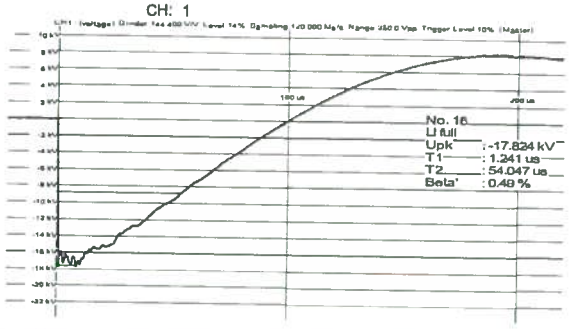
No. 15 LI full Upk: -17.824 kV T1: 1.240 us T2: -- Beta': 0.20 %

3U CH: 2



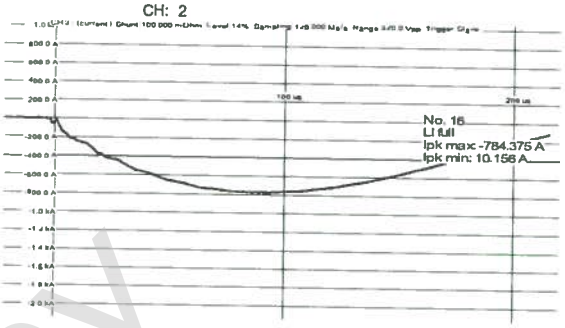
No. 15 LI full Ipk max: -783.594 A Ipk min: 10.938 A

3U CH: 1



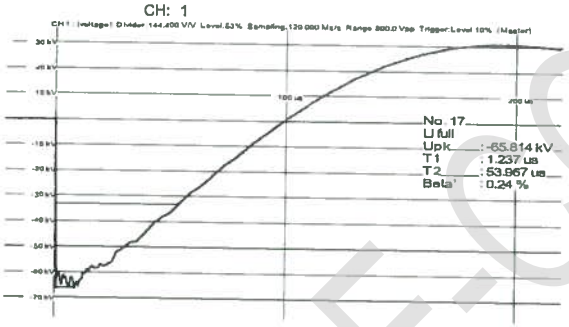
No. 16 LI full Upk: -17.824 kV T1: 1.241 us T2: 54.047 us Beta': 0.49 %

3U CH: 2



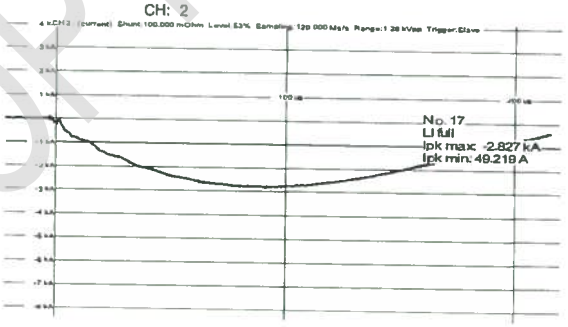
No. 16 LI full Ipk max: -784.375 A Ipk min: 10.156 A

3U CH: 1



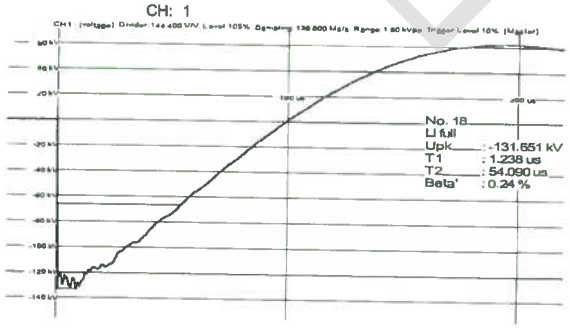
No. 17 LI full Upk: -65.814 kV T1: 1.237 us T2: 53.967 us Beta': 0.24 %

3U CH: 2



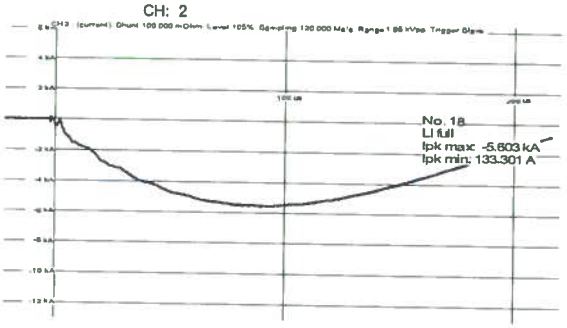
No. 17 LI full Ipk max: -2.827 kA Ipk min: 49.219 A

3U CH: 1



No. 18 LI full Upk: -131.651 kV T1: 1.238 us T2: 54.090 us Beta': 0.24 %

3U CH: 2



No. 18 LI full Ipk max: -5.603 kA Ipk min: 133.301 A

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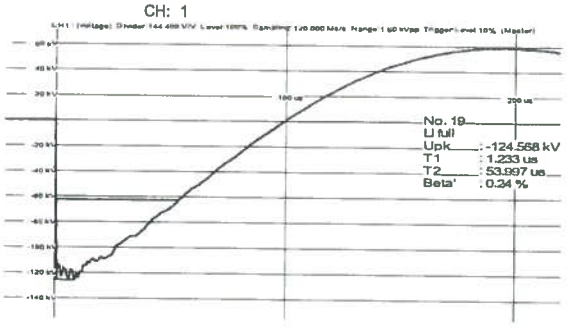
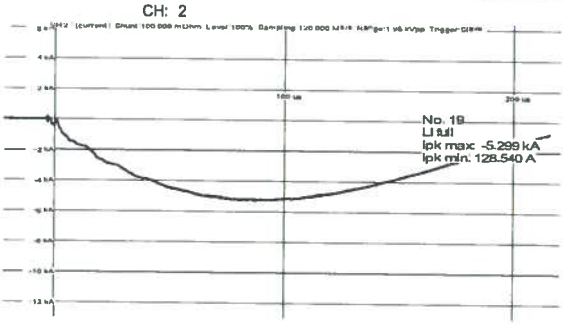
3U CH: 1



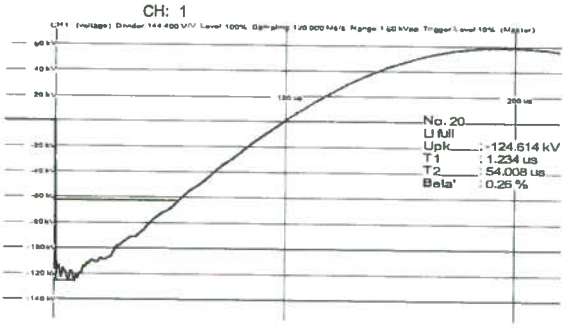
No. 19 LI full Upk: -124.568 kV T1: 1.233 us T2: 53.997 us Beta': 0.24 %

3U CH: 2



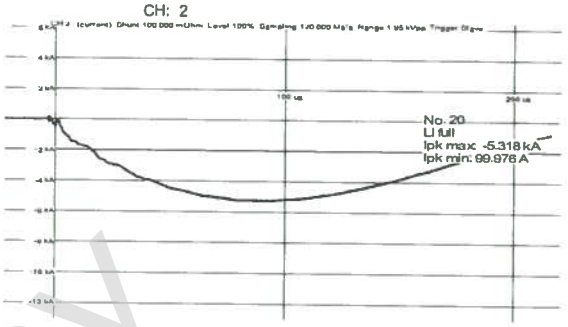
No. 19 LI full Ipk max: -5.299 kA Ipk min: 128.540 A

3U CH: 1



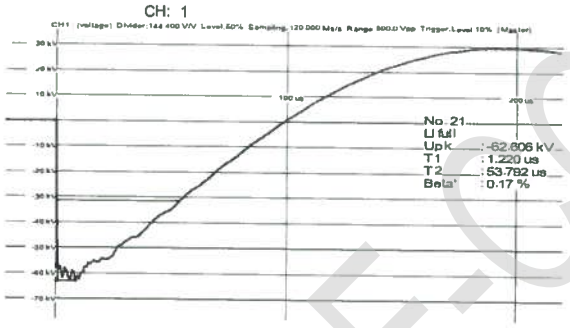
No. 20 LI full Upk: -124.614 kV T1: 1.234 us T2: 54.008 us Beta': 0.26 %

3U CH: 2



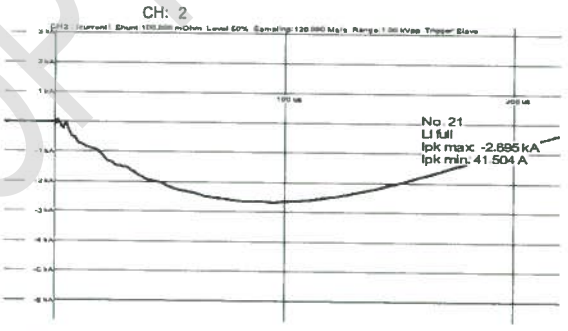
No. 20 LI full Ipk max: -5.318 kA Ipk min: 99.976 A

3V CH: 1



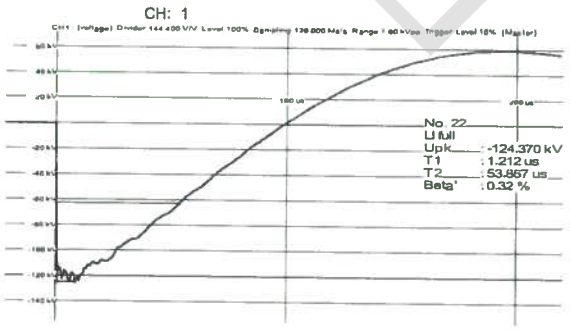
No. 21 LI full Upk: -62.606 kV T1: 1.220 us T2: 53.792 us Beta': 0.17 %

3V CH: 2



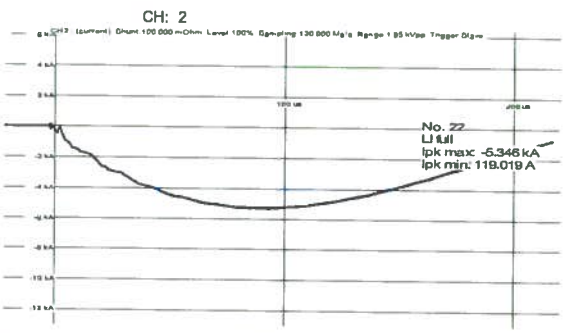
No. 21 LI full Ipk max: -2.695 kA Ipk min: 41.504 A

3V CH: 1



No. 22 LI full Upk: -124.370 kV T1: 1.212 us T2: 53.867 us Beta': 0.32 %

3V CH: 2



No. 22 LI full Ipk max: -5.346 kA Ipk min: 119.019 A

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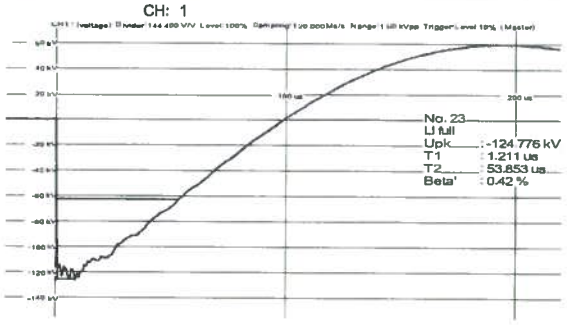
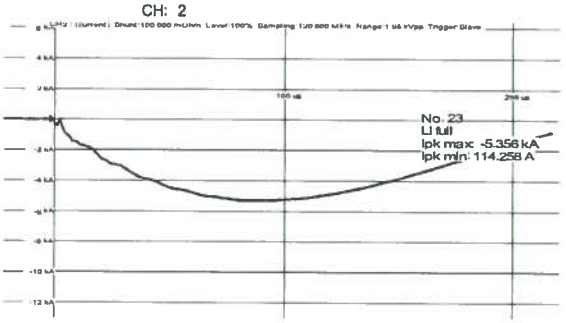
3V CH: 1



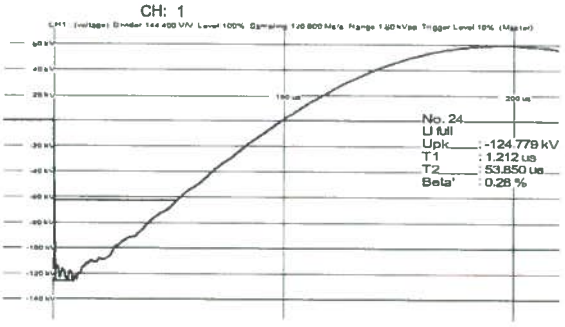
No. 23 LI full Upk: -124.776 kV T1: 1.211 us T2: 53.853 us Beta': 0.42 %

3V CH: 2



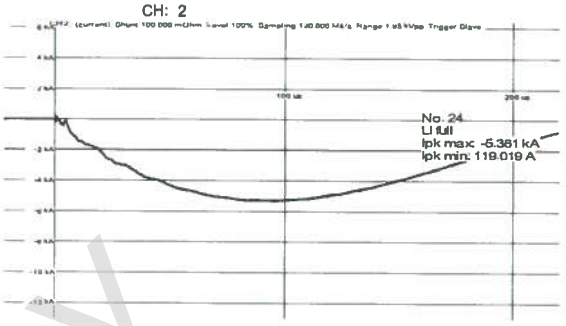
No. 23 LI full Ipk max: -5.356 kA Ipk min: 114.258 A

3V CH: 1



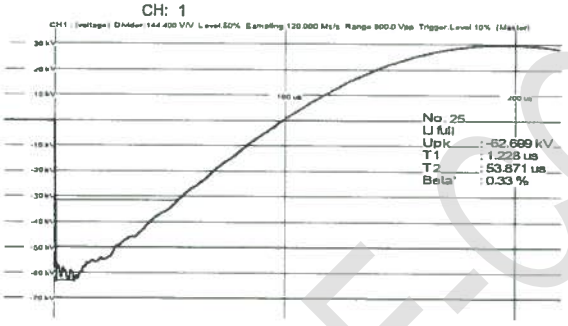
No. 24 LI full Upk: -124.779 kV T1: 1.212 us T2: 53.850 us Beta': 0.28 %

3V CH: 2



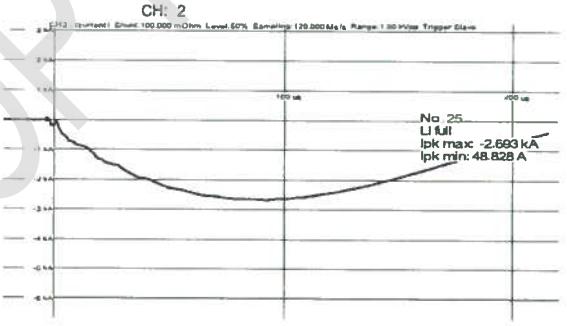
No. 24 LI full Ipk max: -5.361 kA Ipk min: 119.019 A

3W CH: 1



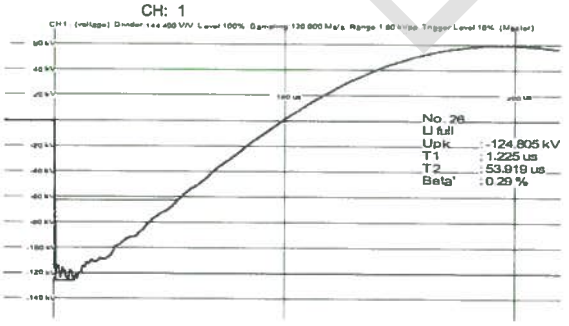
No. 25 LI full Upk: -62.699 kV T1: 1.228 us T2: 53.871 us Beta': 0.33 %

3W CH: 2



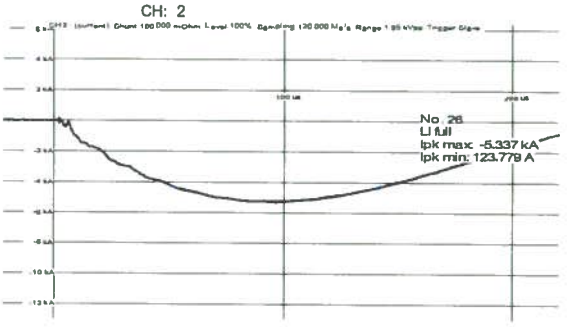
No. 25 LI full Ipk max: -2.693 kA Ipk min: 48.828 A

3W CH: 1



No. 26 LI full Upk: -124.805 kV T1: 1.225 us T2: 53.919 us Beta': 0.29 %

3W CH: 2



No. 26 LI full Ipk max: -5.337 kA Ipk min: 123.779 A

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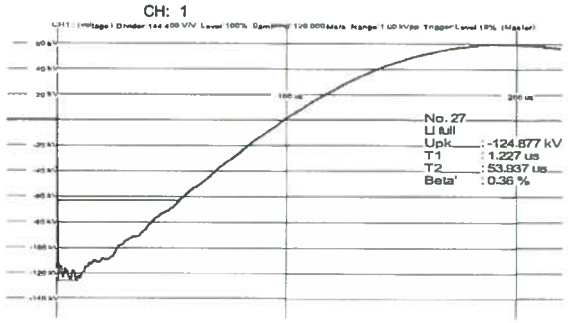
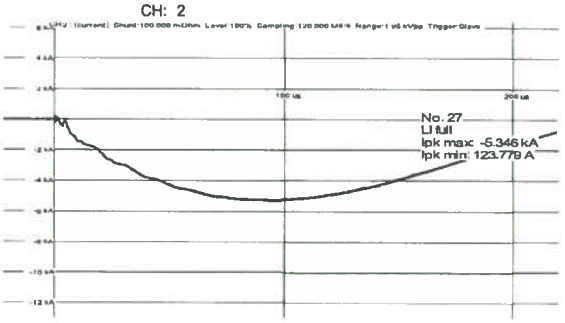
3W CH: 1



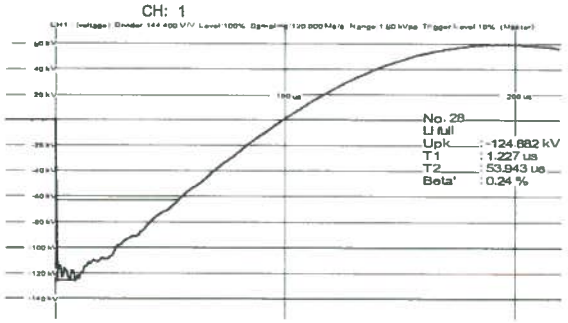
No. 27 LI full Upk: -124.877 kV T1: 1.227 us T2: 53.937 us Beta': 0.36 %

3W CH: 2



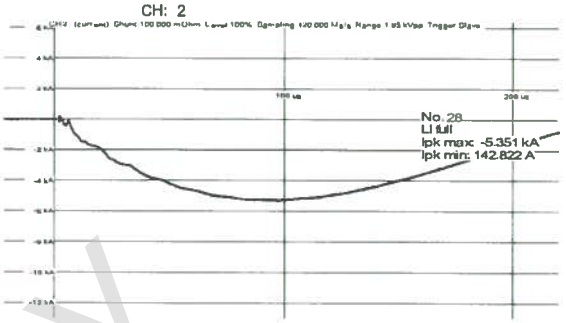
No. 27 LI full Ipk max: -5.346 kA Ipk min: 123.779 A

3W CH: 1



No. 28 LI full Upk: -124.882 kV T1: 1.227 us T2: 53.943 us Beta': 0.24 %

3W CH: 2



No. 28 LI full Ipk max: -5.351 kA Ipk min: 142.822 A

Date:
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ETD TRANSFORMÁTORY a.s.
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(2)

Testing engineer:
ing. Sluncikova

ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
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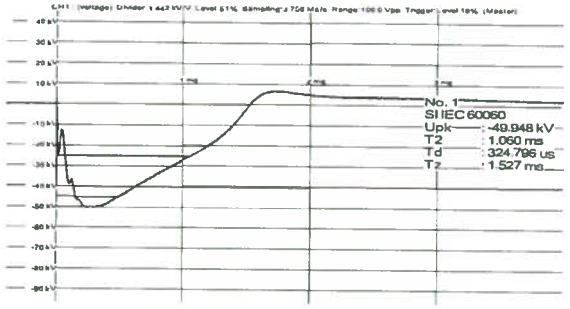
Enclosure to protocol No. ŘJ 14/168A
Switching impulse test

ETD TRANSFORMÁTORY a.s.

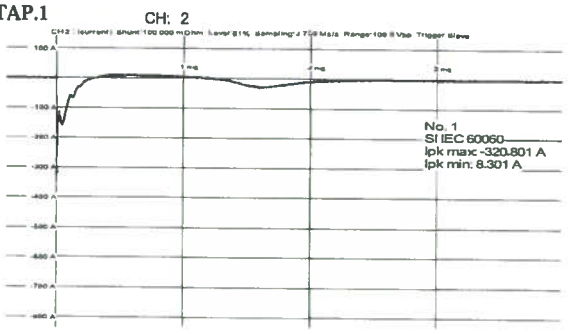
Work No.: 0969196 Temperature: 18,3°C Pressure: 735mmHg

1U_TAP.1 CH: 1



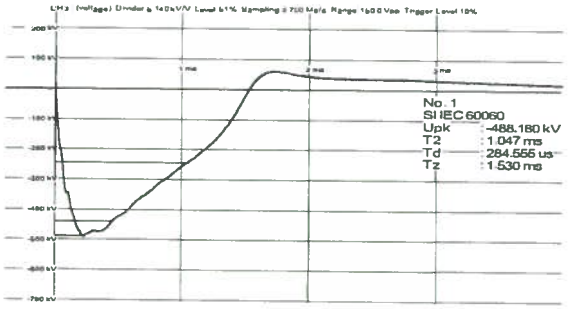
No. 1 SI IEC 60060 Upk: -49.948 kV T2: 1.060 ms Td: 324.796 us Tz: 1.527 m

1U_TAP.1 CH: 2



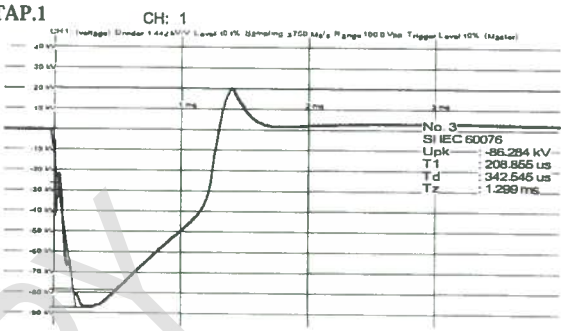
No. 1 SI IEC 60060 Ipk max: -320.801 A Ipk min: 8.301 A

1U_TAP.1 CH: 3



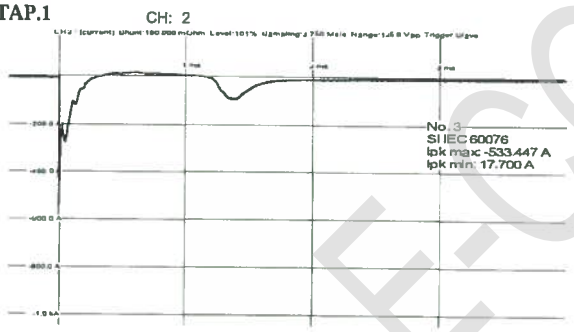
No. 1 SI IEC 60060 Upk: -488.180 kV T2: 1.047 ms Td: 284.555 us Tz: 1.530

1U_TAP.1 CH: 1



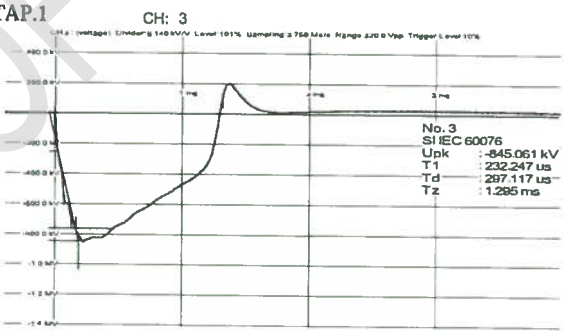
No. 3 SI IEC 60076 Upk: -86.284 kV T1: 208.855 us Td: 342.545 us Tz: 1.299

1U_TAP.1 CH: 2



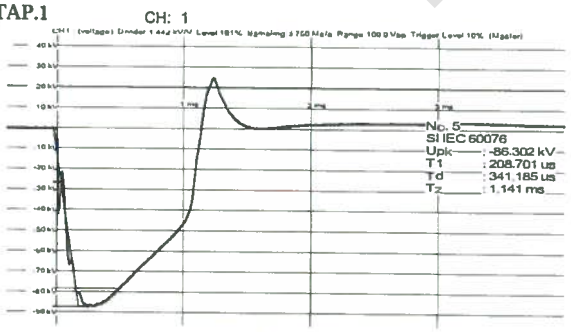
No. 3 SI IEC 60076 Ipk max: -533.447 A Ipk min: 17.700 A

1U_TAP.1 CH: 3



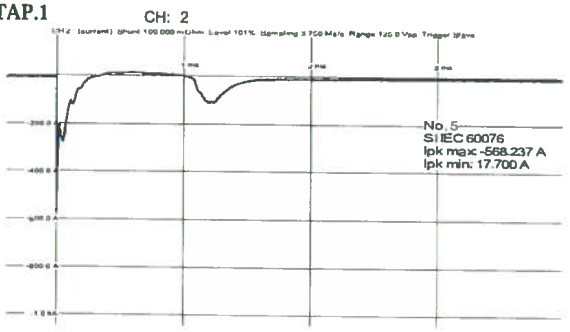
No. 3 SI IEC 60076 Upk: -845.061 kV T1: 232.247 us Td: 297.117 us Tz: 1.295

1U_TAP.1 CH: 1



No. 5 SI IEC 60076 Upk: -86.302 kV T1: 208.701 us Td: 341.185 us Tz: 1.141

1U_TAP.1 CH: 2



No. 5 SI IEC 60076 Ipk max: -568.237 A Ipk min: 17.700 A

Date:
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ETD TRANSFORMÁTORY a.s.
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(2)

Testing engineer:
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ZKU zkratovna HIGH POWER LABORATORY
REPORT No. 14-124
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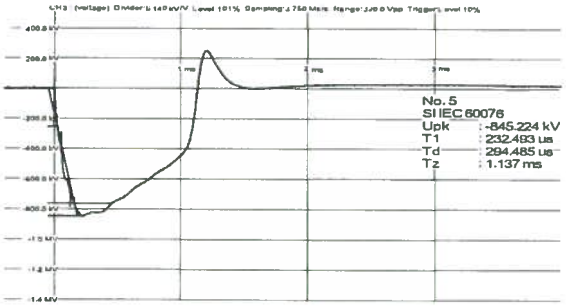
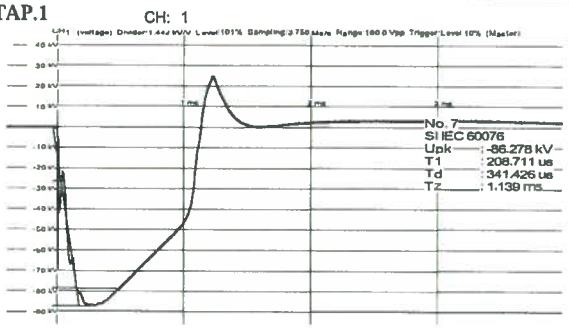
1U_TAP.1 CH: 3



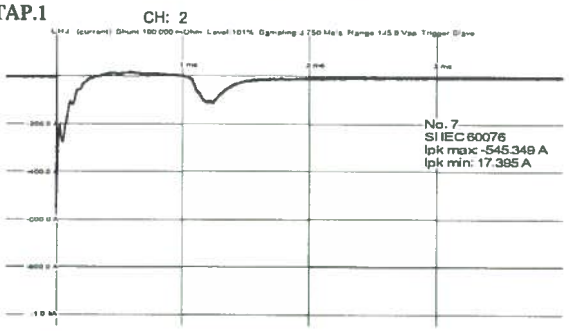
No. 5 SI IEC 60076 Upk: -845.224 kV T1: 232.493 us Td: 294.485 us Tz: 1.137

1U_TAP.1 CH: 1



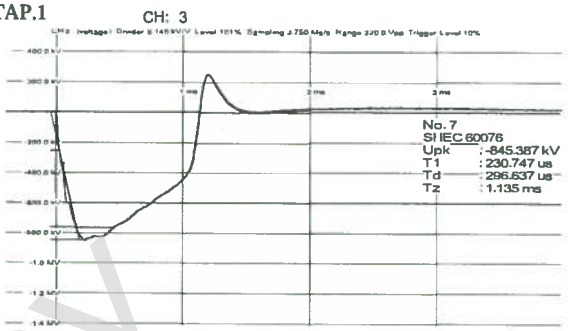
No. 7 SI IEC 60076 Upk: -86.278 kV T1: 208.711 us Td: 341.426 us Tz: 1.139

1U_TAP.1 CH: 2



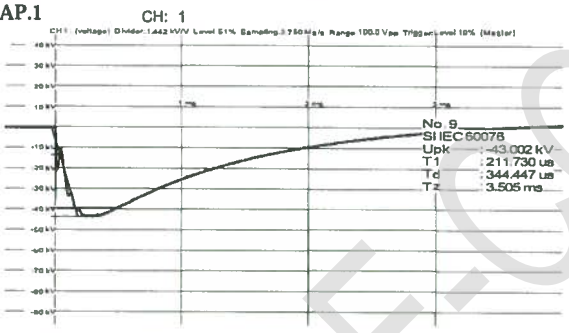
No. 7 SI IEC 60076 Ipk max: -545.349 A Ipk min: 17.395 A

1U_TAP.1 CH: 3



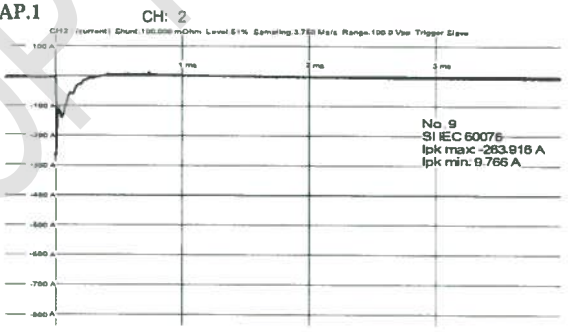
No. 7 SI IEC 60076 Upk: -845.387 kV T1: 230.747 us Td: 296.637 us Tz: 1.135

1V TAP.1 CH: 1



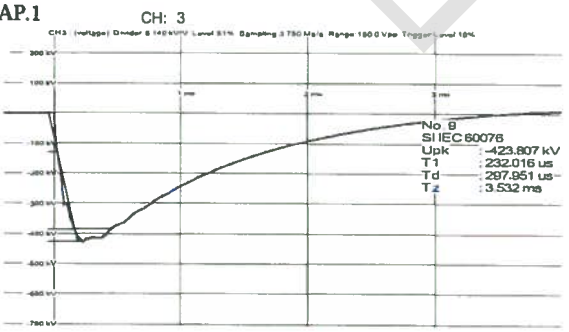
No. 9 SI IEC 60076 Upk: -43.002 kV T1: 211.730 us Td: 344.447 us Tz: 3.505

1V TAP.1 CH: 2



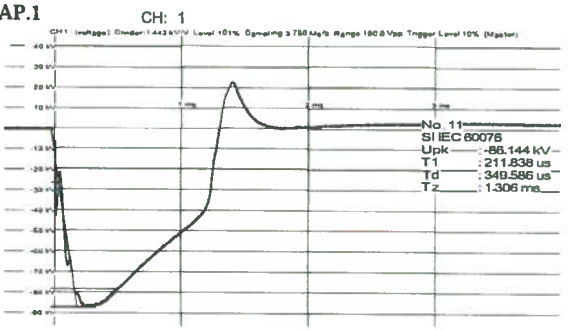
No. 9 SI IEC 60076 Ipk max: -263.916 A Ipk min: 9.766 A

1V TAP.1 CH: 3



No. 9 SI IEC 60076 Upk: -423.807 kV T1: 232.016 us Td: 297.951 us Tz: 3.532

1V TAP.1 CH: 1



No. 11 SI IEC 60076 Upk: -86.144 kV T1: 211.838 us Td: 349.586 us Tz: 1.306

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(2)

Testing engineer:
ing. Sluncikova

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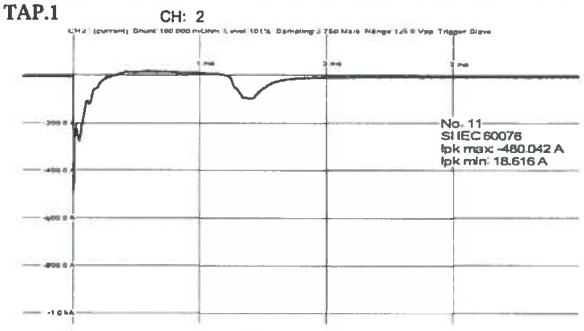
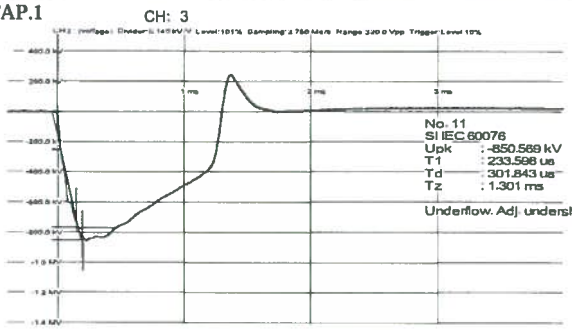
1V TAP.1 CH: 2



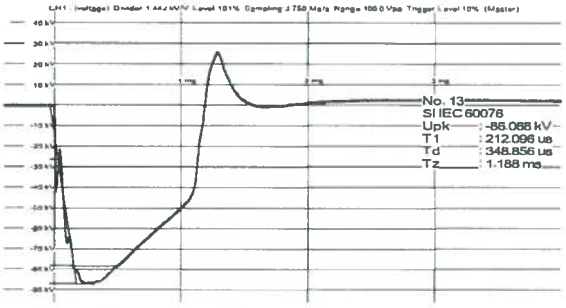
No. 11 SI IEC 60076 Ipk max: -480.042 A Ipk min: 18.616 A

1V TAP.1 CH: 3



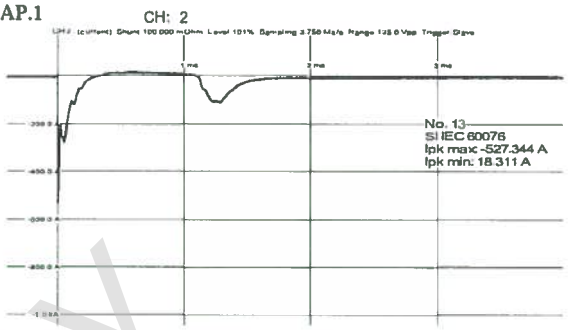
No. 11 SI IEC 60076 Upk: -850.569 kV T1: 233.598 us Td: 301.843 us Tz: 1.30

1V TAP.1 CH: 1



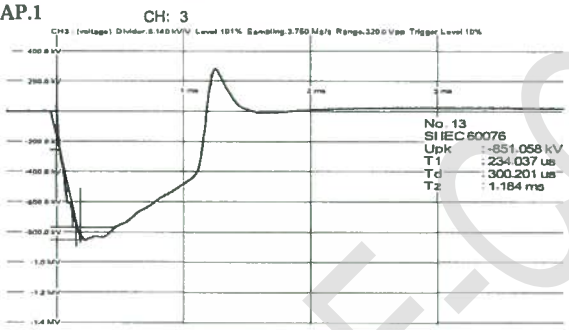
No. 13 SI IEC 60076 Upk: -86.088 kV T1: 212.096 us Td: 348.856 us Tz: 1.188

1V TAP.1 CH: 2



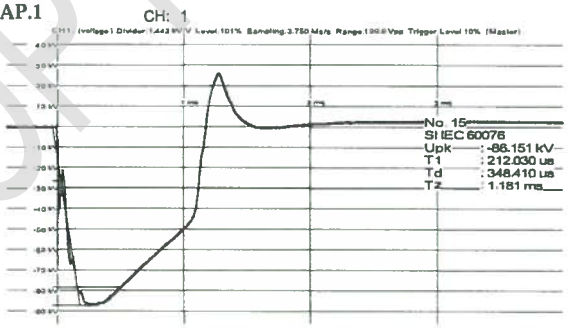
No. 13 SI IEC 60076 Ipk max: -527.344 A Ipk min: 18.311 A

1V TAP.1 CH: 3



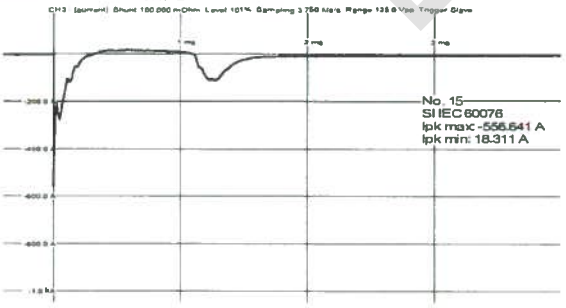
No. 13 SI IEC 60076 Upk: -851.058 kV T1: 234.037 us Td: 300.201 us Tz: 1.18

1V TAP.1 CH: 1



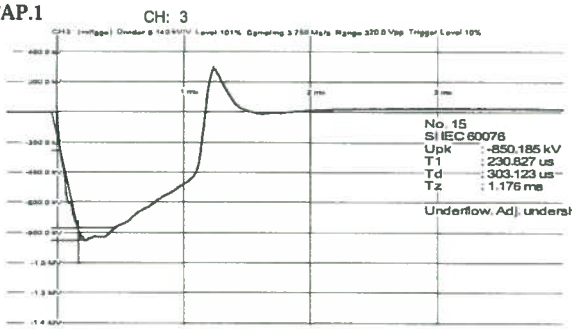
No. 15 SI IEC 60076 Upk: -86.151 kV T1: 212.030 us Td: 348.410 us Tz: 1.181

1V TAP.1 CH: 2



No. 15 SI IEC 60076 Ipk max: -556.641 A Ipk min: 18.311 A

1V TAP.1 CH: 3



No. 15 SI IEC 60076 Upk: -850.185 kV T1: 230.827 us Td: 303.123 us Tz: 1.17

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(2)

Testing engineer:
ing. Sluncikova

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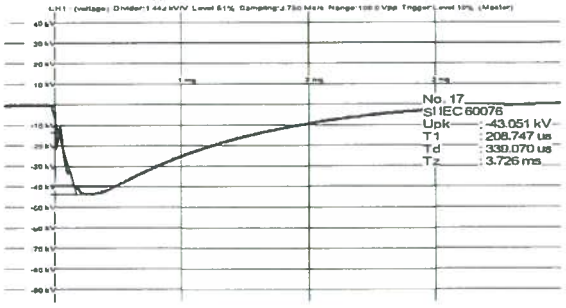
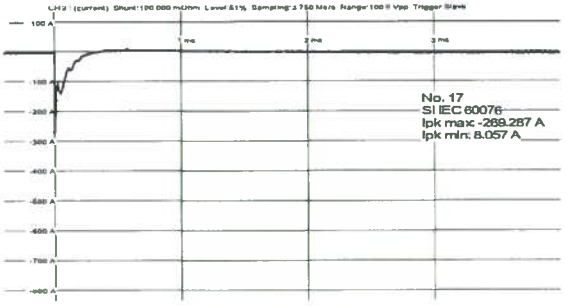
1W_TAP.1 CH: 1



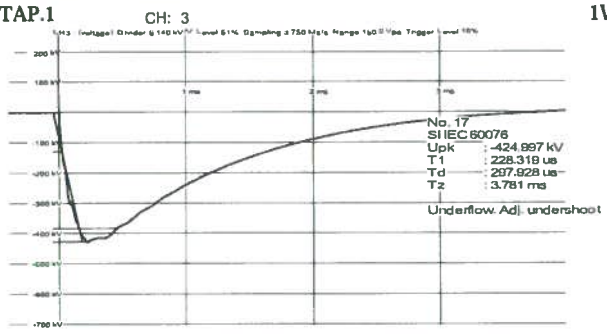
No. 17 SI IEC 60076 Upk: -43.051 kV T1: 208.747 us Td: 339.070 us Tz: 3.726

1W_TAP.1 CH: 2



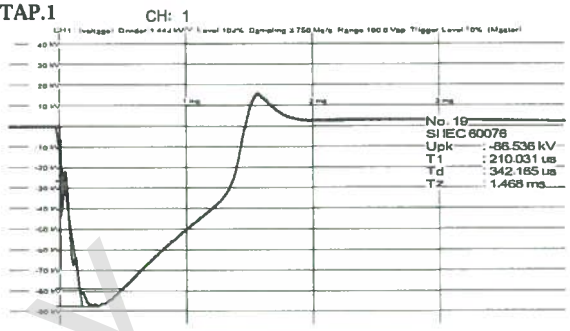
No. 17 SI IEC 60076 Ipk max: -269.287 A Ipk min: 8.057 A

1W_TAP.1 CH: 3



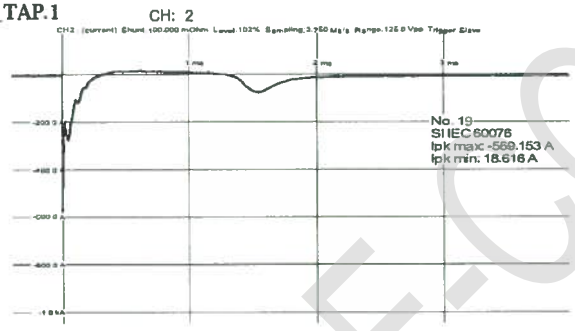
No. 17 SI IEC 60076 Upk: -424.997 kV T1: 228.319 us Td: 297.928 us Tz: 3.78

1W_TAP.1 CH: 1



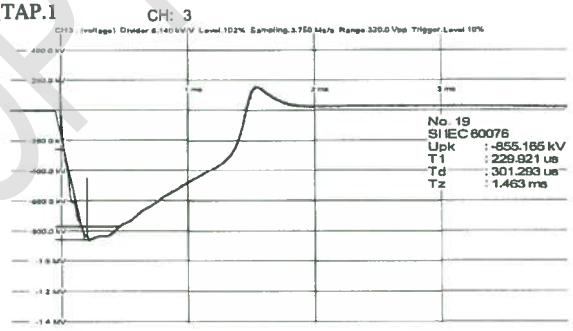
No. 19 SI IEC 60076 Upk: -86.536 kV T1: 210.031 us Td: 342.165 us Tz: 1.468

1W_TAP.1 CH: 2



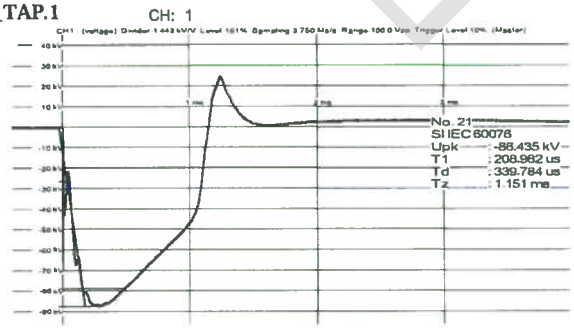
No. 19 SI IEC 60076 Ipk max: -569.153 A Ipk min: 18.616 A

1W_TAP.1 CH: 3



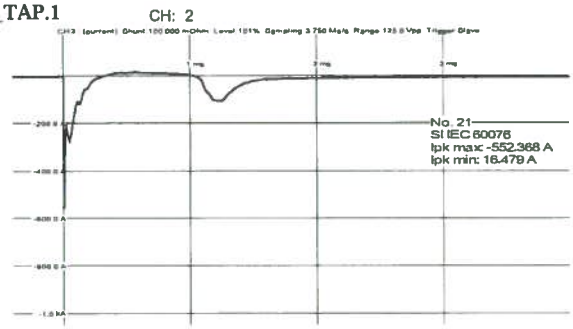
No. 19 SI IEC 60076 Upk: -855.165 kV T1: 229.921 us Td: 301.293 us Tz: 1.46

1W_TAP.1 CH: 1



No. 21 SI IEC 60076 Upk: -86.435 kV T1: 208.982 us Td: 339.784 us Tz: 1.151

1W_TAP.1 CH: 2



No. 21 SI IEC 60076 Ipk max: -552.368 A Ipk min: 16.479 A

Date:
23/09/14

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(2)

Testing engineer:
ing. Sluncikova

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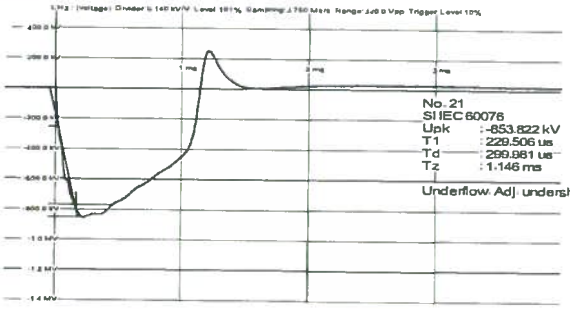
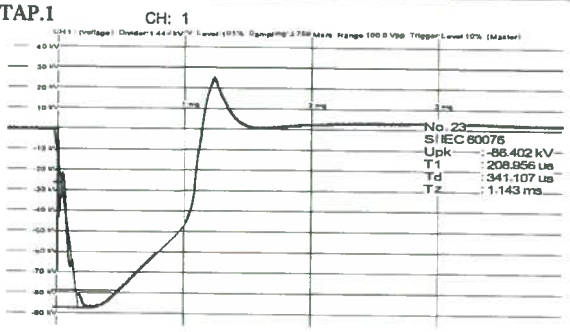
ETD TRANSFORMÁTORY a.s.

1W_TAP.1 CH: 3



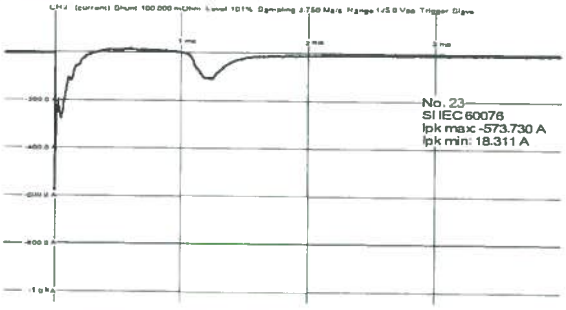
No. 21 SI IEC 60076 Upk: -853.822 kV T1: 229.506 us Td: 299.981 us Tz: 1.14

1W_TAP.1 CH: 1



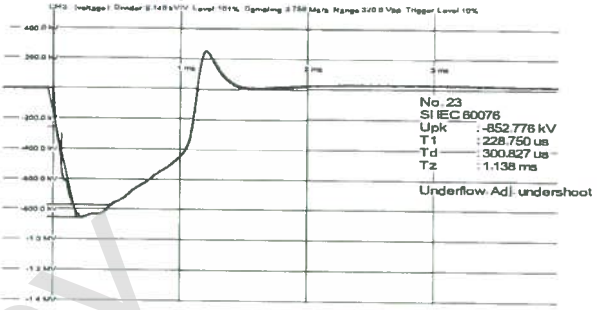
No. 23 SI IEC 60076 Upk: -86.402 kV T1: 208.956 us Td: 341.107 us Tz: 1.143

1W_TAP.1 CH: 2



No. 23 SI IEC 60076 Ipk max: -573.730 A Ipk min: 18.311 A

1W_TAP.1 CH: 3



No. 23 SI IEC 60076 Upk: -852.776 kV T1: 228.750 us Td: 300.827 us Tz: 1.13

Date:
23/09/14

Dr. Michael Amon

Digitálně podepsal Dr. Michael Amon
Datum: 2023.06.30 18:28:05 +02'00'

ETD TRANSFORMÁTORY a.s.
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Testing engineer:
ing. Sluncikova