

Client Tubos Trans Electric S.A.

Address of the client Eliseo Cantón 2342 – (X5003AHL) Córdoba – República Argentina

Manufacturer Tubos Trans Electric S.A.

Tested samples/items Three-phase two-windings oil-immersed power transformer 40 MVA
132 / 13,86 kV

Tests carried out Verification of the dynamic ability to withstand short-circuit

Standards/Specifications IEC 60076-5 (February 2006)

Tests date from June 24, 2014 to June 25, 2014

The results reported in this document relate only to the tested samples/items.
Partial reproduction of this document is permitted only with the written permission from CESI.

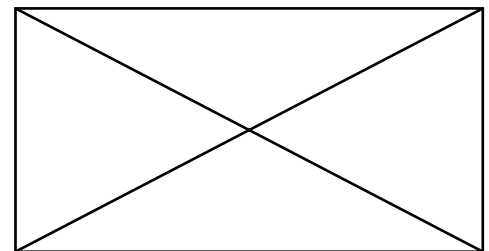
No. of pages 26 **No. of pages annexed** 11

Issue date July 15, 2014

Prepared PHV - Levati Mario
B4015192 2961 AUT

Verified PSV - Vidori Mauro, PHV - Faccheni Fabio
B4015192 2158654 VER B4015192 2158659 VER

Approved PMI - The Manager - Arcidiaco Lorenzo
B4015192 821814 APP



Tests witnessed by

Mr. Pablo A. Arrascaeta
Mr. Miguel E. Marioli

Tubos Trans Electric S.A.
Tubos Trans Electric S.A.

Identification of the object not requested

Test evaluation

With reference to the Standards/Specifications listed in the first page and the characteristics of the tested sample assigned by manufacturer, the carried out tests passed SUCCESSFULLY.

Revision history

| Revision No. | List of modifications |
|--------------|---|
| 0 | First issue |
| 1 | Second issue (modified pag.6 and pag.9) |

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

The reported expanded uncertainties are determined in accordance with the Publication ENV 13005: 1999 “Guide to the expression of uncertainty in measurement” and are based on a standard uncertainty multiplied by a coverage factor $k = 2$, which for a normal distribution provides a level of confidence of approximately 95 %.

- Voltage a.c. $\leq \pm 3,0 \%$
- Current a.c. $\leq \pm 3,0 \%$
- Resistance d.c. $\leq \pm 1,5 \%$
- Inductance $\leq \pm 1,0 \%$
- Time $\leq \pm 1,5 \%$

Laboratory information

Receipt date of the sample June 2014

CESI testing team

M. Levati
L. Brambilla
P. Spelta


Test laboratory code ODV P140
70000273

Rated characteristics of the tested object assigned by the Client
Power transformer

| | |
|--|-------------------------------|
| Manufacturer | Tubos Trans Electric S.A. |
| Transformer triphase type | TATBA 40000/145 |
| Serial number | 49617 |
| Power ONAN/ONAF | 25/40 MVA |
| Frequency | 50 Hz |
| Voltage | |
| H.V. winding | 132 kV $\pm 11 \times 1,43$ % |
| L.V. winding | 13,86 kV |
| Current | |
| H.V. winding | 174,95 A |
| L.V. winding | 1666,23 A |
| Impedance voltage referred to tap changer position at 40 MVA | |
| Referred to the maximum tapping (on-load tap-changer position -11) | 14,023 % |
| Referred to the principal tapping (on-load tap-changer position 0) | 12,962 % |
| Referred to the minimum tapping (on-load tap-changer position +11) | 12,505 % |
| Connection symbol | Ynyn0 |
| Type of functioning | Continuous |
| Type of cooling | ONAN/ONAF |
| Total mass | 63800 kg |
| Mass of the insulating oil | 15380 kg |
| Untanking mass | 36500 kg |

Name and signature of Client's witness

Name Plate of the test object



Tubos Trans Electric

ELISEO CANTÓN 2342 (X5003AHL) - CÓRDOBA - REPÚBLICA ARGENTINA
TEL.(+54)(+351)4894545 / FAX.(+54)(+351)4894617 / www.tte.com.ar

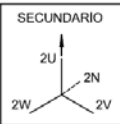
TRANSFORMADOR TRIFÁSICO EN BAÑO DE ACEITE

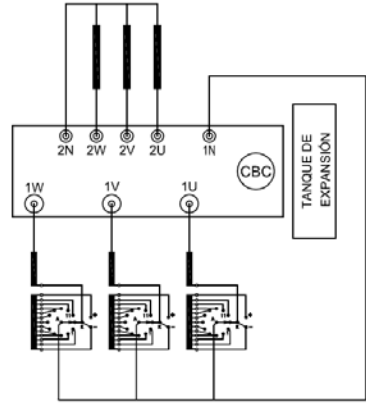
| | | | | | | |
|------------------|------------------|---------------------|---------------|--------------------------------------|---------------------------|-------------|
| TIPO | POTENCIA NOMINAL | TENSIONES NOMIN. | CÓD. PRODUCTO | N° APARATO | NORMA BÁSICA | AÑO FABR. |
| TATBA 40000/145 | 40 MVA | 132 / 13,86 kV | 09A60890000 | 49617 | I.E.C. 60076 | (*) |
| SERVICIO NOMINAL | GRUPO CONEXIÓN | IMPEDANCIA (40 MVA) | FRECUENCIA | LÍQUIDO AISLANTE | SIST. REFRIGER. | AISL. CLASE |
| CONTINUO | YN,yn0 | 12,96 % | 50 Hz | ACEITE MINERAL ASTM D-3487 TIPO I | ONAN 62,5 % ONAF 100 % | A |

| | | | | | | | | |
|--------------------|-------------------|-------------------|----------------|------------------|---------------------------------|------------|---------------|---------------|
| SOBRE TEMP. ACEITE | SOBRE TEMP. COBRE | VOLUMEN DE ACEITE | MASA DE ACEITE | MASA DESENCUBAJE | MASA TRANSPORTE (SIN ACEITE) | MASA TOTAL | ESF. TRACCIÓN | ESF. ARRANQUE |
| 50 °C | 55 °C | 17670 L | 15380 Kg | 36500 Kg | 43400 Kg | 63800 Kg | 1880 daN | 2820 daN |

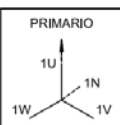
| INDICADOR DE POSICIONES DE PRE-SELECTOR | INDICADOR DE POSICIONES DE SELECTOR | PRIMARIO | | SECUNDARIO | |
|---|-------------------------------------|------------|----------------|----------------|-------------------|
| | | RELACIÓN % | TENSIÓN (VOLT) | TENSIÓN (VOLT) | CORRIENTE (AMPER) |
| -11 | 1 | +15,70 | 152724 | 151,21 | |
| -10 | 2 | +14,27 | 150840 | 153,10 | |
| -9 | 3 | +12,85 | 148956 | 155,04 | |
| -8 | 4 | +11,42 | 147072 | 157,03 | |
| -7 | 5 | +9,99 | 145188 | 159,06 | |
| -6 | 6 | +8,56 | 143304 | 161,15 | |
| -5 | 7 | +7,14 | 141420 | 163,30 | |
| -4 | 8 | +5,71 | 139536 | 165,51 | |
| -3 | 9 | +4,28 | 137652 | 167,77 | |
| -2 | 10 | +2,85 | 135768 | 170,10 | |
| -1 | 11 | +1,43 | 133884 | 172,49 | |
| 0 | K | +0,00 | 132000 | 174,95 | 13860 1666,23 |
| +1 | 1 | -1,43 | 130116 | 177,49 | |
| +2 | 2 | -2,85 | 128232 | 180,10 | |
| +3 | 3 | -4,28 | 126348 | 182,78 | |
| +4 | 4 | -5,71 | 124464 | 185,55 | |
| +5 | 5 | -7,14 | 122580 | 188,40 | |
| +6 | 6 | -8,56 | 120696 | 191,34 | |
| +7 | 7 | -9,99 | 118812 | 194,37 | |
| +8 | 8 | -11,42 | 116928 | 197,51 | |
| +9 | 9 | -12,85 | 115044 | 200,74 | |
| +10 | 10 | -14,27 | 113160 | 204,08 | |
| +11 | 11 | -15,70 | 111276 | 207,54 | |

SECUNDARIO





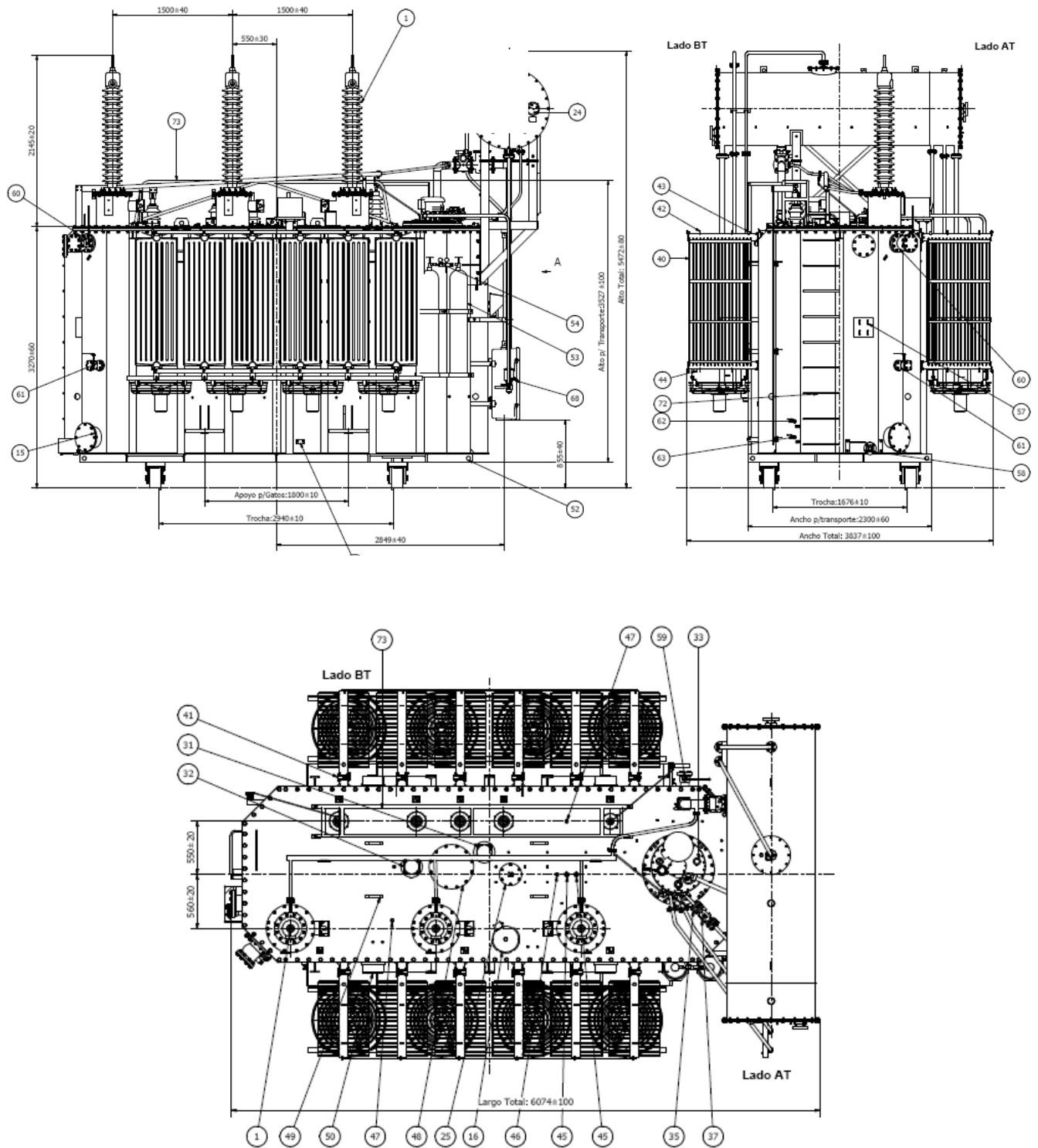
PRIMARIO



| NIVELES DE AISLACIÓN | | |
|----------------------------|-----------|---------------|
| ENSAYO DIELECTRICO | PRIMARIO | SECUNDARIO |
| APLICADA (kV) - 50Hz - 60s | 38 | 38 |
| INDUCIDA (kV) - 125Hz | 145 / 125 | 15,23 / 13,13 |
| IMPULSO (kV) - 1.2/50µs | 550 | 95 |

INDUSTRIA ARGENTINA

Composition of the tested object



Requested values

Pcc: 10000 MVA

| Tap changer position | Vn | Vcc | Zcc =U/(RADQ(3)*In*100/Vcc) | Short-network impedanc | Short-circuit primary current (*1) | | Notes |
|----------------------|---------|--------|--------------------------------|------------------------|------------------------------------|------------|-------|
| | | | | | rms value | Peak value | |
| - | V | % | Ω | Ω | A | A | - |
| Maximum (-11) | 152,724 | 14,023 | 81,772 | 1,742 | 1056 | 2692 | |
| Principal (0) | 132,00 | 12,961 | 56,462 | 1,742 | 1309 | 3339 | |
| Minimum (+11) | 111,276 | 12,505 | 38,712 | 1,742 | 1588 | 4049 | |

(*1) Values of short-circuit current of the High-voltage winding (star-connected).

Testing procedure

The short-circuit withstand tests have been performed with the post-set short-circuit applied on the LV side after the energization of the transformer.

Nine tests were performed (three tests on each tap changer position):

- three tests with the tap-changer in the position corresponding to the highest voltage ratio (with the maximum peak current on the outer limb)
- three tests with the tap-changer in the position corresponding to the lowest voltage ratio (with the maximum peak current on one of the outer limbs),
- three tests with the tap-changer in the position corresponding to the rated voltage ratio (with the maximum peak current on the middle limbs),

Measurement procedure

The short-circuit inductance of the transformer was measured with Schering bridge (Maxwell diagram) : Reproducibility $\pm 0,1$ %.

The measurements were effected:

- before and after each tests on the H.V. side with the L.V. terminals short-circuited,
- before and after each tests on the L.V. side with the H.V. terminals short-circuited,

Three-phase short-circuit withstand tests**Test circuit :** See D0021 Frequency : 50 Hz

Condition of the apparatus before the tests: new Supply side of the test circuit connected to : H.V. terminals

Date: June 24, 2014

| Test | Oscillogram | | Tap changer position | Limb with maximum asymmetry | Duration | Applied phase voltage | H.V. side current | | L.V. side current | | Gas relay intervention | |
|-------------|-------------|--------|----------------------|-----------------------------|----------|-----------------------|----------------------|--------------|-------------------------|--------------|------------------------|--|
| | No. | Sheets | | | | | Symmetrical | Maximum peak | Symmetrical | Maximum peak | | |
| No. | No. | Sheets | - | - | S | kV | A | A | A | A | Yes / No | |
| Preliminary | 5 | 1 | 0 | V | 0,1 | 41,9 | 695 697 693 | 1940 | 6760 6750 6710 | 18600 | No | |
| 1 | 7 | 1 | 0 | V | 0,26 | 80,8 | 1280 1260 1280 | 3370 | 12200 12100 12200 | 33100 | No | |
| 2 | 8 | 1 | 0 | V | 0,26 | 81,1 | 1280 1260 1280 | 3360 | 12200 12200 12200 | 33500 | No | |
| 3 | 9 | 1 | 0 | V | 0,26 | 81,1 | 1280 1270 1280 | 3330 | 12200 12300 12200 | 33400 | No | |

Condition of the apparatus after the tests: no remarks, the outside of the transformer was as before the tests

Three-phase short-circuit withstand tests

Test circuit : See D0021 Frequency : 50 Hz

Condition of the apparatus before the tests: as after the test No. 3 Supply side of the test circuit connected to : H.V. terminals

Date: June 24, 2014

| Test No. | Oscillogram | | Tap changer position | Limb with maximum asymmetry | Duration s | Applied phase voltage kV | H.V. side current | | L.V. side current | | Gas relay intervention | |
|----------|-------------|--------|----------------------|-----------------------------|------------|--------------------------|----------------------|----------------|-------------------------|----------------|------------------------|--|
| | No. | Sheets | | | | | Symmetrical A | Maximum peak A | Symmetrical A | Maximum peak A | | |
| 4 | 10 | 1 | +11 | W | 0,26 | 72,9 | 1620 1610 1600 | 4270 | 13000 13000 13000 | 34800 | No | |
| 5 | 11 | 1 | +11 | W | 0,26 | 72,9 | 1600 1580 1590 | 4120 | 12900 12900 12800 | 33700 | No | |
| 6 | 12 | 1 | +11 | W | 0,26 | 72,9 | 1610 1590 1600 | 4180 | 12900 12900 12800 | 34400 | No | |

Condition of the apparatus after the tests: no remarks, the outside of the transformer was as before the tests

Three-phase short-circuit withstand tests

Test circuit : See D0021 Frequency : 50 Hz

Condition of the apparatus before the tests: as after the test No. 6 Supply side of the test circuit connected to : H.V. terminals

Date: June 25, 2014

| Test | Oscillogram | | Tap changer position | Limb with maximum asymmetry | Duration | Applied phase voltage | H.V. side current | | L.V. side current | | Gas relay intervention | |
|-------------|-------------|--------|----------------------|-----------------------------|----------|-----------------------|----------------------|--------------|-------------------------|--------------|------------------------|--|
| | No. | Sheets | | | | | Symmetrical | Maximum peak | Symmetrical | Maximum peak | | |
| No. | No. | Sheets | - | - | S | kV | A | A | A | A | Yes / No | |
| Preliminary | 14 | 1 | -11 | W | 0,11 | 44,1 | 526 527 526 | 1490 | 5870 5950 5880 | 16500 | No | |
| 7 | 15 | 1 | -11 | U | 0,26 | 88,7 | 1030 1010 1020 | 2750 | 11200 11200 11300 | 30900 | No | |
| 8 | 16 | 1 | -11 | U | 0,26 | 88,1 | 1030 1010 1030 | 2730 | 11200 11200 11300 | 30800 | No | |
| 9 | 17 | 1 | -11 | U | 0,26 | 88,4 | 1030 1010 1020 | 2770 | 11200 11200 11300 | 31100 | No | |

Condition of the apparatus after the tests: no remarks, the outside of the transformer was as before the tests.

No gas was found in the Buchholz relay, didn't operate

Maximum inductance variations: **0,19%**. HV side

Maximum inductance variations: **0,17%**. MV side

Maximum variation of short-circuit inductance stated by Standard: 2 %.

After the tests, the transformer was sealed with to red seals numbered 0009013,0009918, 0009916 and 0009917- see photos no. 4,5,6 and 7

Short-circuit inductance measurements

Measurements conditions : Tap changer position : Principal (0) Measured terminals : HV Short-circuited terminals : MV

Instrument: Bridge TETTEX type 2801 – CESI ref. No.8449 (Scheme : MAXWELL) Supply voltage : 25 V, 50 Hz

R2 (Ω) 1000
 R3 (Ω) 500
 RX (Ω) 500

| Measure | | Date Hour | Measured terminals | R4 | C4 | LX (R2xR3xC4) | Difference | Column | LX | Difference |
|--------------------|---|--------------|-----------------------|----------|---------------|------------------|------------|--------|---------|------------|
| | | - | - | Ω | μF | mH | % | - | mH | % |
| Before the tests | | 24-giu-14 | 1U - 1V | 992,95 | 0,71619 | 358,095 | - | U | 179,630 | - |
| | | | 1U - 1W | 992,68 | 0,71509 | 357,545 | - | V | 178,465 | - |
| | | 17:30 | 1V - 1W | 993,71 | 0,71276 | 356,380 | - | W | 177,915 | - |
| After the test No. | 1 | 24-giu-14 | 1U - 1V | 994,31 | 0,71558 | 357,790 | -0,09 | U | 179,378 | -0,14 |
| | | | 1U - 1W | 993,49 | 0,71493 | 357,465 | -0,02 | V | 178,413 | -0,03 |
| | | 11:30 | 1V - 1W | 993,72 | 0,71300 | 356,500 | 0,03 | W | 178,088 | 0,10 |
| After the test No. | 2 | 25-giu-14 | 1U - 1V | 993,66 | 0,71604 | 358,020 | -0,02 | U | 179,575 | -0,03 |
| | | | 1U - 1W | 988,65 | 0,71508 | 357,540 | 0,00 | V | 178,445 | -0,01 |
| | | 00:00 | 1V - 1W | 988,66 | 0,71282 | 356,410 | 0,01 | W | 177,965 | 0,03 |
| After the test No. | 3 | 25-giu-14 | 1U - 1V | 994,42 | 0,71589 | 357,945 | -0,04 | U | 179,488 | -0,08 |
| | | | 1U - 1W | 994,12 | 0,71472 | 357,360 | -0,05 | V | 178,458 | 0,00 |
| | | 00:30 | 1V - 1W | 994,48 | 0,71266 | 356,330 | -0,01 | W | 177,873 | -0,02 |
| After the test No. | 9 | 25-giu-14 | 1U - 1V | 993,81 | 0,71566 | 357,830 | -0,07 | U | 179,345 | -0,16 |
| | | | 1U - 1W | 993,59 | 0,71464 | 357,320 | -0,06 | V | 178,485 | 0,01 |
| | | 23:30 | 1V - 1W | 993,65 | 0,71292 | 356,460 | 0,02 | W | 177,975 | 0,03 |

Short-circuit inductance measurements

Measurements conditions : Tap changer position : Minimum (+11) Measured terminals : HV Short-circuited terminals : MV

Instrument: Bridge TETTEX type 2801 – CESI ref. No.8449 (Scheme : MAXWELL) Supply voltage : 25 V, 50 Hz

R2 (Ω) 1000
R3 (Ω) 500
RX (Ω) 500

| Measure | | Date Hour | Measured terminals | R4 | C4 | LX (R2xR3xC4) | Difference | Column | LX | Difference |
|--------------------|---|--------------|-----------------------|--------|---------|------------------|------------|--------|---------|-------------|
| | | - | - | Ω | μF | mH | % | - | mH | % |
| Before the tests | | 24-giu-14 | 1U - 1V | 993,89 | 0,49061 | 245,305 | - | U | 123,643 | - |
| | | | 1U - 1W | 993,77 | 0,49206 | 246,030 | - | V | 121,663 | - |
| | | 17:40 | 1V - 1W | 994,60 | 0,48810 | 244,050 | - | W | 122,388 | - |
| After the test No. | 3 | 25-giu-14 | 1U - 1V | 994,75 | 0,49062 | 245,310 | 0,00 | U | 123,665 | 0,02 |
| | | | 1U - 1W | 994,60 | 0,49211 | 246,055 | 0,01 | V | 121,645 | -0,01 |
| | | 00:30 | 1V - 1W | 995,34 | 0,48807 | 244,035 | -0,01 | W | 122,390 | 0,00 |
| After the test No. | 4 | 25-giu-14 | 1U - 1V | 994,51 | 0,49065 | 245,325 | 0,01 | U | 123,600 | -0,03 |
| | | | 1U - 1W | 994,13 | 0,49213 | 246,065 | 0,01 | V | 121,725 | 0,05 |
| | | 01:00 | 1V - 1W | 994,48 | 0,48838 | 244,190 | 0,06 | W | 122,465 | 0,06 |
| After the test No. | 5 | 25-giu-14 | 1U - 1V | 994,54 | 0,49067 | 245,335 | 0,01 | U | 123,653 | 0,01 |
| | | | 1U - 1W | 993,68 | 0,49234 | 246,170 | 0,06 | V | 121,683 | 0,02 |
| | | 01:30 | 1V - 1W | 993,98 | 0,48840 | 244,200 | 0,06 | W | 122,518 | 0,11 |
| After the test No. | 6 | 25-giu-14 | 1U - 1V | 995,20 | 0,49050 | 245,250 | -0,02 | U | 123,565 | -0,06 |
| | | | 1U - 1W | 993,74 | 0,49238 | 246,190 | 0,07 | V | 121,685 | 0,02 |
| | | 02:00 | 1V - 1W | 993,98 | 0,48862 | 244,310 | 0,11 | W | 122,625 | 0,19 |
| After the test No. | 9 | 25-giu-14 | 1U - 1V | 994,66 | 0,49034 | 245,170 | -0,06 | U | 123,465 | -0,14 |
| | | | 1U - 1W | 994,58 | 0,49186 | 245,930 | -0,04 | V | 121,705 | 0,03 |
| | | 23:30 | 1V - 1W | 994,55 | 0,48834 | 244,170 | 0,05 | W | 122,465 | 0,06 |

Short-circuit inductance measurements

Measurements conditions : Tap changer position : Maximum (-11) Measured terminals : HV Short-circuited terminals : MV

Instrument: Bridge TETTEX type 2801 – CESI ref. No.8449 (Scheme : MAXWELL) Supply voltage : 25 V, 50 Hz

R2 (Ω) 1000
R3 (Ω) 1000
RX (Ω) 1000

| Measure | | Date Hour | Measured terminals | R4 | C4 | LX (R2xR3xC4) | Difference | Column | LX | Difference |
|--------------------|---|--------------|-----------------------|--------|---------|------------------|------------|--------|---------|------------|
| | | - | - | Ω | μF | mH | % | - | mH | % |
| Before the tests | | 24-giu-14 | 1U - 1V | 995,74 | 0,51805 | 518,050 | - | U | 258,575 | - |
| | | | 1U - 1W | 995,50 | 0,51496 | 514,960 | - | V | 259,475 | - |
| | | 17:50 | 1V - 1W | 995,91 | 0,51586 | 515,860 | - | W | 256,385 | - |
| After the test No. | 6 | 24-giu-14 | 1U - 1V | 996,51 | 0,51802 | 518,020 | -0,01 | U | 258,595 | 0,01 |
| | | | 1U - 1W | 995,49 | 0,51499 | 514,990 | 0,01 | V | 259,425 | -0,02 |
| | | 01:30 | 1V - 1W | 995,77 | 0,51582 | 515,820 | -0,01 | W | 256,395 | 0,00 |
| After the test No. | 7 | 25-giu-14 | 1U - 1V | 996,29 | 0,51766 | 517,660 | -0,08 | U | 258,375 | -0,08 |
| | | | 1U - 1W | 994,56 | 0,51473 | 514,730 | -0,04 | V | 259,285 | -0,07 |
| | | 22:30 | 1V - 1W | 995,51 | 0,51564 | 515,640 | -0,04 | W | 256,355 | -0,01 |
| After the test No. | 8 | 25-giu-14 | 1U - 1V | 996,52 | 0,51764 | 517,640 | -0,08 | U | 258,240 | -0,13 |
| | | | 1U - 1W | 995,71 | 0,51480 | 514,800 | -0,03 | V | 259,400 | -0,03 |
| | | 22:50 | 1V - 1W | 995,94 | 0,51596 | 515,960 | 0,02 | W | 256,560 | 0,07 |
| After the test No. | 9 | 25-giu-14 | 1U - 1V | 995,86 | 0,51771 | 517,710 | -0,07 | U | 258,285 | -0,11 |
| | | | 1U - 1W | 995,77 | 0,51476 | 514,760 | -0,04 | V | 259,425 | -0,02 |
| | | 23:30 | 1V - 1W | 995,84 | 0,51590 | 515,900 | 0,01 | W | 256,475 | 0,04 |

Short-circuit inductance measurements

Measurements conditions : Tap changer position : Principal (0) Measured terminals : MV Short-circuited terminals : HV

Instrument: Bridge TETTEX type 2801 – CESI ref. No.8449 (Scheme : MAXWELL) Supply voltage : 6 V, 50 Hz

R2 (Ω) 1000
 R3 (Ω) 10
 RX (Ω) 10

| Measure | | Date Hour | Measured terminals | R4 | C4 | LX (R2xR3xC4) | Difference | Column | LX | Difference |
|--------------------|---|--------------|-----------------------|----------|---------------|------------------|------------|--------|-------|--------------|
| | | - | - | Ω | μF | mH | % | - | mH | % |
| Before the tests | | 24-giu-14 | 2U - 2V | 1004,18 | 0,39822 | 3,982 | - | U | 1,999 | - |
| | | | 2U - 2W | 1003,46 | 0,39840 | 3,984 | - | V | 1,984 | - |
| | | 22:00 | 2V - 2W | 1001,99 | 0,39692 | 3,969 | - | W | 1,986 | - |
| After the test No. | 9 | 25-giu-14 | 2U - 2V | 995,95 | 0,39805 | 3,981 | -0,04 | U | 2,000 | 0,08 |
| | | | 2U - 2W | 996,92 | 0,39840 | 3,984 | 0,00 | V | 1,980 | -0,17 |
| | | 23:30 | 2V - 2W | 994,95 | 0,39642 | 3,964 | -0,13 | W | 1,984 | -0,08 |

Short-circuit inductance measurements

Measurements conditions : Tap changer position : Minimum (+11) Measured terminals : MV Short-circuited terminals : HV

Instrument: Bridge TETTEX type 2801 – CESI ref. No.8449 (Scheme : MAXWELL) Supply voltage : 6 V, 50 Hz

R2 (Ω) 1000
 R3 (Ω) 10
 RX (Ω) 10

| Measure | | Date Hour | Measured terminals | R4 | C4 | LX (R2xR3xC4) | Difference | Column | LX | Difference |
|--------------------|---|--------------|-----------------------|----------|---------------|------------------|------------|--------|-------|------------|
| | | - | - | Ω | μF | mH | % | - | mH | % |
| Before the tests | | 24-giu-14 | 2U - 2V | 1005,82 | 0,384340 | 3,843 | - | U | 1,927 | - |
| | | | 2U - 2W | 1004,88 | 0,387200 | 3,872 | - | V | 1,917 | - |
| | | 22:00 | 2V - 2W | 1005,58 | 0,386180 | 3,862 | - | W | 1,945 | - |
| After the test No. | 9 | 25-giu-14 | 2U - 2V | 989,72 | 0,384610 | 3,846 | 0,07 | U | 1,927 | 0,03 |
| | | | 2U - 2W | 991,80 | 0,387480 | 3,875 | 0,07 | V | 1,919 | 0,11 |
| | | 23:30 | 2V - 2W | 995,62 | 0,386630 | 3,866 | 0,12 | W | 1,948 | 0,12 |

Short-circuit inductance measurements

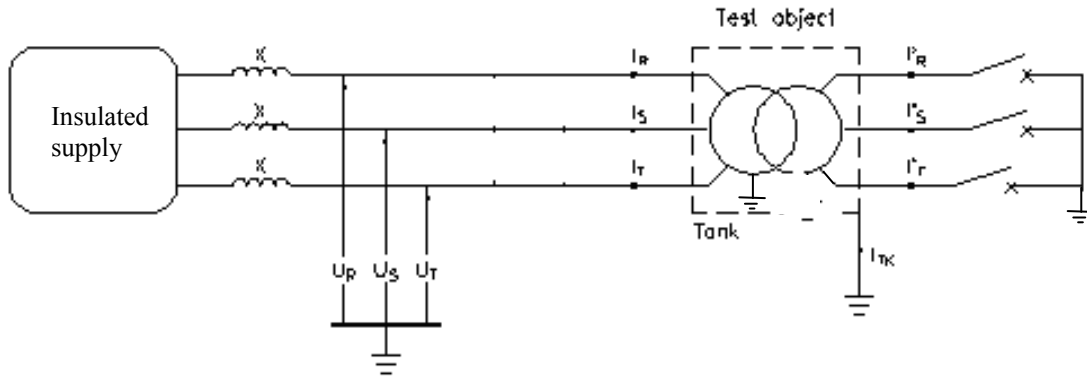
Measurements conditions : Tap changer position : Maximum (-11) Measured terminals : MV Short-circuited terminals : HV

Instrument: Bridge TETTEX type 2801 – CESI ref. No.8449 (Scheme : MAXWELL) Supply voltage : 6 V, 50 Hz

R2 (Ω) 1000
 R3 (Ω) 10
 RX (Ω) 10

| Measure | | Date Hour | Measured terminals | R4 | C4 | LX (R2xR3xC4) | Difference | Column | LX | Difference |
|--------------------|---|--------------|-----------------------|----------|---------------|------------------|------------|--------|-------|------------|
| | | - | - | Ω | μF | mH | % | - | mH | % |
| Before the tests | | 24-giu-14 | 2U - 2V | 1003,44 | 0,429360 | 4,294 | - | U | 2,149 | - |
| | | | 2U - 2W | 1004,68 | 0,428050 | 4,281 | - | V | 2,144 | - |
| | | 22:00 | 2V - 2W | 1006,42 | 0,427560 | 4,276 | - | W | 2,131 | - |
| After the test No. | 9 | 25-giu-14 | 2U - 2V | 995,84 | 0,428900 | 4,289 | -0,11 | U | 2,148 | -0,06 |
| | | | 2U - 2W | 998,75 | 0,428140 | 4,281 | 0,02 | V | 2,141 | -0,16 |
| | | 23:30 | 2V - 2W | 998,92 | 0,427440 | 4,274 | -0,03 | W | 2,133 | 0,10 |

Test circuit D0021



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

Correspondence between laboratory circuit phase and test object terminal

| Laboratory circuit phase | Test object terminal |
|--------------------------|----------------------|
| R | U |
| S | V |
| T | W |



Photo No.1
Panoramic view
H.V. Side



Photo No.2
Panoramic view
M.V. side

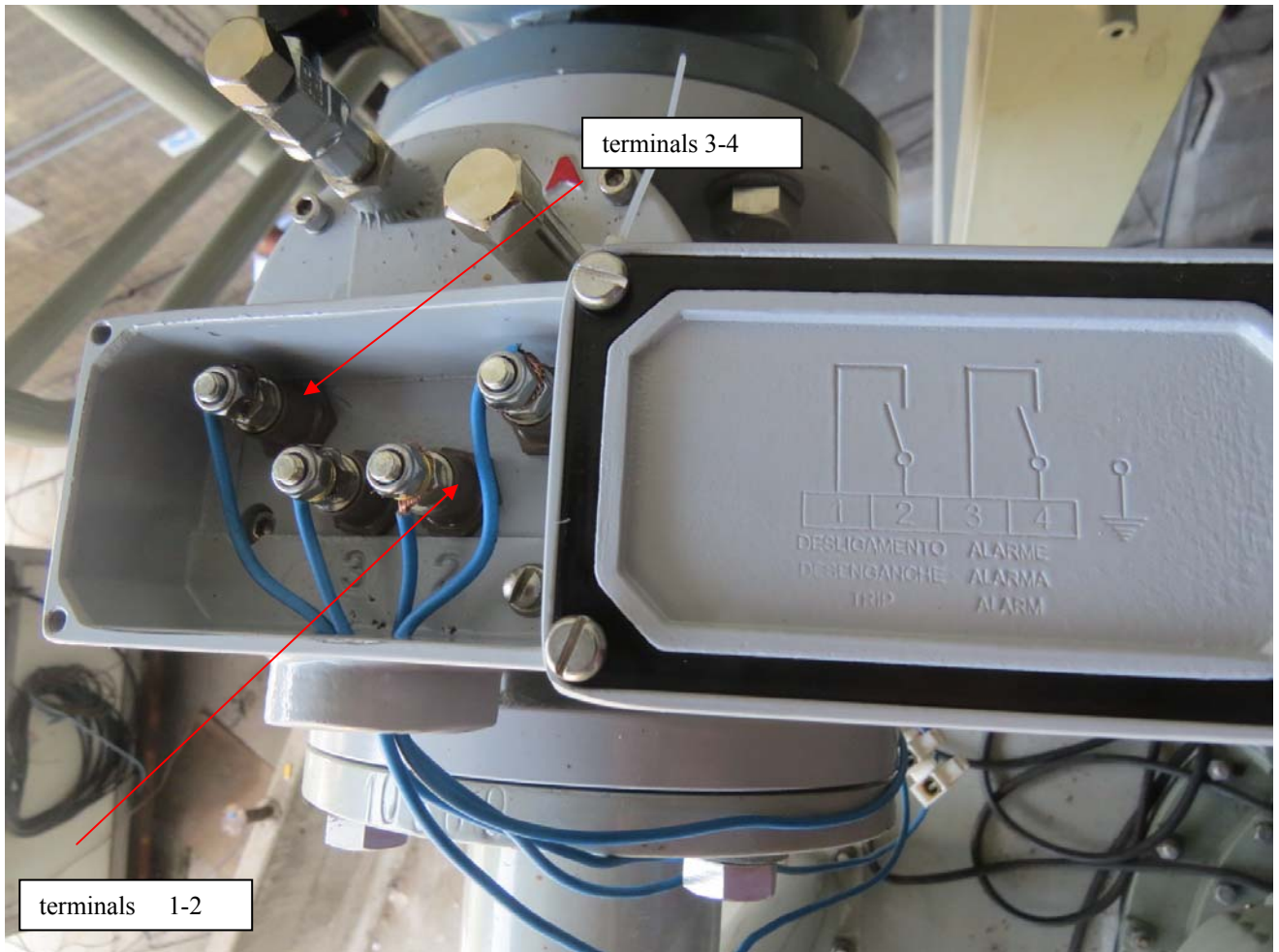


Photo No.3
Bucholtz release
Contact with terminal no. 1-2 and no.3-4

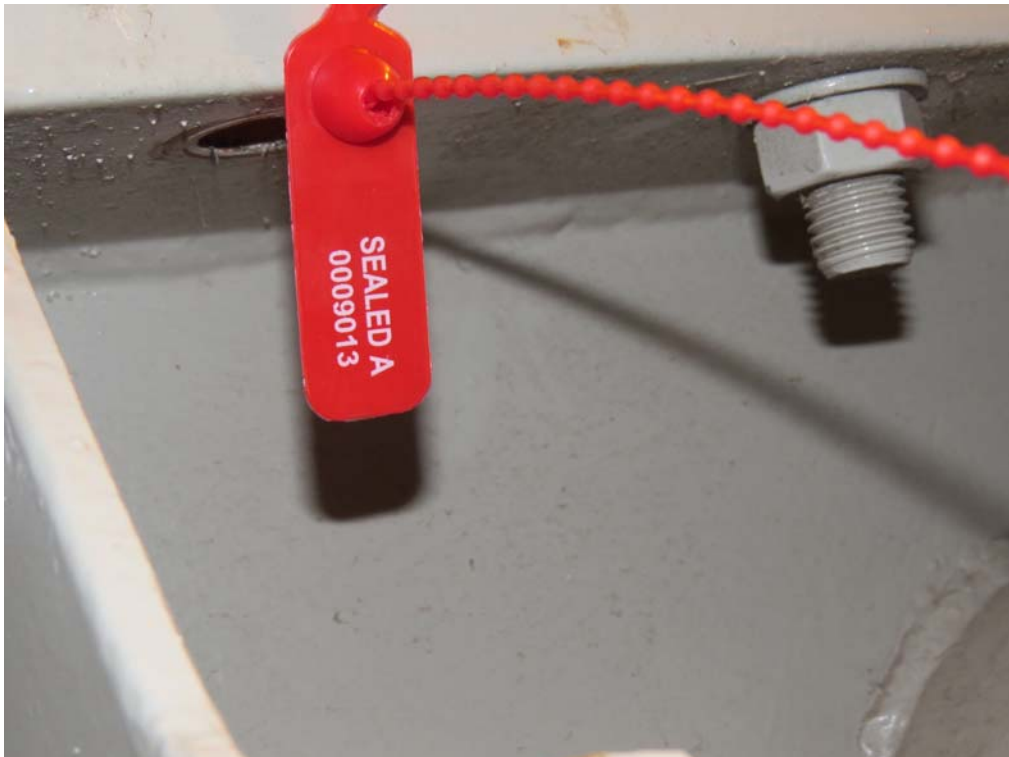


Photo no. 4
Sealed 0009013
After tests



Photo no. 5
Sealed 0009918
After tests



Photo No.6
Sealed 0009916
After tests



Photo No.7
Sealed 0009917
After tests

Test circuit parameters

| | | | | | | | | |
|-------------------------------|----------------------|-------------------------|--------------------------------|----------------------|-----------|-----------|-----------|----|
| From test to test | | No. | Preliminary | 1 to 3 | 4 to 6 | 7 to 9 | | |
| Test circuit | | No | D0021 | D0021 | D0021 | D0021 | | |
| Test laboratory | | Ref. | P140 | P140 | P140 | P140 | | |
| Supply | Generator | Voltage | kV | | | | | |
| | | Over excitation current | kA | | | | | |
| | | Frequency | Hz | | | | | |
| | | X-14-1 | mΩ | | | | | |
| | | X-14-2 | Ω | | | | | |
| | | TA 14-1 ratio | K | | | | | |
| | Transformers | Ref. | No. | Preliminary | 1-6 | 1-6 | 1-6 | |
| | | Ratio | K | 130/30+10 | 130/60+20 | 130/60+10 | 260/60+40 | |
| | | Connection | Type | Yp/yp | Yp/yp | Yp/yp | Ds/yp | |
| | | Neutral condition | T - I | T/I | T/I | T/I | T/I | |
| | | Ref. | No. | | | | | |
| | | Ratio | K | | | | | |
| | | Connection | Type | | | | | |
| | | Neutral condition | T - I | | | | | |
| | Circuit | Supply | X-supply network (prospective) | Ω | 11 | 11 | 11 | 11 |
| | | | X-supply network (actual) | Ω | 11 | 11 | 11 | 11 |
| X-AT | | | Ω | 12 | 12 | 12 | 6 | |
| X-MT (X-30) for calibration | | | Ω | | | | | |
| C-MT (C-30) | | | nF | | | | | |
| R-MT (R-30) | | | Ω | | | | | |
| CM (capacity) | | | μF | | | | | |
| Connection / Neutral | | | S-D / T-I | | | | | |
| Load | | Transformers | No. | | | | | |
| | | | K | | | | | |
| | | | Neutral condition | T - I | | | | |
| | | R (resistance) | Ω | | | | | |
| | | | Connection / Neutral | S-D / T-I | | | | |
| | | | X (reactance) | Ω | | | | |
| | | | | Connection / Neutral | S-D / T-I | | | |
| | | | CV1 (capacity) | μF | | | | |
| | Connection / Neutral | | | S-D / T-I | | | | |
| | CV2 (capacity) | | μF | | | | | |
| Connection / Neutral | | S-D / T-I | | | | | | |

Legend : S = Star - D = Delta - T = Earthed - I = Insulated

Warning : Reactance values are referred to 50 Hz.

Measuring system characteristics

Date: June 24 to 25, 2014

| Symbol | Ref. (1 st) | Transducer Pos. | Ref. (2 nd) | Optical link Ref. | National Instrument Channel |
|--------|-------------------------|--------------------|-------------------------|----------------------|--------------------------------|
| - | - | K | - | - | No. |
| Ur | D1 | | | H1 | 8 |
| Us | D2 | | | H2 | 9 |
| Ut | D3 | | | H3 | 10 |
| Ir | A1 | | | AS1 | 11 |
| Is | A2 | | | AS2 | 12 |
| It | A3 | | | AS3 | 13 |
| I'R | E8 | | | H4 | 4 |
| I'S | E9 | | | H5 | 5 |
| I'T | E10 | | | H6 | 6 |
| Itk | C12 | | R4 | J1 | 17 |
| Allarm | | | | J2 | 18 |
| Trip | | | | J3 | 19 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Symbols assigned in "Ref." columns refer to measuring equipment listed in page:
Laboratory P140 - Measuring system characteristics

Additional instrumentation:

Laboratory P140

 Measuring system characteristics (2nd)

| Ref. | Type | Pos. or K | CESI No. |
|------|---|-----------------------|----------|
| R1 | Shunt x TA 160mΩ 2A – Ir | 0,1616 Ω | 9886 |
| R2 | Shunt x TA 160mΩ 2A – Is | 0,1612 Ω | |
| R3 | Shunt x TA 160mΩ 2A – It | 0,1622 Ω | |
| Q1 | Shunt x TA 160mΩ 2A – Ir | 0,1628 Ω | 9782 |
| Q2 | Shunt x TA 160mΩ 2A – Is | 0,1617 Ω | |
| Q3 | Shunt x TA 160mΩ 2A – It | 0,1617 Ω | |
| R4 | Shunt x TA 60mΩ 5A – Ir | 0,0581 Ω | 9885 |
| R5 | Shunt x TA 60mΩ 5A – Is | 0,0621 Ω | |
| R6 | Shunt x TA 60mΩ 5A – It | 0,0618 Ω | |
| Q4 | Shunt x TA 60mΩ 5A – Ir | 0,0619 Ω | 9783 |
| Q5 | Shunt x TA 60mΩ 5A – Is | 0,0629 Ω | |
| Q6 | Shunt x TA 60mΩ 5A – It | 0,0620 Ω | |
| R7 | Shunt x TA 0,5 Ω 5A – Ir | 0,506 Ω | 17676 |
| R8 | Shunt x TA 0,5 Ω 5A – Is | 0,507 Ω | |
| R9 | Shunt x TA 0,5 Ω 5A – It | 0,506 Ω | |
| R10 | Shunt x TA 1 Ω 5A – Ir | 1,066 Ω | 17681 |
| R11 | Shunt x TA 1 Ω 5A – Is | 1,065 Ω | |
| R12 | Shunt x TA 1 Ω 5A – It | 1,059 Ω | |
| G1 | Shunt 2mΩ – 20A x 1s | 1,824 Ω | 28964 |
| G2 | Shunt 1mΩ – 40A x 1s | 991,3 mΩ | 5794 |
| G3 | Shunt 1mΩ – 40A x 1s | 986,3 mΩ | 11038 |
| C1 | Current transformer | 1000/5 | 11291 |
| C2 | Current transformer | 1000/5 | 11293 |
| C3 | Current transformer | 1200/5 | 6812 |
| C4 | Current transformer | 10 | 14191 |
| C5 | Current transformer | 10 | 17056 |
| C6 | Current transformer | 10 | 17057 |
| C7 | Current transformer | 10 | 17058 |
| C8 | Current transformer | 800 | 14383 |
| C9 | Current transformer | 20-40/5 | 14822 |
| C10 | Current transformer | 20-40/5 | 14823 |
| C11 | Current transformer | 20-40/5 | 14824 |
| C12 | Current transformer | 600 | 13403 |
| F1 | Schering bridge | Maxwell C2 | 8449 |
| F2 | Decade resistance box | 0 ÷ 10 ⁵ Ω | 3446 |
| TV1 | Voltage transformer 30 kV – Vrs | 300 | 9306 |
| TV2 | Voltage transformer 30 kV – Vtr | 300 | 9305 |
| M1 | Multimeter Fluke 77 | | 4523 |
| M2 | Multimeter Fluke 1587 (V mis res) | | 56772 |
| M3 | Multimeter Fluke 8842A (I mis res) | | 9079 |
| M4 | Multimeter ESCORT EDM-3150 | | 14470 |
| P0 | Scope Corder DL850 Yokogawa 6 + 16 canali | | 56855 |
| P1 | PXI 6368 16 channels (HF) | | 56679 |
| P2 | PXI 6368 16 channels (MF) | | 56678 |
| P3 | Clock PXIe 8431/e | | 56673 |
| | | | |
| | | | |
| | | | |

Prepared by: M. Levati

Date: 6/2/2014

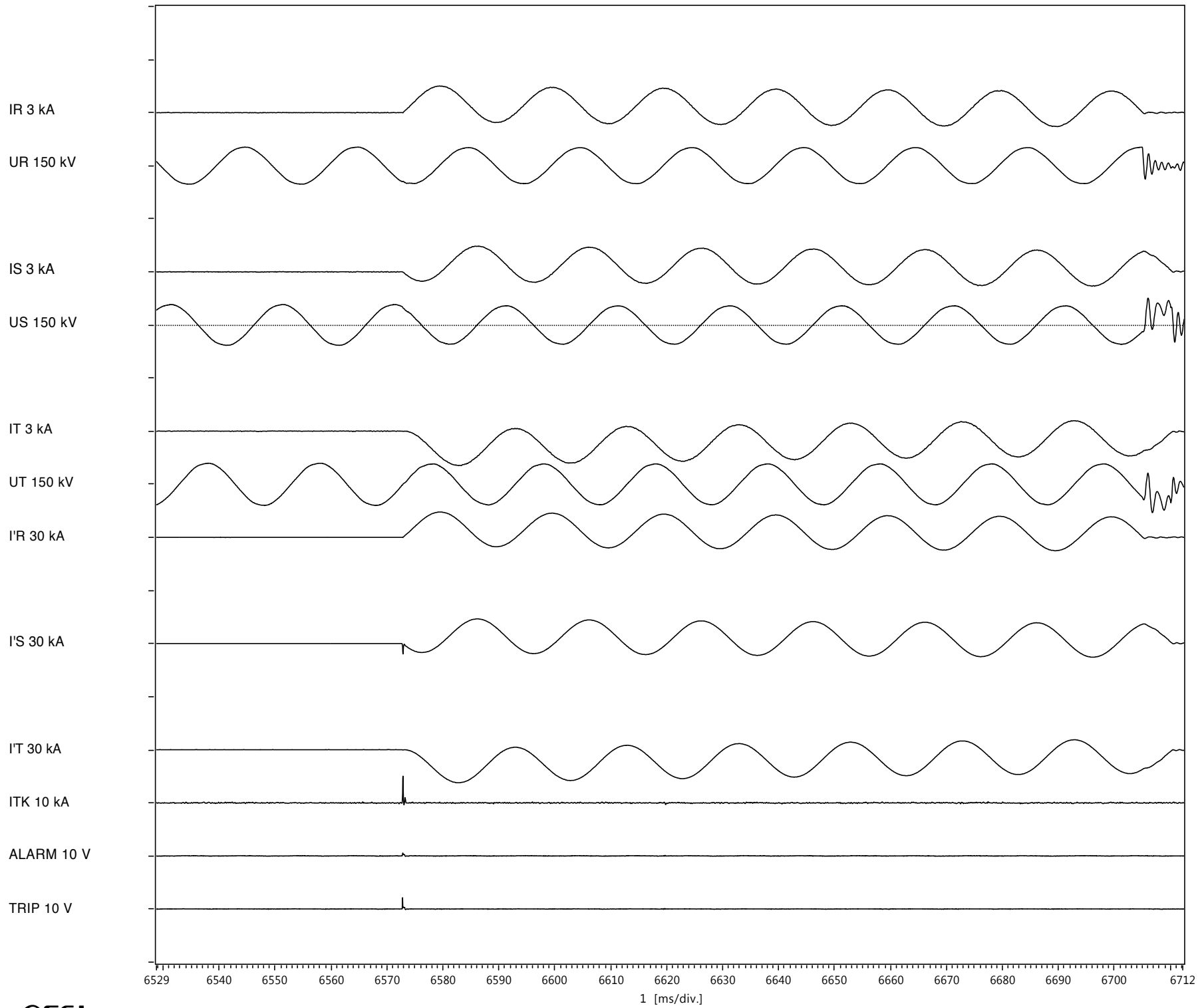
Laboratory P140

 Measuring system characteristics (3rd)

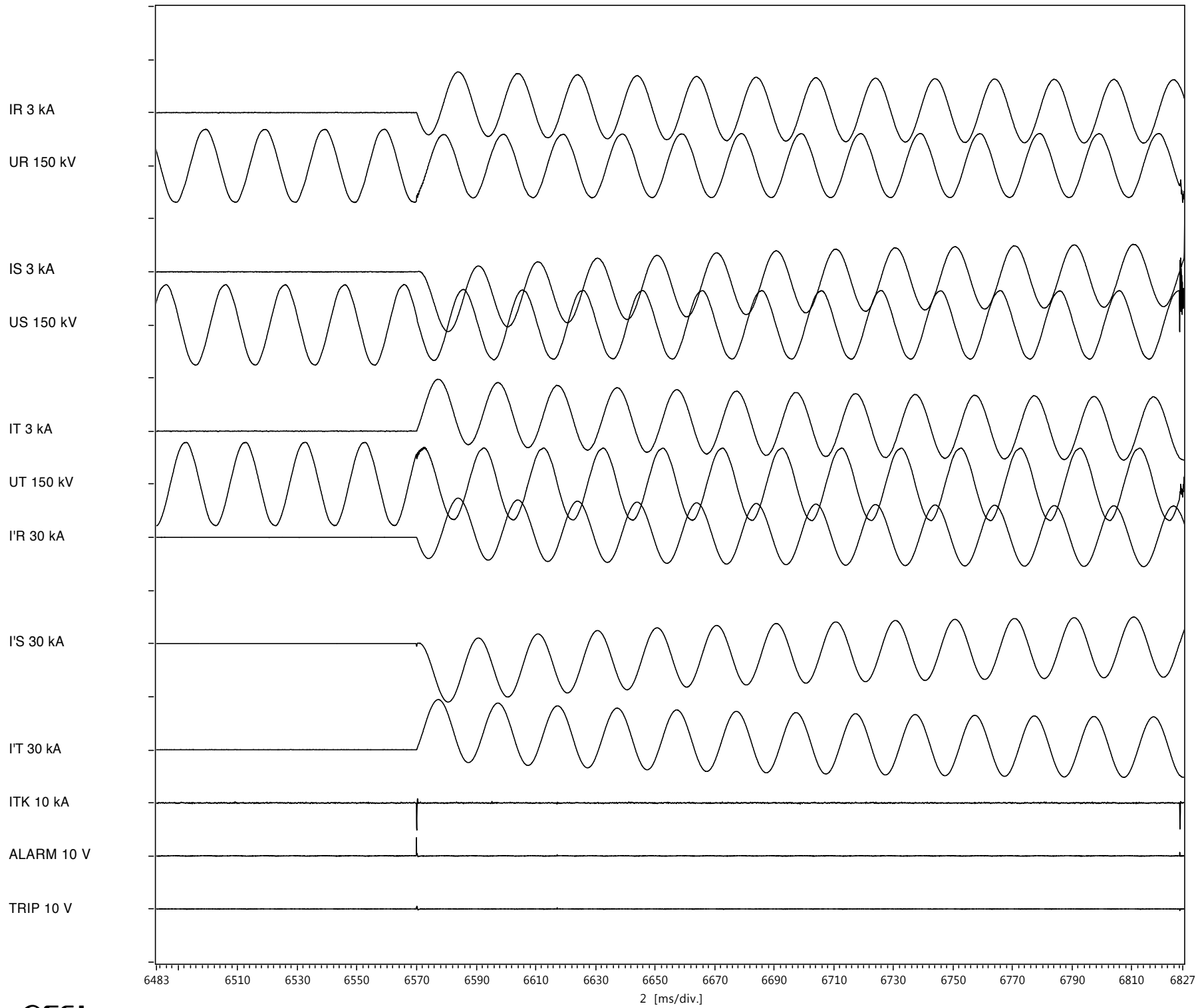
| Ref. | Type | Pos. or K | CESI No. |
|------|--|--------------|----------|
| H1 | Isolation amplifier n.1 | 0,1÷1000 | 56891 |
| H2 | Isolation amplifier n.2 | 0,1÷1000 | 56893 |
| H3 | Isolation amplifier n.3 | 0,1÷1000 | 56892 |
| H4 | Isolation amplifier n.4 | 0,1÷1000 | 56896 |
| H5 | Isolation amplifier n.5 | 0,1÷1000 | 56894 |
| H6 | Isolation amplifier n.6 | 0,1÷1000 | 56895 |
| H7 | Isolation amplifier n.7 | 0,1÷1000 | 57544 |
| H8 | Isolation amplifier n.8 | 0,1÷1000 | 57545 |
| H9 | Isolation amplifier n.9 | 0,1÷1000 | 57546 |
| H10 | Isolation amplifier n.10 | 0,1÷1000 | 57547 |
| H11 | Isolation amplifier n.11 | 0,1÷1000 | 57548 |
| H12 | Isolation amplifier n.12 | 0,1÷1000 | 57549 |
| S1 | Optical link (30) Ur | 1÷250/5 | 56381-2 |
| S2 | Optical link (30) Us | 1÷250/5 | 56375-6 |
| S3 | Optical link (30) Ut | 1÷250/5 | 56377-8 |
| S4 | Optical link (30) Ir | 0,1÷25/5 | 56365-6 |
| S5 | Optical link (30) Is | 1÷250/5 | 56379-80 |
| S6 | Optical link (30) It | 0,1÷25/5 | 56367-8 |
| J1 | Optical Link (office) n.1 | 1÷300/10 | 4805 |
| J2 | Optical Link (office) n.2 | 1÷300/10 | 4815 |
| J3 | Optical Link (office) n.3 | 1÷300/10 | 4809 |
| J4 | Optical Link (office) n.4 | 1÷300/10 | 4817 |
| J5 | Optical Link (office) n.5 | 1÷300/10 | 4821 |
| AS1 | Optical Link (shunt 50μΩ) Ir | 0,1÷100/5 | 57506 |
| AS2 | Optical Link (shunt 50μΩ) Is | 0,1÷100/5 | 57505 |
| AS3 | Optical Link (shunt 50μΩ) It | 0,1÷100/5 | 57504 |
| AS4 | Optical Link (spare) | 0,1÷100/5 | 57503 |
| K1 | Optical Link (shunt 4mΩ) Ir | 0,1÷10/10 | 38225 |
| K2 | Optical Link (shunt 4mΩ) Is | 0,1÷10/10 | 22331 |
| K3 | Optical Link (shunt 4mΩ) It | 0,1÷10/10 | 22329 |
| K4 | Optical Link (spare) | 0,1÷10/10 | 38223 |
| V1 | Optical link (float) n.3 - 300 kHz | 1÷300/10 | 5973-4 |
| V2 | Optical link (float) n.8 - 300 kHz | 1÷300/10 | 5967-70 |
| V3 | Optical link (float) n.9 - 300 kHz | 1÷300/10 | 5968-9 |
| V4 | Optical link (float) n.10 - 1 MHz - f1 | 1÷300/10 | 5989-90 |
| V5 | Optical link (float) n.11 - 300 kHz | 1÷300/10 | 5985-6 |
| V6 | Optical link (float) n.12 - 300 kHz | 1÷300/10 | 5955-6 |
| V7 | Optical link (float) n.13 - 300 kHz | 1÷300/10 | 5977-8 |
| V8 | Optical link (float) n.15 - 300 kHz | 1÷300/10 | 5981-2 |
| V9 | Optical link (float) n.18 - 1 MHz | 1÷300/10 | 5987-8 |
| I1 | Rogowsky current waveform trasducer | 20000 | 56794 |
| I2 | Rogowsky current waveform trasducer | 20000 | 57492 |
| I3 | Rogowsky current waveform trasducer | 20000 | 57493 |
| | | | |
| | | | |
| | | | |

Prepared by: M. Levati

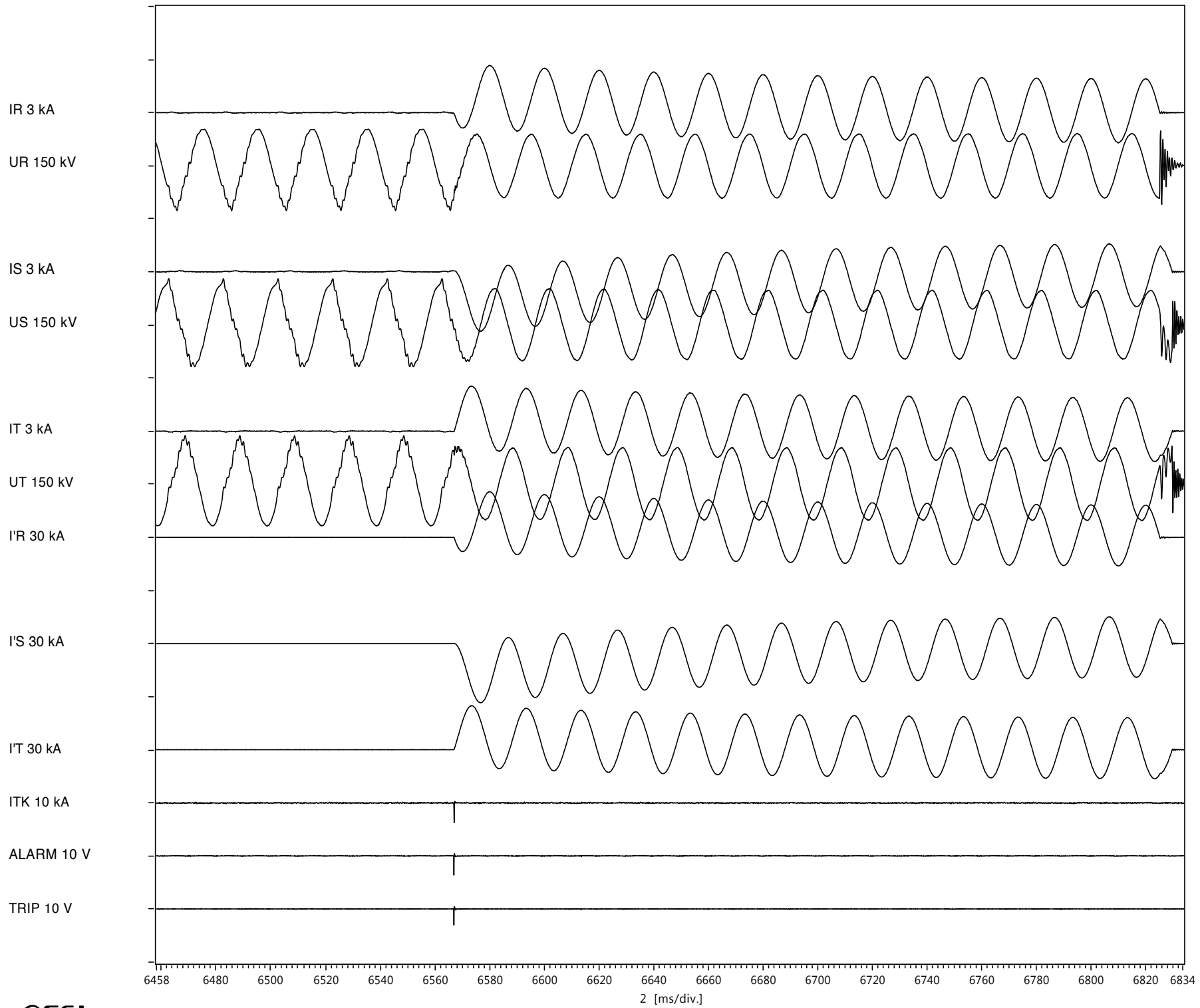
Date: 6/2/2014



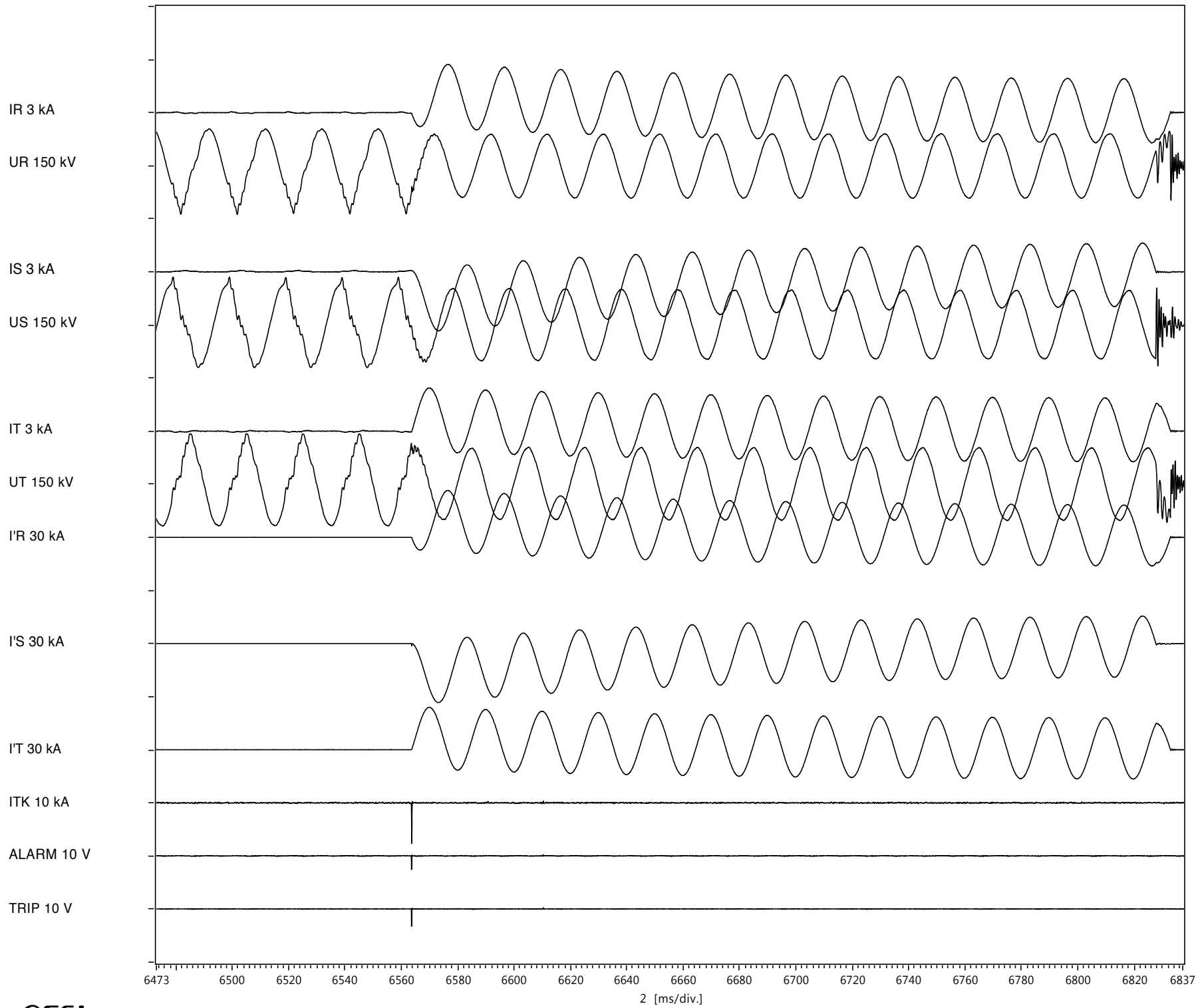
I.R= 695 A
I.S= 697 A
I.T= 693 A
Ip.T= 1,94 kA
I.'R= 6,76 kA
I.'S= 6,75 kA
I.'T= 6,71 kA
Ip.'T= 18,6 kA
Vbm= 41,9 kV



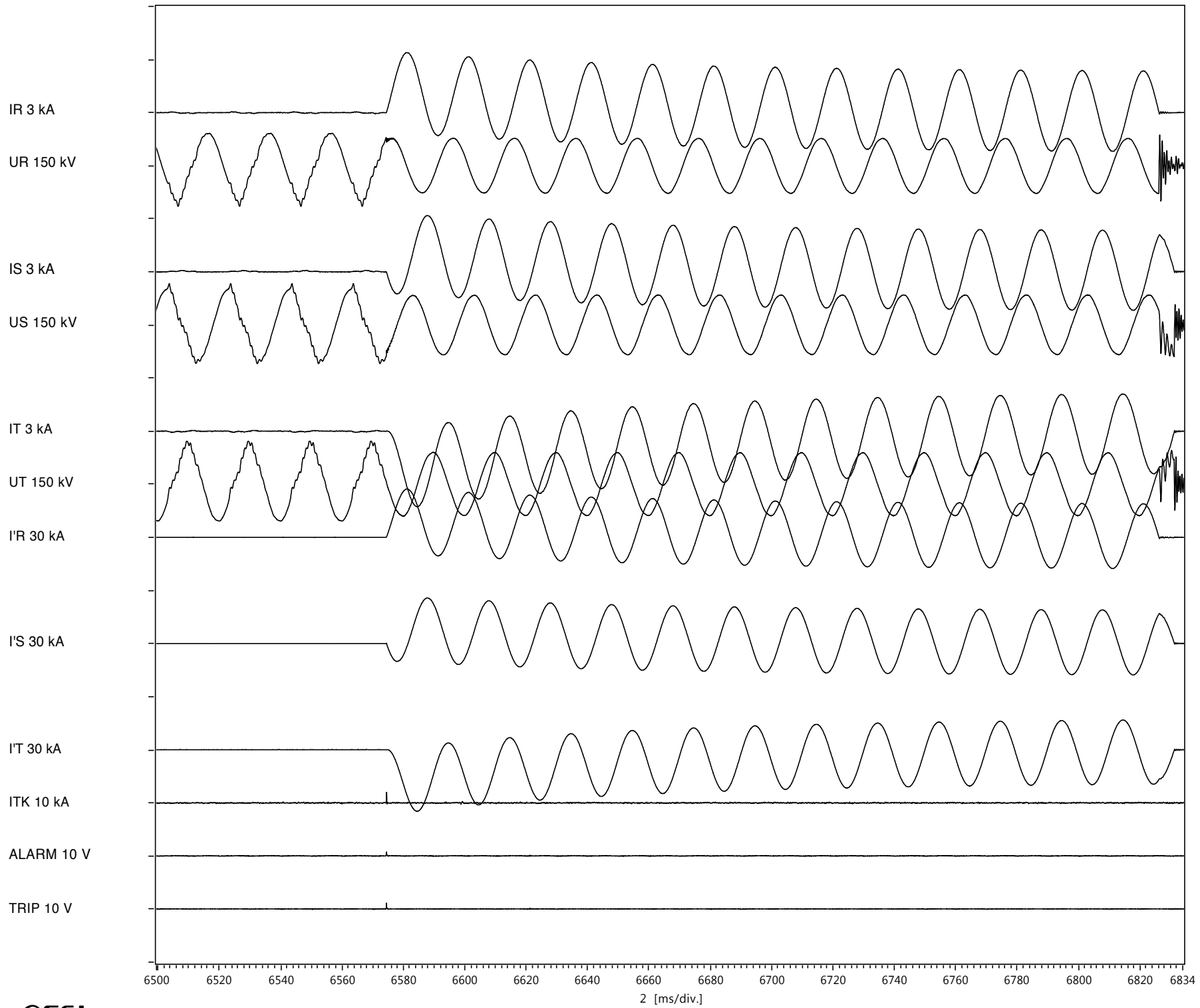
I.R= 1,28 kA
I.S= 1,26 kA
Ip.S= 3,37 kA
I.T= 1,28 kA
Dc= 256 ms
I.'R= 12,2 kA
I.'S= 12,1 kA
I.'T= 12,2 kA
Ip.'S= 33,1 kA
Vbm= 72,8 kV



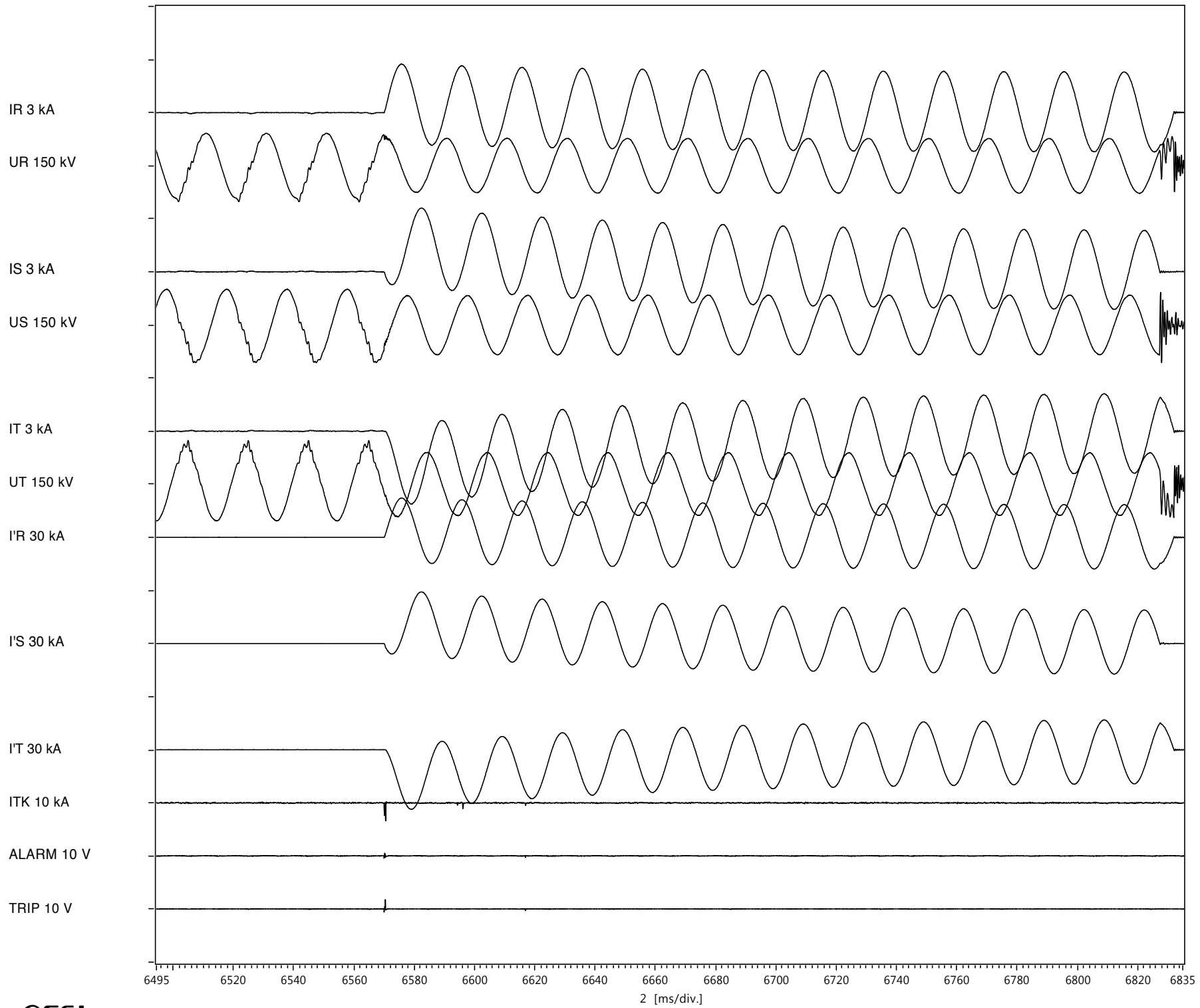
I.R= 1,28 kA
I.S= 1,26 kA
I.T= 1,28 kA
Ip.S= 3,36 kA
I.'R= 12,2 kA
I.'S= 12,2 kA
I.'T= 12,2 kA
Ip.'S= 33,5 kA
Vbm= 81,1 kV
dT= 263 ms



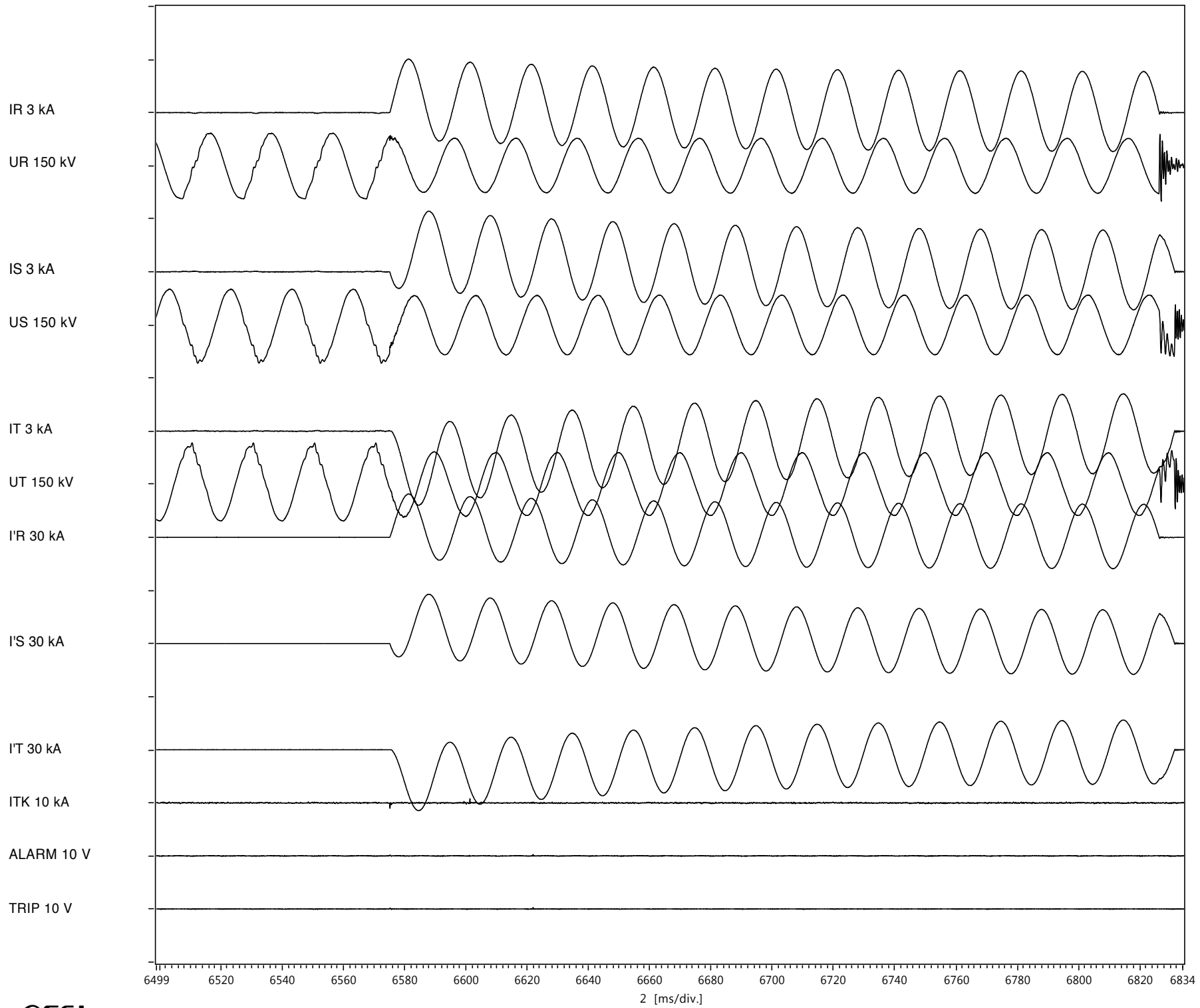
I.R= 1,28 kA
I.S= 1,27 kA
I.T= 1,28 kA
Ip.S= 3,33 kA
I.'R= 12,2 kA
I.'S= 12,3 kA
I.'T= 12,2 kA
Ip.'S= 33,4 kA
Vbm= 81,1 kV
dT= 264 ms



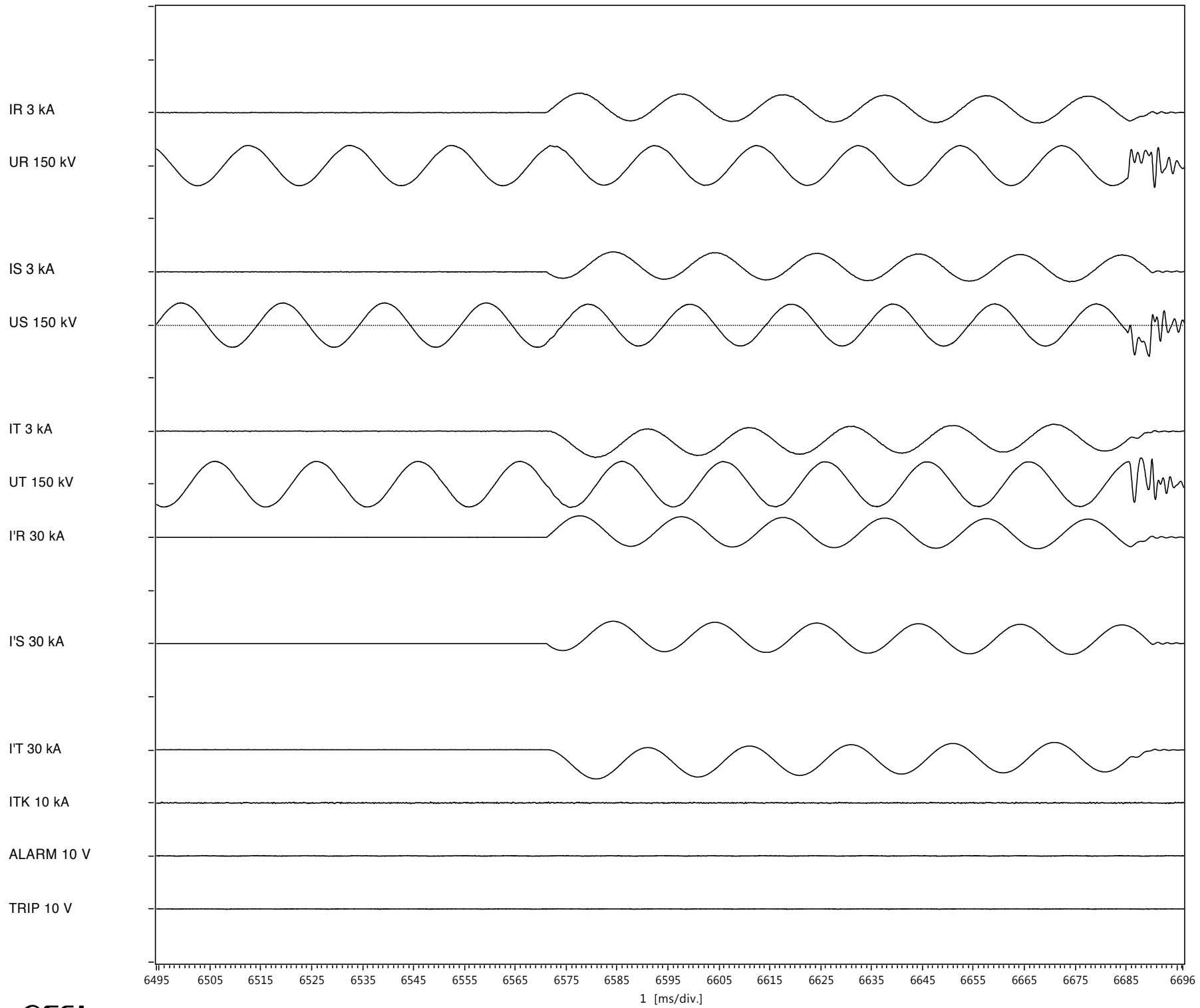
I.R= 1,62 kA
I.S= 1,61 kA
I.T= 1,6 kA
Ip.T= 4,27 kA
I.'R= 13 kA
I.'S= 13 kA
I.'T= 12,9 kA
Ip.'T= 34,8 kA
Vbm= 72,9 kV
dT= 257 ms



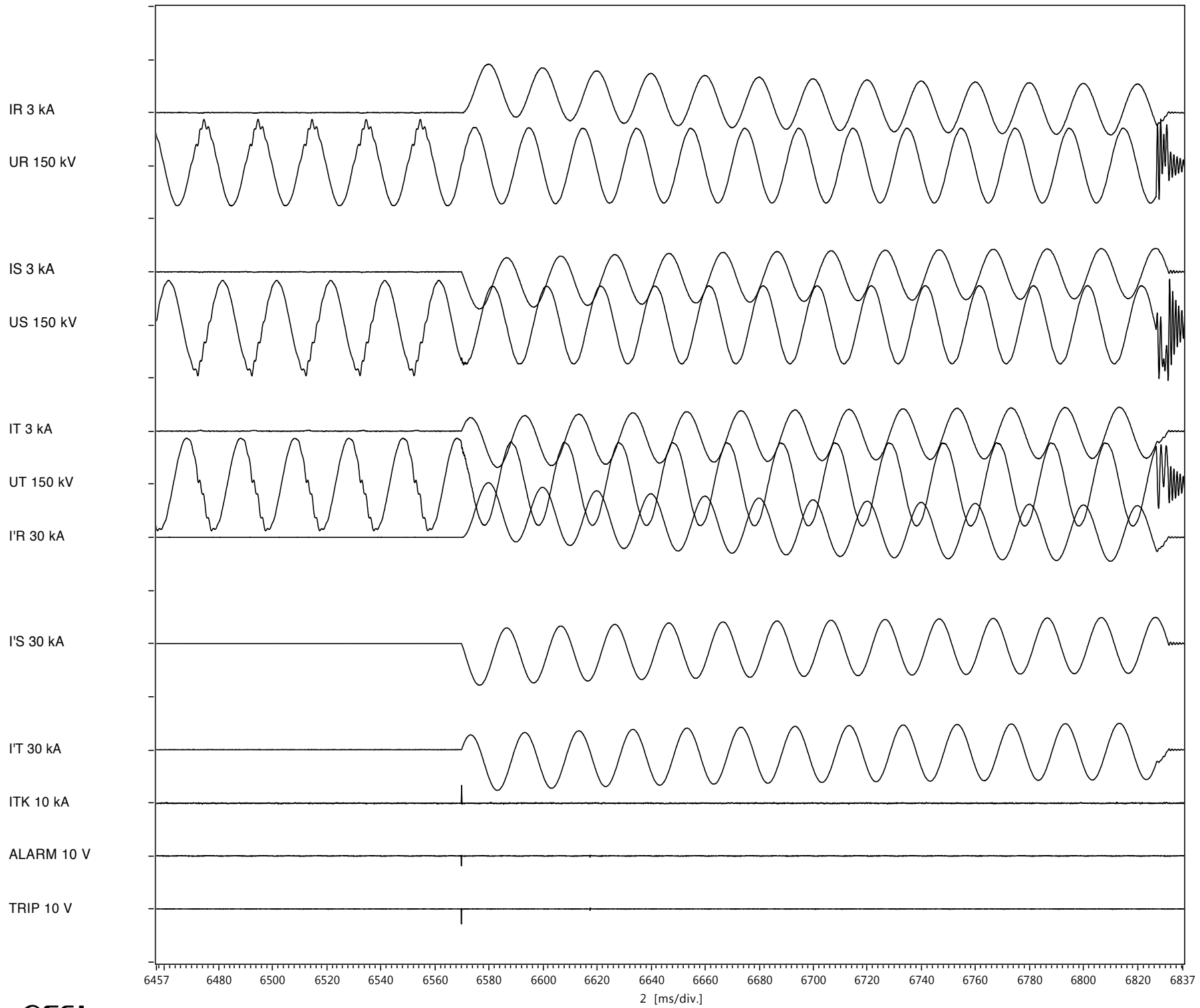
I.R= 1,6 kA
I.S= 1,58 kA
I.T= 1,59 kA
Ip.T= 4,12 kA
I.'R= 12,9 kA
I.'S= 12,9 kA
I.'T= 12,8 kA
Ip.'T= 33,7 kA
Vbm=72,9 kV
dT= 262 ms



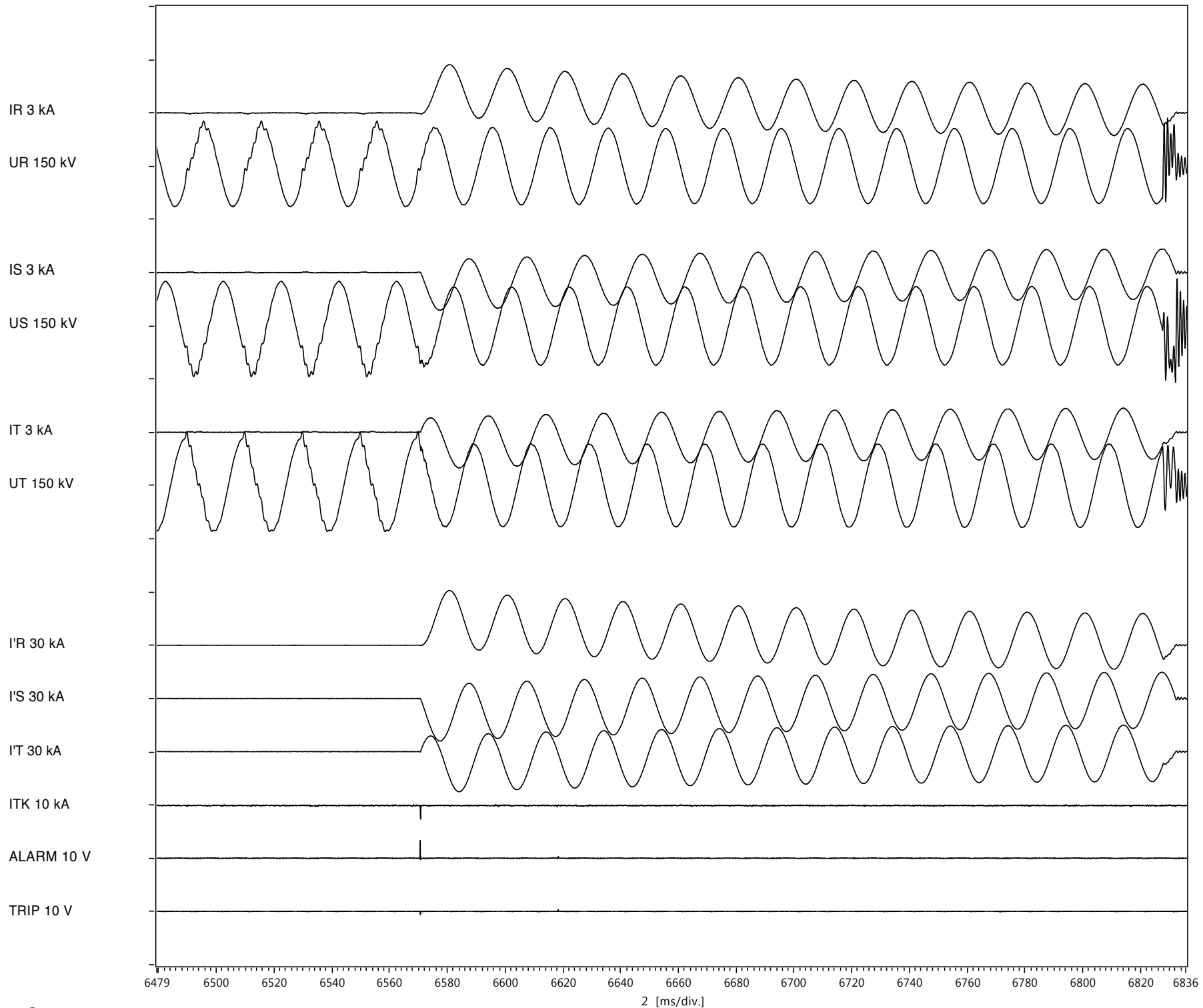
I.R= 1,61 kA
I.S= 1,59 kA
I.T= 1,6 kA
Ip.T= 4,18 kA
I.'R= 12,9 kA
I.'S= 12,9 kA
I.'T= 12,8 kA
Ip.'T= 34,4 kA
Vbm= 72,9 kV
dT= 256 ms



I.R= 526 A
I.S= 527 A
I.T= 526 A
Ip.T= 1,49 kA
I.'R= 5,87 kA
I.'S= 5,95 kA
I.'T= 5,88 kA
Ip.'T= 16,5 kA
Vbm= 44,1 kV
dT= 119 ms



I.R= 1,03 kA
I.S= 1,01 kA
I.T= 1,02 kA
Ip.R= 2,75 kA
I.'R= 11,2 kA
I.'S= 11,2 kA
I.'T= 11,3 kA
Ip.'R= 30,9 kA
Vbm= 88,7 kV
dT= 262 ms



I.R= 1,03 kA
I.S= 1,01 kA
I.T= 1,03 kA
Ip.R= 2,73 kA
I.'R= 11,2 kA
I.'S= 11,2 kA
I.'T= 11,3 kA
Ip.'R= 30,8 kA
Vbm= 88,1 kV
dT= 262 ms

