

# Transformer 201421A/01

|                |   |                                             |       |            |
|----------------|---|---------------------------------------------|-------|------------|
| Customer       | : | Siemens Transmission & Distribution Limited |       |            |
| Final Customer | : | Dunamis                                     |       |            |
| Order          | : | 4511887431                                  | dated | 11/02/2020 |
| Plant location | : | Minety Project                              |       |            |

## CONTENTS

SECTION 1      ROUTINE TESTS

---

|             |    |       |   |            |        |   |              |
|-------------|----|-------|---|------------|--------|---|--------------|
| Transformer |    | N°    | : | 201421A/01 |        |   |              |
| Power       |    | [MVA] | : | 110,000    | ONAN   | / | 120,000 ONAF |
| Voltage     | HV | [kV]  | : | 132,000    | ± 12 x |   | 1,250%       |
| Voltage     | MV | [kV]  | : | 33,000     | -      |   | -            |

|      |   |               |
|------|---|---------------|
| Date | : | 07 ÷ 10/07/20 |
|------|---|---------------|

### Tests witnessed by :

For the customer :

-

\_\_\_\_\_

-

\_\_\_\_\_

-

\_\_\_\_\_

For Siemens Transformers S.p.A. :

- Gabriele ZENI

\_\_\_\_\_

- Fabiano POJER

\_\_\_\_\_

# SECTION 1

**Transformer**      **N°**      **201421A/01**

|                 |      | Power    |   | [MVA]   | Voltage |        | [kV]   |
|-----------------|------|----------|---|---------|---------|--------|--------|
| Type of cooling |      | ONAN     | - | ONAF    |         |        |        |
| Winding         | HV   | 110,000  | - | 120,000 | 132,000 | ± 12 x | 1,250% |
| Winding         | MV   | 110,000  | - | 120,000 | 33,000  | -      | -      |
| Vector Group    |      | YN d 1 - |   |         |         |        |        |
| Frequency       | [Hz] | 50       |   |         |         |        |        |

LIST OF TESTS PERFORMED ACCORDING TO STANDARD:

IEC 60076

### ROUTINE TESTS

Pages

|                                                                   |             |
|-------------------------------------------------------------------|-------------|
| Check of guaranteed values.                                       | - 2.1       |
| Measurement of voltage ratio and check of phase displacement.     | 3.1 ÷ 3.2   |
| Lightning impulse test (LI, LIC, LIN, LIMT).                      | 4.1 ÷ 4.16  |
| Applied voltage test (AV)                                         | - 5.1       |
| Measurement of insulation resistance.                             | - 6.1       |
| Measurement of insulation resistance of the core and core frames. | - 6.1       |
| Winding capacitance measurement and tg Delta.                     | - 6.2       |
| Induced overvoltage withstand tests.                              | 7.1 ÷ 7.6   |
| Measurement of no-load loss and current.                          | 8.1 ÷ 8.3   |
| Measurement of winding resistance.                                | 9.1 ÷ 9.2   |
| Measurement of short-circuit impedance and load loss.             | 10.1 ÷ 10.7 |
| Efficiencies determinations                                       | - 10.8      |
| Test on on-load tap changer.                                      | - 11.1      |
| Dielectric strength test for oil.                                 | - 12.1      |
| Dimensional, auxiliary equipments and accessories checks.         | - 13.1      |
| Ratio and polarity checks on CTs                                  | - 13.2      |
| Tank Pressure test                                                | - 20.1      |

Date

07 ÷ 10/07/20

Customer

Restricted

Transformer

N°

201421A/01

| Summary of guaranteed and measured values             |            |                             |            |                  |              | HV/MV  |  |
|-------------------------------------------------------|------------|-----------------------------|------------|------------------|--------------|--------|--|
| Measurement of no-load loss and current.              |            |                             |            | ONAN: 110 MVA    |              |        |  |
|                                                       |            |                             | Guaranteed | Tolerances (IEC) | Measured [%] |        |  |
|                                                       | Losses     | Vn [W]                      | 48000      | + 15 %           | 46802        | -2,5%  |  |
|                                                       | Losses     | 0,90 Vn [W]                 | -          | -                | 34327        | -      |  |
|                                                       | Losses     | 1,10 Vn [W]                 | -          | -                | 70062        | -      |  |
|                                                       | Current    | Vn [%]                      | -          | -                | 0,058%       | -      |  |
|                                                       | Current    | 0,90 Vn [%]                 | -          | -                | 0,038%       | -      |  |
|                                                       | Current    | 1,10 Vn [%]                 | -          | -                | 0,263%       | -      |  |
| Measurement of short-circuit impedance and load loss. |            |                             |            | ONAN: 110 MVA    |              |        |  |
| T.C. Position                                         |            |                             | Guaranteed | Tolerances (IEC) | Measured [%] |        |  |
| 13                                                    | 132,000 kV | Losses [W]                  | 354000     | + 15 %           | 390670       | 10,36% |  |
|                                                       |            | Short circuit impedance [%] | 14,50      | ± 7,5 %          | 14,46        | -0,30% |  |
|                                                       |            | Total Losses [W]            | 402000     | + 10 %           | 437472       | 8,82%  |  |
| 1                                                     | 151,800 kV | Losses [W]                  | -          | -                | 387079       | -      |  |
|                                                       |            | Short circuit impedance [%] | -          | -                | 15,97        | -      |  |
|                                                       |            | Total Losses [W]            | -          | -                | 433881       | -      |  |
| 25                                                    | 112,200 kV | Losses [W]                  | -          | -                | 417353       | -      |  |
|                                                       |            | Short circuit impedance [%] | -          | -                | 13,33        | -      |  |
|                                                       |            | Total Losses [W]            | -          | -                | 464155       | -      |  |
| Measurement of short-circuit impedance and load loss. |            |                             |            | ONAF: 120 MVA    |              |        |  |
| T.C. Position                                         |            |                             | Guaranteed | Tolerances (IEC) | Measured [%] |        |  |
| 13                                                    | 132,000 kV | Losses [W]                  | -          | -                | 464929       | -      |  |
|                                                       |            | Short circuit impedance [%] | -          | -                | 15,77        | -      |  |
|                                                       |            | Total Losses [W]            | -          | -                | 511732       | -      |  |
| 1                                                     | 151,800 kV | Losses [W]                  | -          | -                | 460656       | -      |  |
|                                                       |            | Short circuit impedance [%] | -          | -                | 17,42        | -      |  |
|                                                       |            | Total Losses [W]            | -          | -                | 507458       | -      |  |
| 25                                                    | 112,200 kV | Losses [W]                  | -          | -                | 496685       | -      |  |
|                                                       |            | Short circuit impedance [%] | -          | -                | 14,55        | -      |  |
|                                                       |            | Total Losses [W]            | -          | -                | 543487       | -      |  |
| Peak Efficiency Index (PEI)                           |            | ONAF: 120 MVA               | 99,737%    | - 0,0 %          | 99,754%      |        |  |

Date

07 ÷ 10/07/20

Customer

---

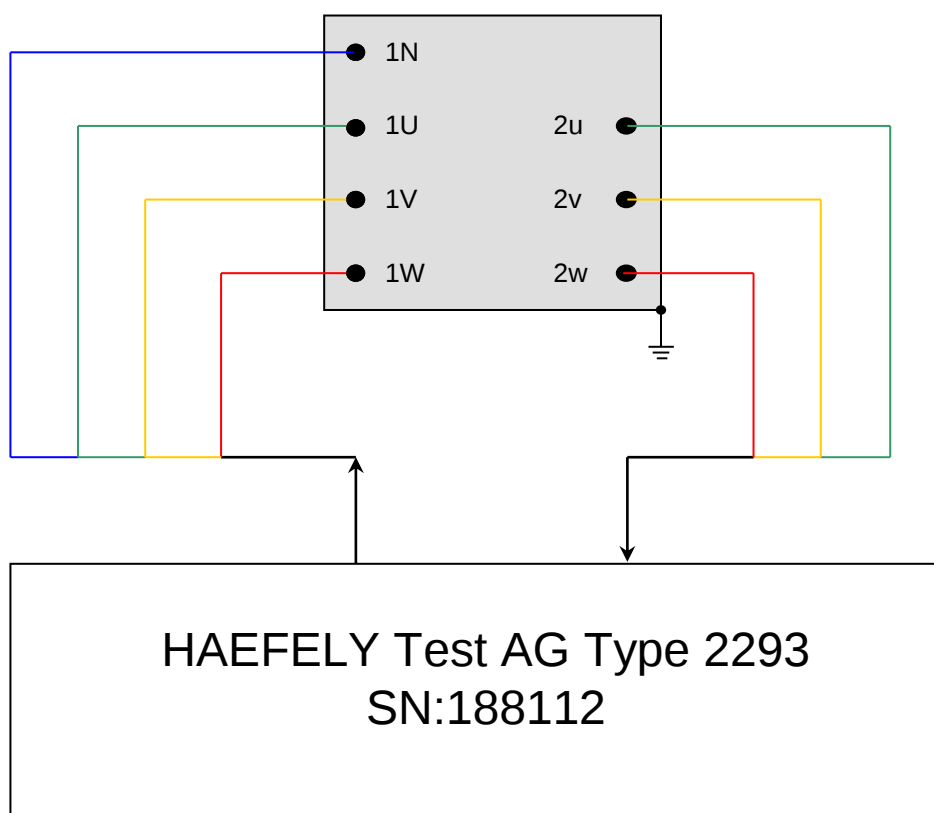
---

Transformer N° : 201421A/01

---

---

Measurement of voltage ratio and check of phase displacement.



Instrument used: STM233 HAEFELY Test AG Type 2293 SN:188112

**References / Standards:**

- IEC 60076-1 Ed.3 (2011-04), clause 10: "Table 1 - Tolerances", clause 11.3:  
"Measurement of voltage ratio and check of phase displacement"[1]

---

---

Drafted by: M.Norena

Approved by: G.Zeni

Date 08/07/20

Customer

|                    |      |   |                   |               |               |
|--------------------|------|---|-------------------|---------------|---------------|
| <b>Transformer</b> | N°   | : | <b>201421A/01</b> |               |               |
| Voltage HV         | [kV] | : | <b>132,000</b>    | <b>± 12 x</b> | <b>1,250%</b> |
| Voltage MV         | [kV] | : | <b>33,000</b>     | <b>-</b>      | <b>-</b>      |
| Vector Group       |      | : | <b>YN d 1</b>     |               |               |

### Measurement of voltage ratio and check of phase displacement.

| Position<br>T.C. | HV<br>[kV]     | Position<br>T.C. | MV<br>[kV]    | Ratio<br>Theoretical | Measured Ratio |               |               | Max<br>Δ%    |
|------------------|----------------|------------------|---------------|----------------------|----------------|---------------|---------------|--------------|
|                  |                |                  |               |                      | UN / uv        | VN / vw       | WN / wu       |              |
| 1                | 151,800        | -                | 33,000        | 2,656                | 2,6566         | 2,6565        | 2,6565        | 0,03%        |
| 2                | 150,150        | -                | 33,000        | 2,627                | 2,6278         | 2,6278        | 2,6278        | 0,03%        |
| 3                | 148,500        | -                | 33,000        | 2,598                | 2,5990         | 2,5990        | 2,5991        | 0,04%        |
| 4                | 146,850        | -                | 33,000        | 2,569                | 2,5703         | 2,5703        | 2,5703        | 0,04%        |
| 5                | 145,200        | -                | 33,000        | 2,540                | 2,5415         | 2,5415        | 2,5416        | 0,05%        |
| 6                | 143,550        | -                | 33,000        | 2,511                | 2,5128         | 2,5128        | 2,5128        | 0,05%        |
| 7                | 141,900        | -                | 33,000        | 2,483                | 2,4841         | 2,4841        | 2,4841        | 0,06%        |
| 8                | 140,250        | -                | 33,000        | 2,454                | 2,4553         | 2,4554        | 2,4553        | 0,07%        |
| 9                | 138,600        | -                | 33,000        | 2,425                | 2,4267         | 2,4266        | 2,4266        | 0,08%        |
| 10               | 136,950        | -                | 33,000        | 2,396                | 2,3979         | 2,3979        | 2,3979        | 0,08%        |
| 11               | 135,300        | -                | 33,000        | 2,367                | 2,3692         | 2,3691        | 2,3691        | 0,09%        |
| 12               | 133,650        | -                | 33,000        | 2,338                | 2,3405         | 2,3404        | 2,3404        | 0,10%        |
| <b>13</b>        | <b>132,000</b> | <b>-</b>         | <b>33,000</b> | <b>2,309</b>         | <b>2,3117</b>  | <b>2,3117</b> | <b>2,3117</b> | <b>0,10%</b> |
| 14               | 130,350        | -                | 33,000        | 2,281                | 2,2830         | 2,2830        | 2,2830        | 0,11%        |
| 15               | 128,700        | -                | 33,000        | 2,252                | 2,2543         | 2,2543        | 2,2543        | 0,12%        |
| 16               | 127,050        | -                | 33,000        | 2,223                | 2,2255         | 2,2255        | 2,2255        | 0,12%        |
| 17               | 125,400        | -                | 33,000        | 2,194                | 2,1967         | 2,1968        | 2,1968        | 0,13%        |
| 18               | 123,750        | -                | 33,000        | 2,165                | 2,1681         | 2,1681        | 2,1681        | 0,14%        |
| 19               | 122,100        | -                | 33,000        | 2,136                | 2,1394         | 2,1393        | 2,1393        | 0,15%        |
| 20               | 120,450        | -                | 33,000        | 2,107                | 2,1106         | 2,1106        | 2,1106        | 0,16%        |
| 21               | 118,800        | -                | 33,000        | 2,078                | 2,0819         | 2,0819        | 2,0819        | 0,17%        |
| 22               | 117,150        | -                | 33,000        | 2,050                | 2,0532         | 2,0532        | 2,0532        | 0,18%        |
| 23               | 115,500        | -                | 33,000        | 2,021                | 2,0244         | 2,0245        | 2,0244        | 0,19%        |
| 24               | 113,850        | -                | 33,000        | 1,992                | 1,9958         | 1,9957        | 1,9957        | 0,20%        |
| 25               | 112,200        | -                | 33,000        | 1,963                | 1,9670         | 1,9670        | 1,9670        | 0,20%        |

Check of Vector Group : **YN d 1**Tolerances **0,50%**

The test was carried out with the same instrument used for the measurement of voltage ratio.

**Result : SATISFACTORY.**

Drafted by: M.Norena

Approved by: G.Zeni

Date

08/07/2020

Customer

## Transformer

Nº

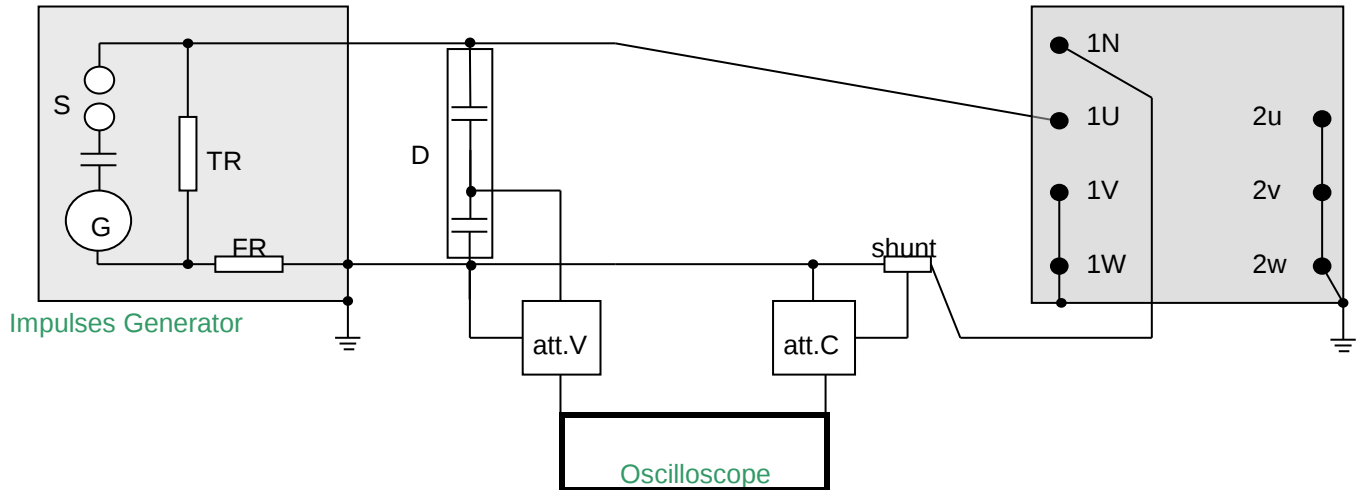
•

•

201421A/01

## Full wave lightning impulse test (LI).

HV



|    |   |                     |
|----|---|---------------------|
| G  | = | Generator           |
| S  | = | Dischargers Spheres |
| TR | = | Tail resistance     |
| ER | = | Exit resistance     |
| FR | = | Front resistance    |
| D  | = | Divider HV          |

Oscilloscope = STM173 High Volt Mias

### References / Standards:

- IEC 60060-1 (1994), High-Voltage test techniques - Part 1:"General definitions and test requirements"[21]
- IEC 60060-1 (1994), High-Voltage test techniques - Part 2:"Measuring systems"[22]
- IEC 60076-3 (2013), clause 13:"Lightning impulse tests (LI, LIC, LIN, LIMT)"[3]
- IEC 60076-4 (2002), "Guide to lightning impulse and switching impulse tests of power transformers and reactors"[4]
- IEC 61138-1 Instruments and Software Used for Measurement in High-Voltage Impulse Tests - Part 1: Requirements for Instruments
- IEC 61138-2 Instruments and Software Used for Measurement in High-Voltage Impulse Tests - Part 1: Requirements for Software

Drafted by: G.Bert

Approved by: G.Zeni

Date

07/07/20

Customer

Transformer N° : 201421A/01

## Full wave lightning impulse test (LI).

HV

## Configuration of the Impulse Generator

|                                   |     |    |
|-----------------------------------|-----|----|
| Number of capacitors in operation | 8   |    |
| Number of stages in parallel      | 1   |    |
| Number of stages                  | 8   |    |
| Rated energy                      | 80  | kJ |
| Generators capacitance            | 250 | nF |

## Configuration of the Voltage Divider

|                      |   |       |    |
|----------------------|---|-------|----|
| Divider HV           | D | 800   | kV |
| Parallel capacitance | D | 1,000 | nF |

## Impulse test voltage (BIL)

550 kV

## WAVE SHAPE

standard

|                    |   |               |       |
|--------------------|---|---------------|-------|
| Front time         | : | 1,2 ± 30,0 %  | µsec. |
| Time of half value | : | 50,0 ± 20,0 % | µsec. |
| Polarity           | : | negative      |       |

| Wave<br>N° | Phase | Position<br>T.C.<br>- | Type<br>of<br>Impulse | Voltage<br>[ kV ] | Front<br>resistance<br>FR<br>Ω | Tail<br>resistance<br>TR<br>Ω | Return<br>resistance<br>R<br>Ω | Shunt<br>Ω |
|------------|-------|-----------------------|-----------------------|-------------------|--------------------------------|-------------------------------|--------------------------------|------------|
| 1          | 1U    | 25                    | Reduced               | 275,0             | 217                            | 448                           | -                              | 0,2        |
| 2          | 1U    | 25                    | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 3          | 1U    | 25                    | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 4          | 1U    | 25                    | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 5          | 1V    | 13                    | Reduced               | 275,0             | 217                            | 448                           | -                              | 0,2        |
| 6          | 1V    | 13                    | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 7          | 1V    | 13                    | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 8          | 1V    | 13                    | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 9          | 1W    | 1                     | Reduced               | 275,0             | 217                            | 448                           | -                              | 0,2        |
| 10         | 1W    | 1                     | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 11         | 1W    | 1                     | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |
| 12         | 1W    | 1                     | Full                  | 550,0             | 217                            | 448                           | -                              | 0,2        |

Result : SATISFACTORY.

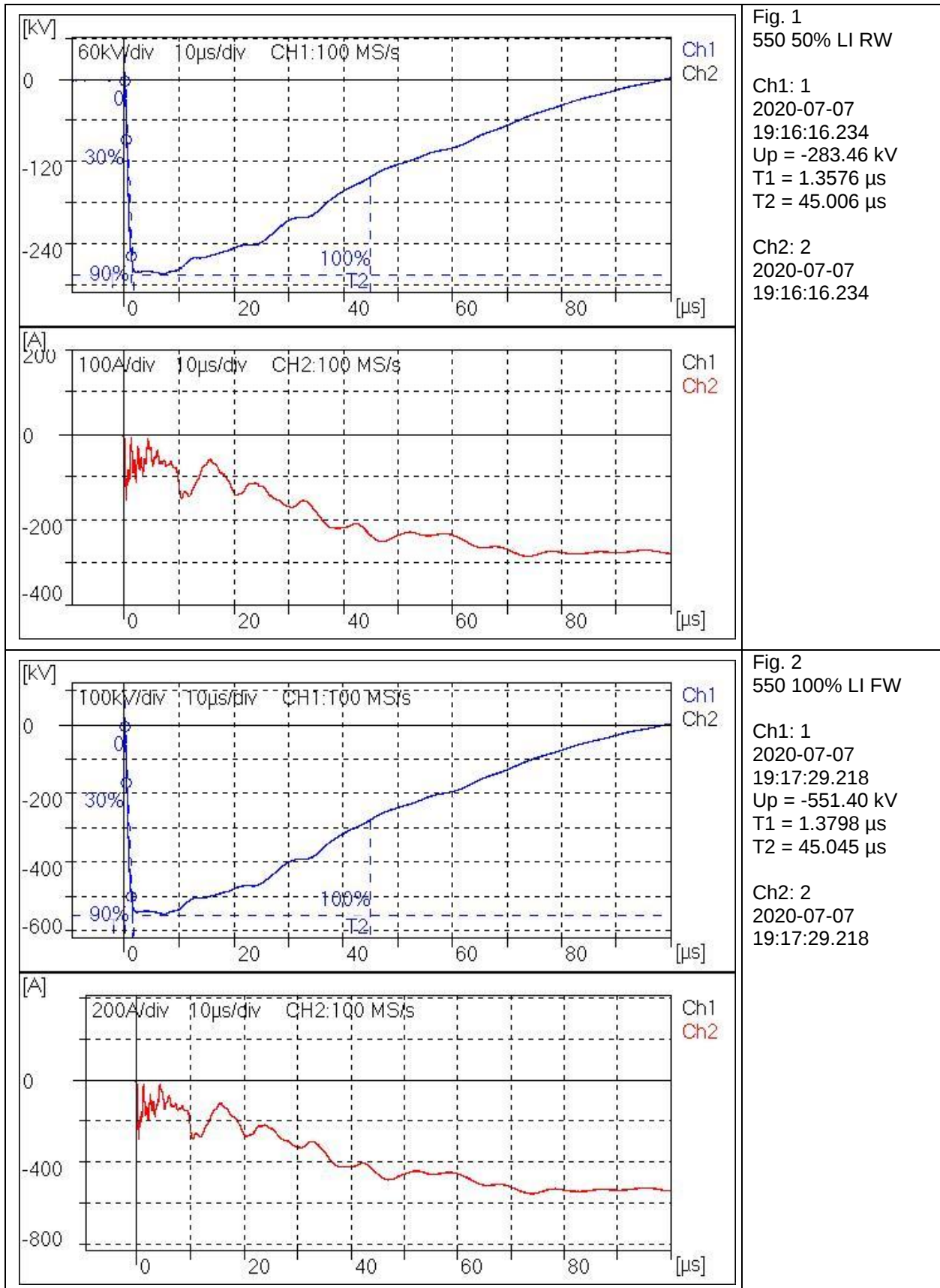
Drafted by: G.Bert

Approved by: G.Zeni

Date

07/07/20

Customer



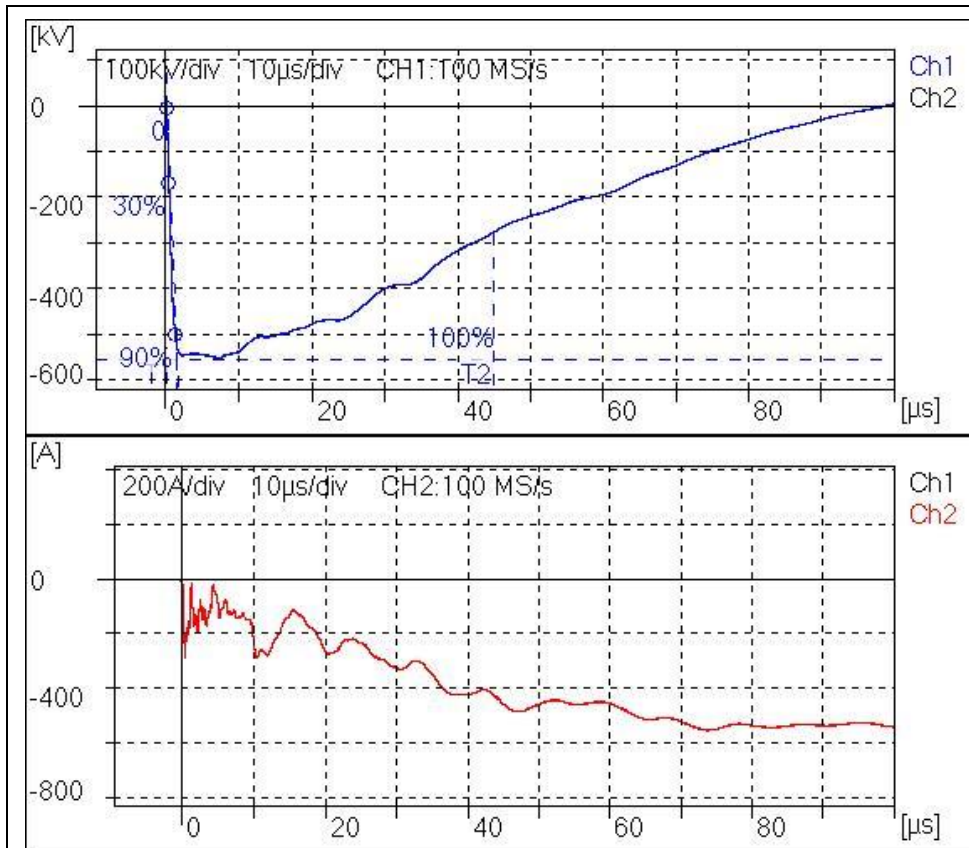


Fig. 3  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:18:22.609  
Up = -551.28 kV  
T1 = 1.3817 μs  
T2 = 45.030 μs

Ch2: 2  
2020-07-07  
19:18:22.609

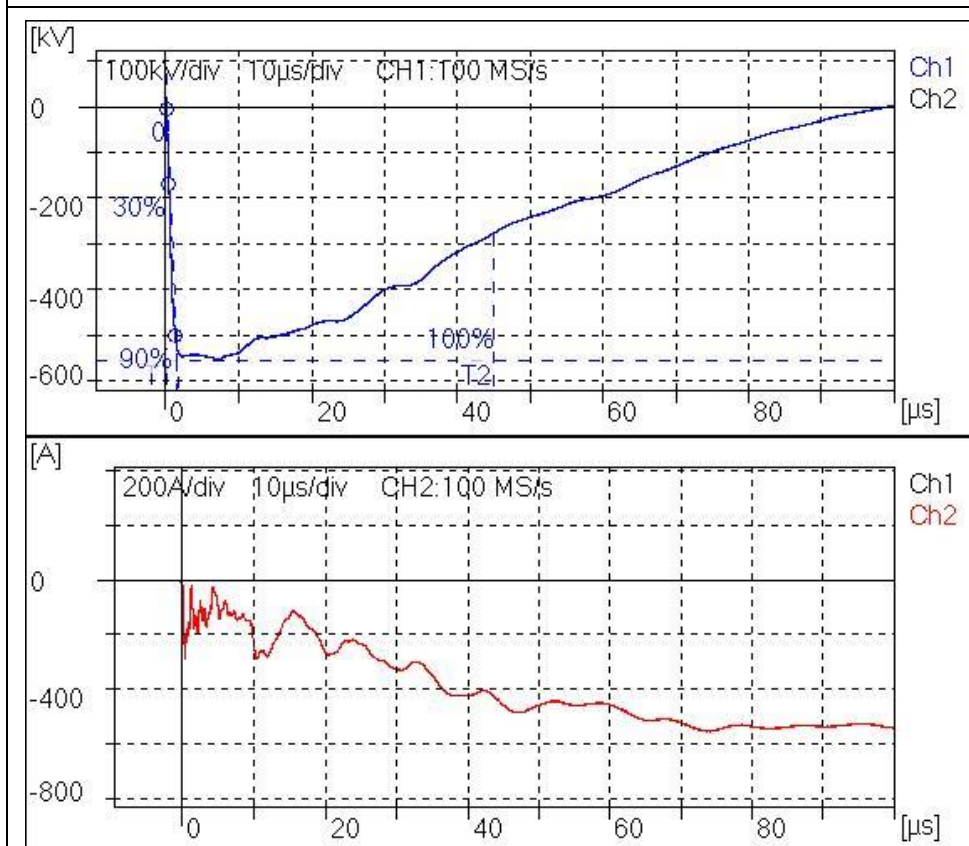


Fig. 4  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:19:40.812  
Up = -551.42 kV  
T1 = 1.3828 μs  
T2 = 45.055 μs

Ch2: 2  
2020-07-07  
19:19:40.812

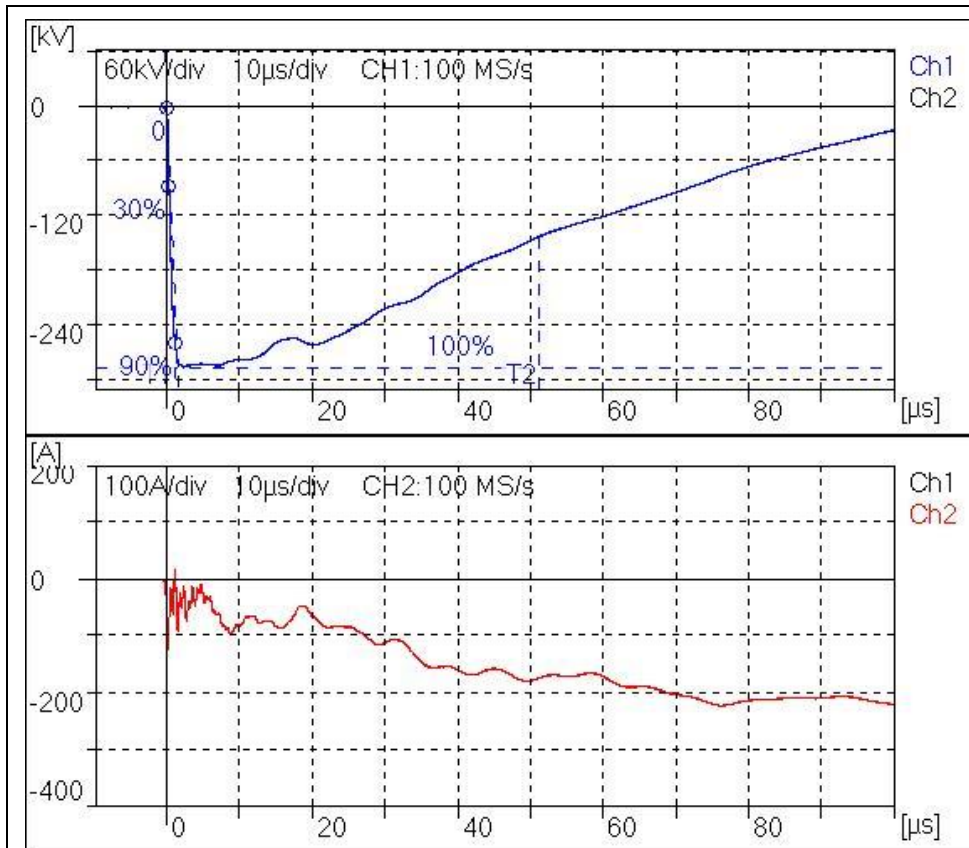


Fig. 5  
550 50% LI RW

Ch1: 1  
2020-07-07  
19:26:11.000  
Up = -285.18 kV  
T1 = 1.3382 μs  
T2 = 51.214 μs

Ch2: 2  
2020-07-07  
19:26:11.000

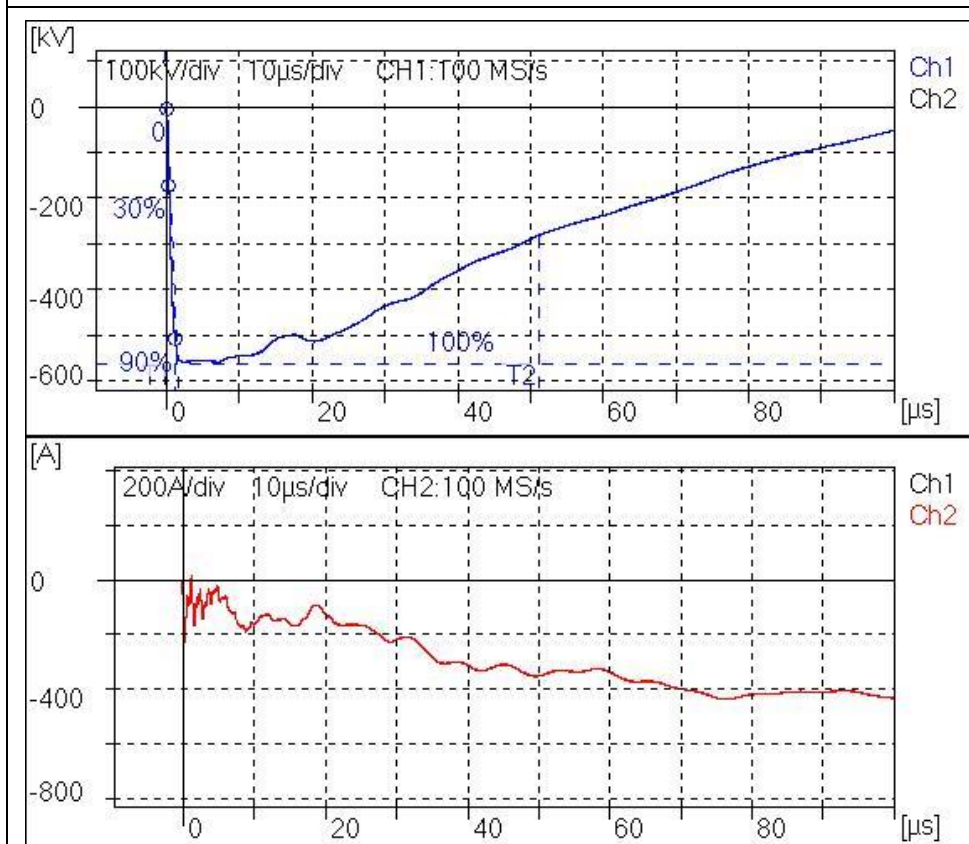


Fig. 6  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:27:28.796  
Up = -559.64 kV  
T1 = 1.3513 μs  
T2 = 51.287 μs

Ch2: 2  
2020-07-07  
19:27:28.796

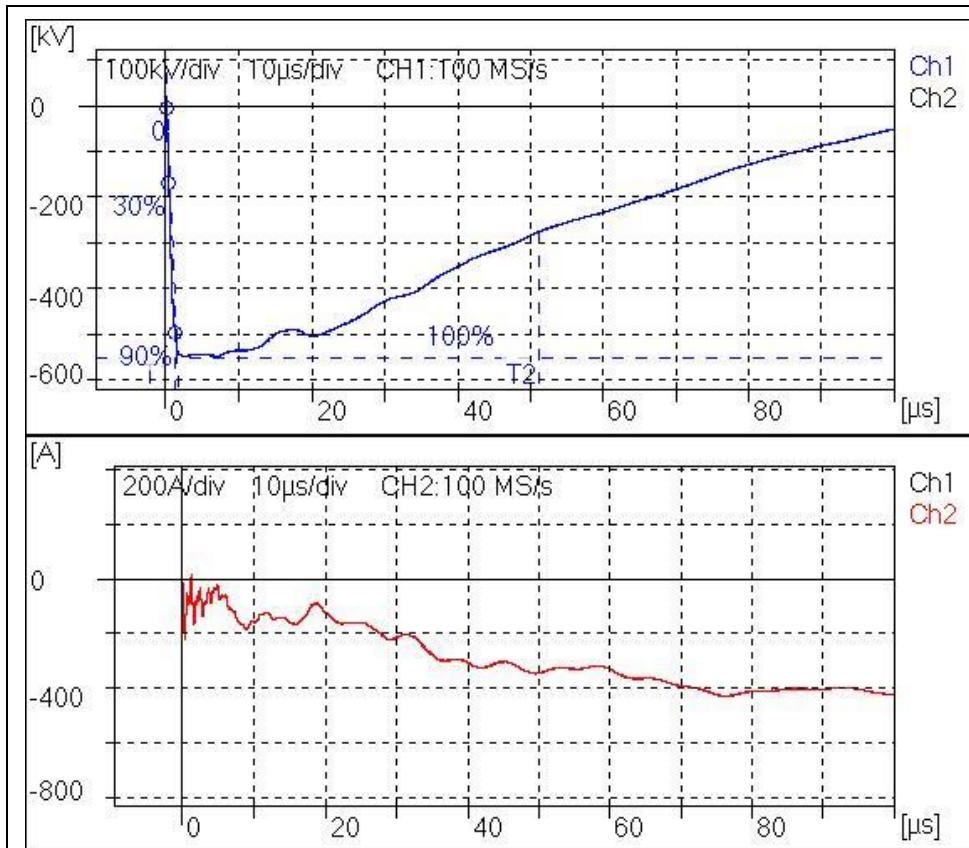


Fig. 7  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:29:03.390  
Up = -548.84 kV  
T1 = 1.3517 μs  
T2 = 51.327 μs

Ch2: 2  
2020-07-07  
19:29:03.390

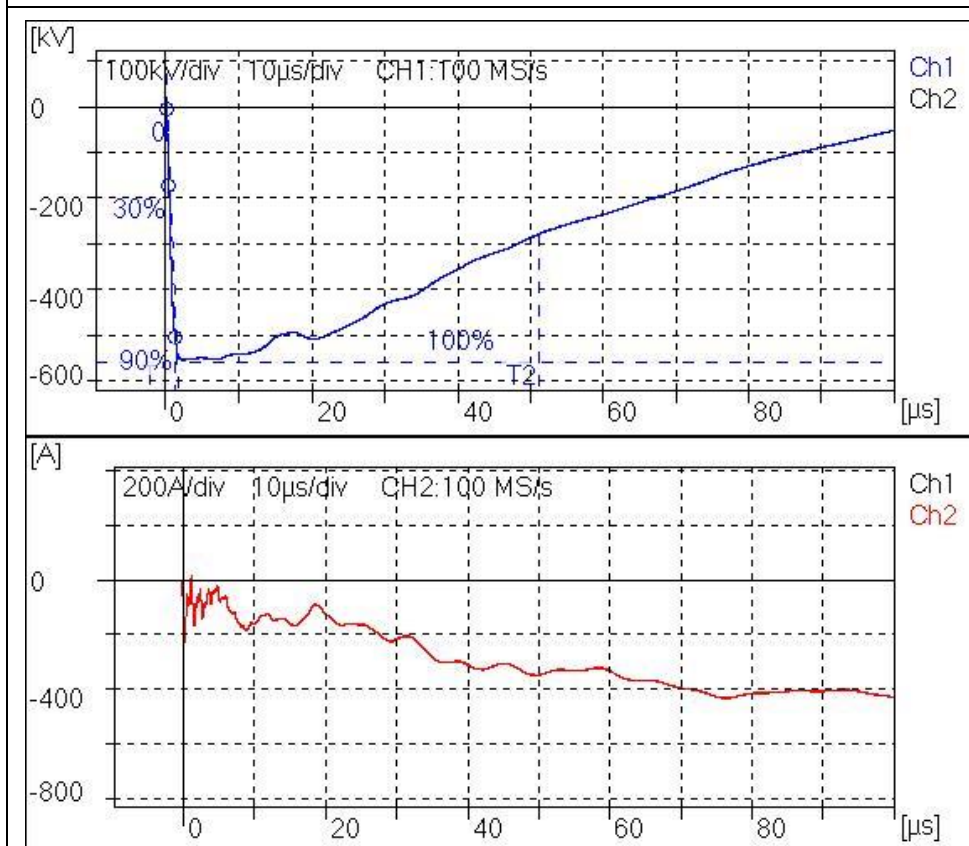


Fig. 8  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:30:04.796  
Up = -554.01 kV  
T1 = 1.3469 μs  
T2 = 51.304 μs

Ch2: 2  
2020-07-07  
19:30:04.796

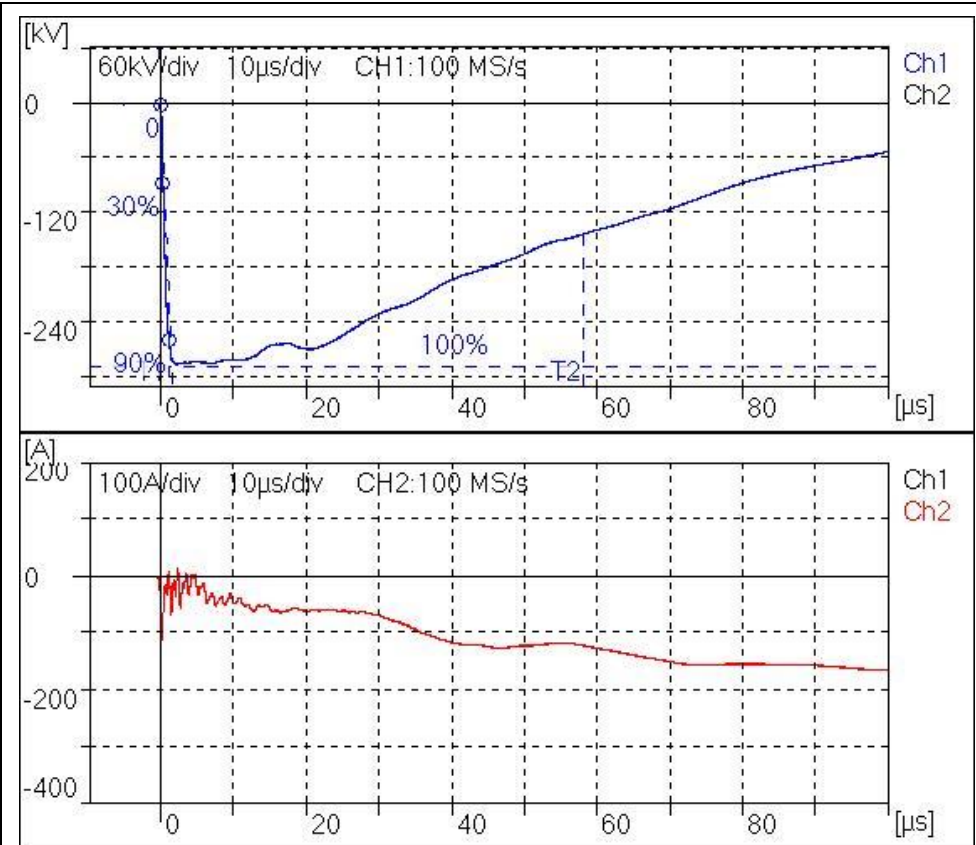


Fig. 9  
550 50% LI RW

Ch1: 1  
2020-07-07  
19:37:03.171  
Up = -286.16 kV  
T1 = 1.3302 μs  
T2 = 58.119 μs

Ch2: 2  
2020-07-07  
19:37:03.171

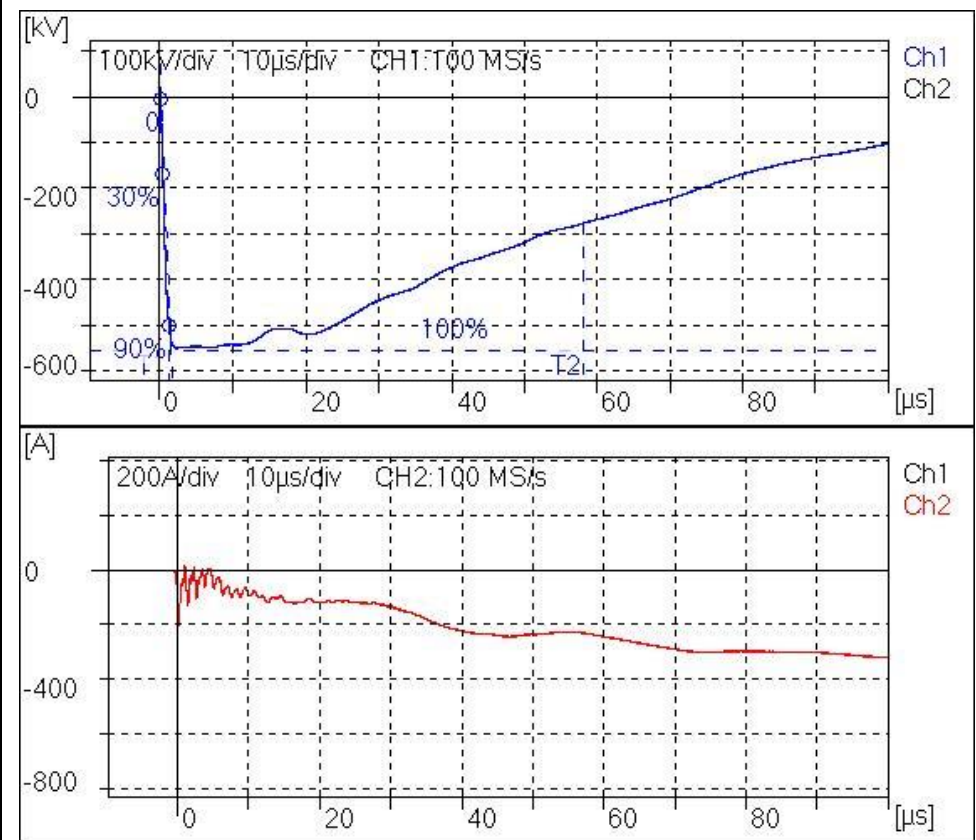


Fig. 10  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:38:14.562  
Up = -550.16 kV  
T1 = 1.3405 μs  
T2 = 58.237 μs

Ch2: 2  
2020-07-07  
19:38:14.562

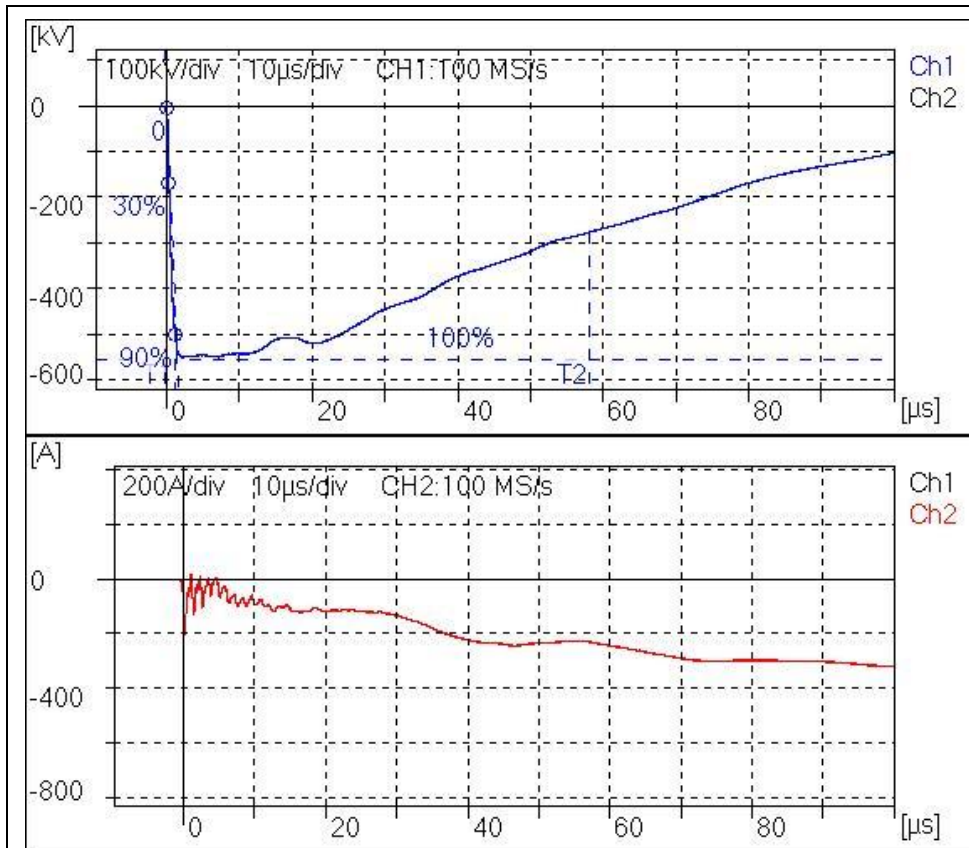


Fig. 11  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:39:06.765  
Up = -550.29 kV  
T1 = 1.3391 μs  
T2 = 58.254 μs

Ch2: 2  
2020-07-07  
19:39:06.765

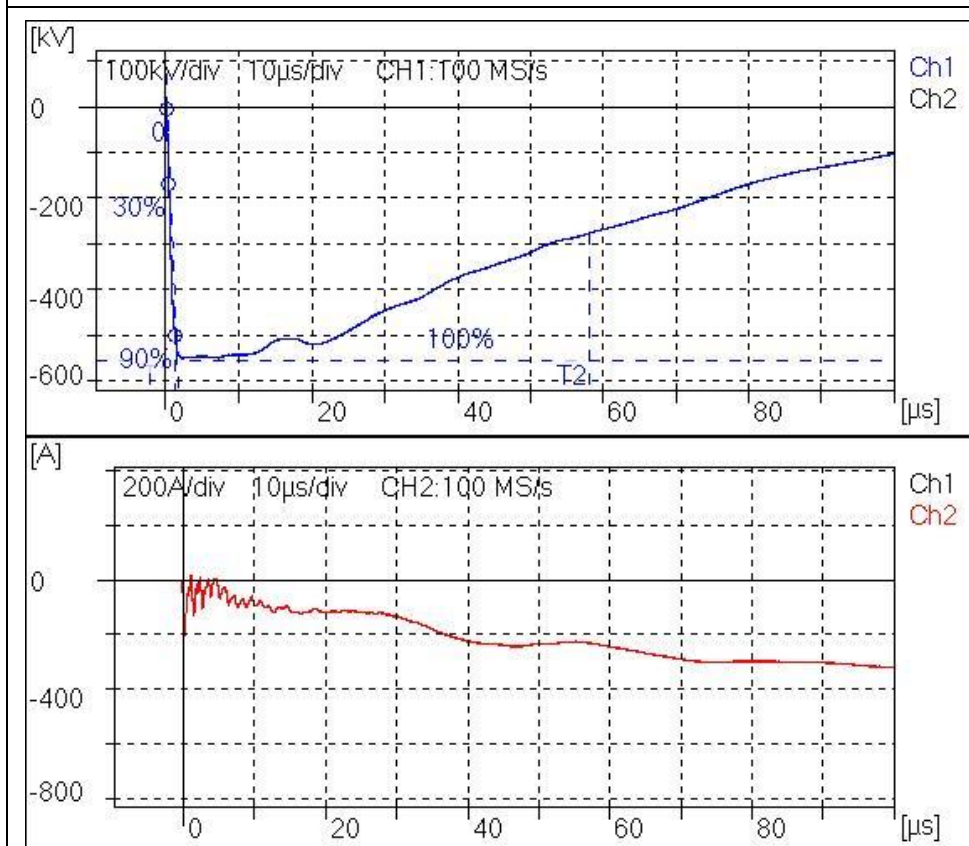


Fig. 12  
550 100% LI FW

Ch1: 1  
2020-07-07  
19:39:57.171  
Up = -550.34 kV  
T1 = 1.3426 μs  
T2 = 58.302 μs

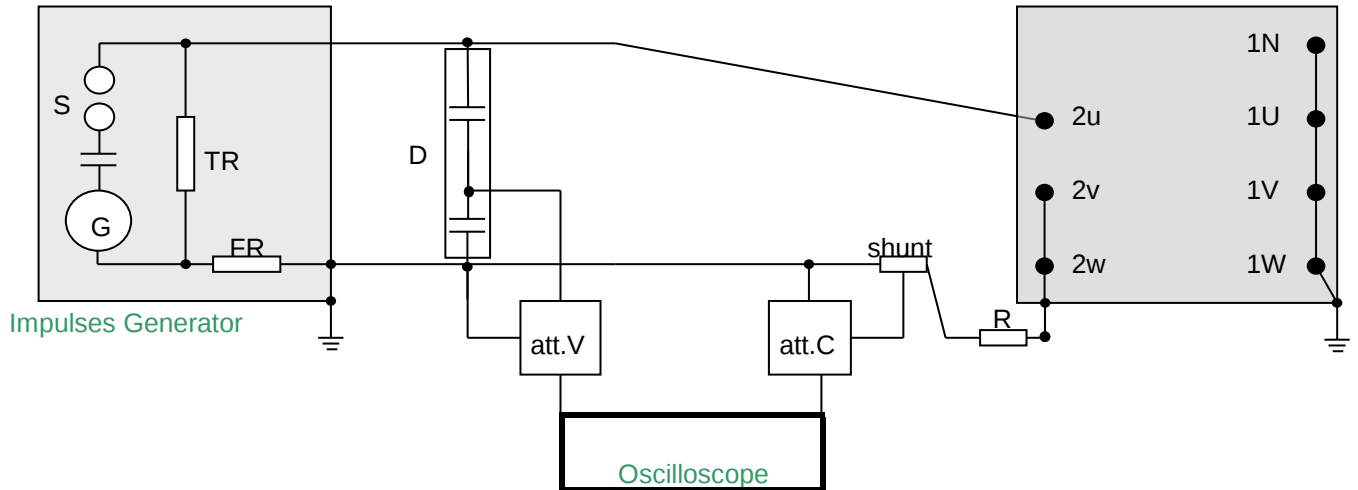
Ch2: 2  
2020-07-07  
19:39:57.171

Transformer

N° : 201421A/01

## Full wave lightning impulse test (LI).

MV



|    |   |                     |
|----|---|---------------------|
| G  | = | Generator           |
| S  | = | Dischargers Spheres |
| TR | = | Tail resistance     |
| ER | = | Exit resistance     |
| FR | = | Front resistance    |
| D  | = | Divider HV          |
| R  | = | Return resistance   |

Oscilloscope = STM173 High Volt Mias

## References / Standards:

- IEC 60060-1 (1994), High-Voltage test techniques - Part 1:"General definitions and test requirements"[21]
- IEC 60060-1 (1994), High-Voltage test techniques - Part 2:"Measuring systems"[22]
- IEC 60076-3 (2013), clause 13:"Lightning impulse tests (LI, LIC, LIN, LIMT)"[3]
- IEC 60076-4 (2002), "Guide to lightning impulse and switching impulse tests of power transformers and reactors"[4]
- IEC 61138-1 Instruments and Software Used for Measurement in High-Voltage Impulse Tests - Part 1: Requirements for Instruments
- IEC 61138-2 Instruments and Software Used for Measurement in High-Voltage Impulse Tests - Part 1: Requirements for Software

Drafted by: G.Bert

Approved by: G.Zeni

Date

07/07/20

Customer

Transformer N° : 201421A/01

## Full wave lightning impulse test (LI).

MV

## Configuration of the Impulse Generator

|                                   |      |    |
|-----------------------------------|------|----|
| Number of capacitors in operation | 8    |    |
| Number of stages in parallel      | 4    |    |
| Number of stages                  | 2    |    |
| Rated energy                      | 80   | kJ |
| Generators capacitance            | 4000 | nF |

## Configuration of the Voltage Divider

|                      |   |       |    |
|----------------------|---|-------|----|
| Divider HV           | D | 200   | kV |
| Parallel capacitance | D | 4,000 | nF |

## Impulse test voltage (BIL)

170 kV

## WAVE SHAPE

standard

|                    |   |               |       |
|--------------------|---|---------------|-------|
| Front time         | : | 1,2 ± 30,0 %  | µsec. |
| Time of half value | : | 50,0 ± 20,0 % | µsec. |
| Polarity           | : | negative      |       |

| Wave<br>N° | Phase | Position<br>T.C.<br>- | Type<br>of<br>Impulse | Voltage<br>[ kV ] | Front<br>resistance<br>FR<br>Ω | Tail<br>resistance<br>TR<br>Ω | Return<br>resistance<br>R<br>Ω | Shunt<br>Ω |
|------------|-------|-----------------------|-----------------------|-------------------|--------------------------------|-------------------------------|--------------------------------|------------|
| 1          | 2u    | -                     | Reduced               | 85,0              | 59                             | 79                            | -                              | 0,2        |
| 2          | 2u    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 3          | 2u    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 4          | 2u    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 5          | 2v    | -                     | Reduced               | 85,0              | 59                             | 79                            | -                              | 0,2        |
| 6          | 2v    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 7          | 2v    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 8          | 2v    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 9          | 2w    | -                     | Reduced               | 85,0              | 59                             | 79                            | -                              | 0,2        |
| 10         | 2w    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 11         | 2w    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |
| 12         | 2w    | -                     | Full                  | 170,0             | 59                             | 79                            | -                              | 0,2        |

Result : SATISFACTORY.

Drafted by: G.Bert

Approved by G.Zeni

Date

07/07/20

Customer

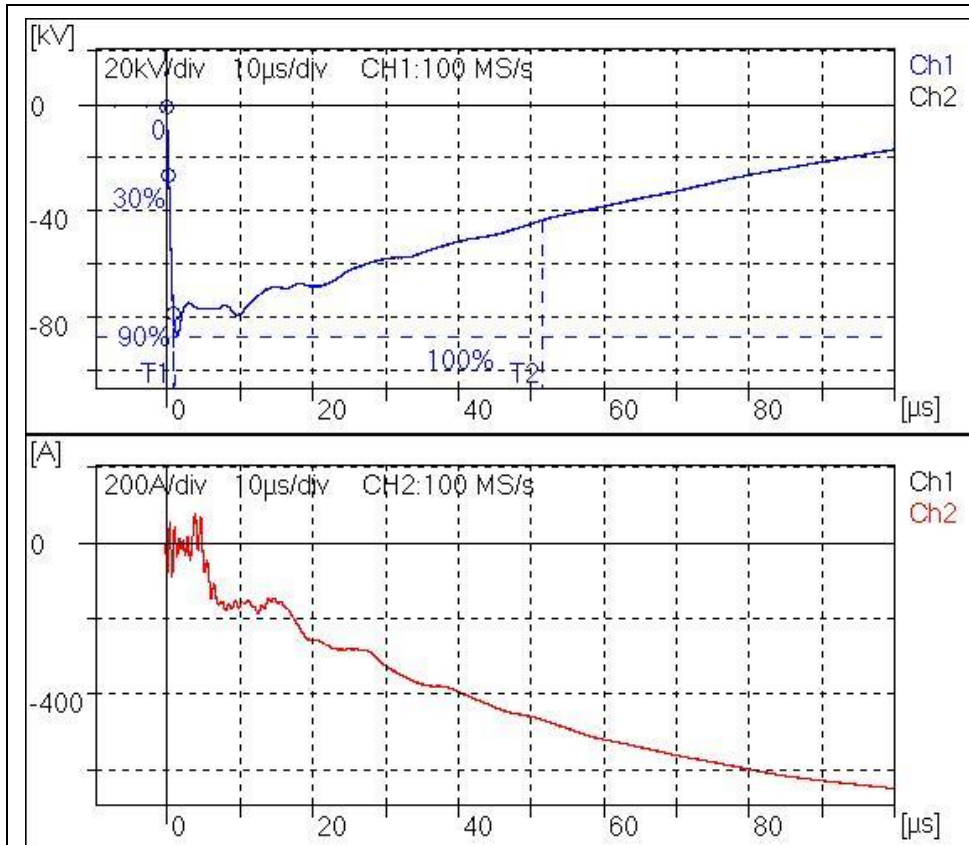


Fig. 1  
170 50% LI RW

Ch1: 1  
2020-07-07  
18:12:36.140  
Up = -86.289 kV  
T1 = 1.1202 μs  
T2 = 51.594 μs

Ch2: 2  
2020-07-07  
18:12:36.140

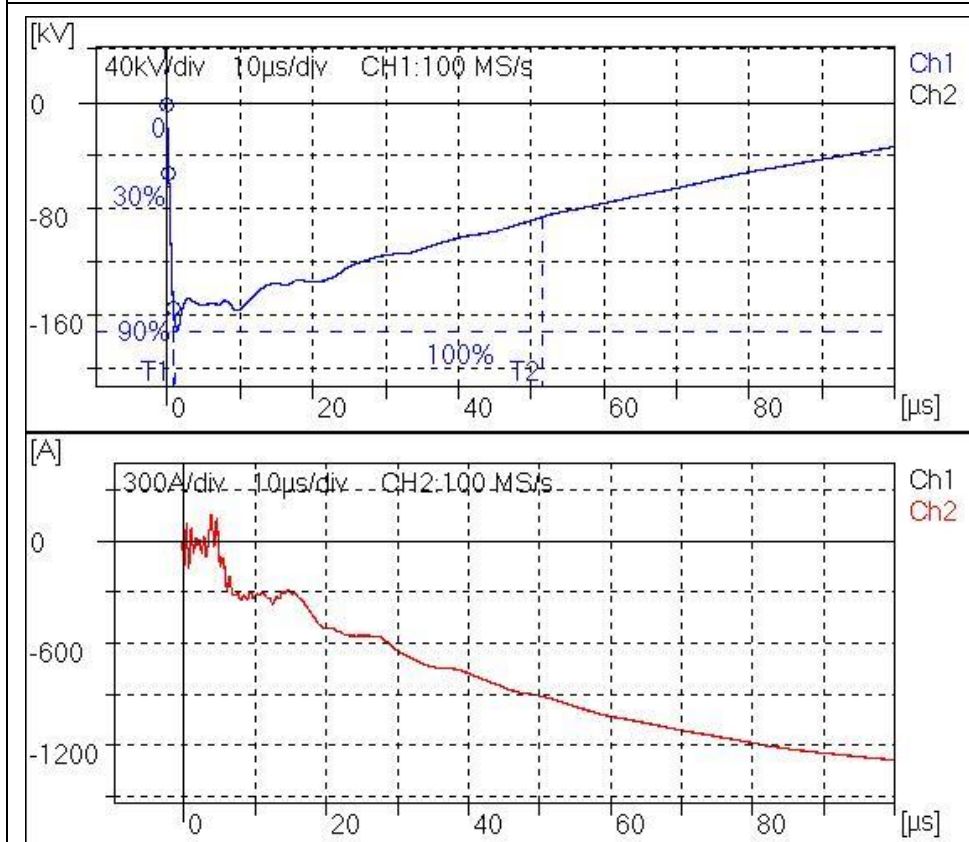


Fig. 2  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:14:50.750  
Up = -170.47 kV  
T1 = 1.1323 μs  
T2 = 51.712 μs

Ch2: 2  
2020-07-07  
18:14:50.750

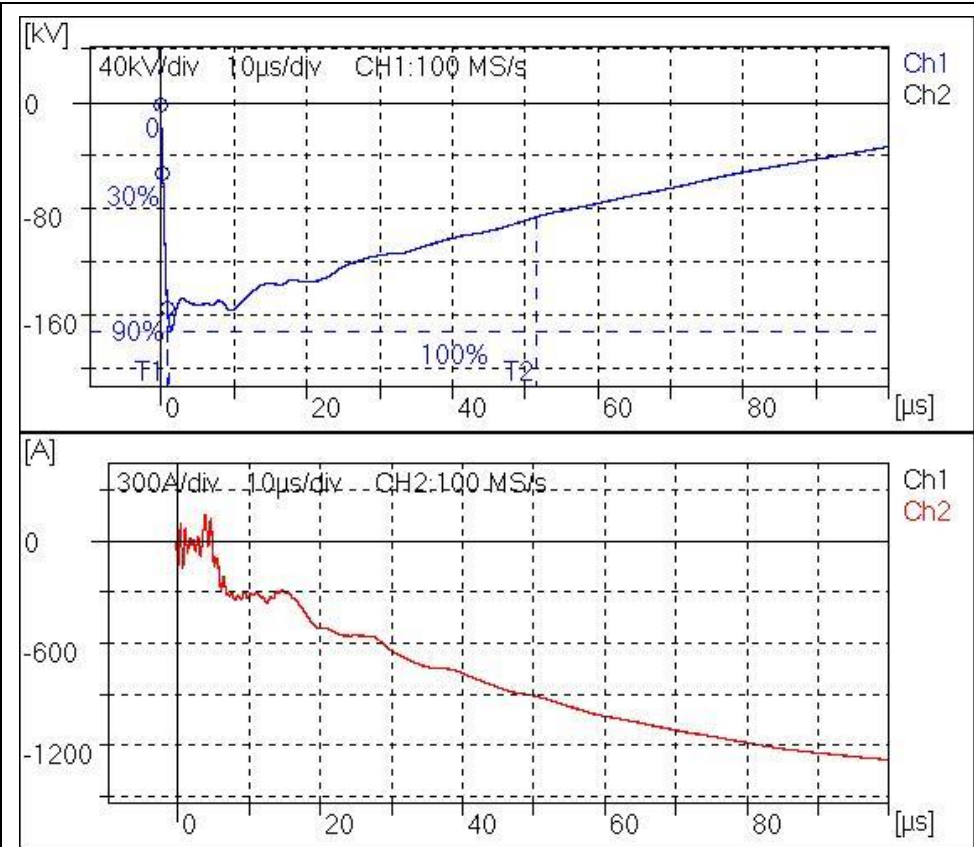


Fig. 3  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:15:56.734  
Up = -170.54 kV  
T1 = 1.1374 μs  
T2 = 51.717 μs

Ch2: 2  
2020-07-07  
18:15:56.734

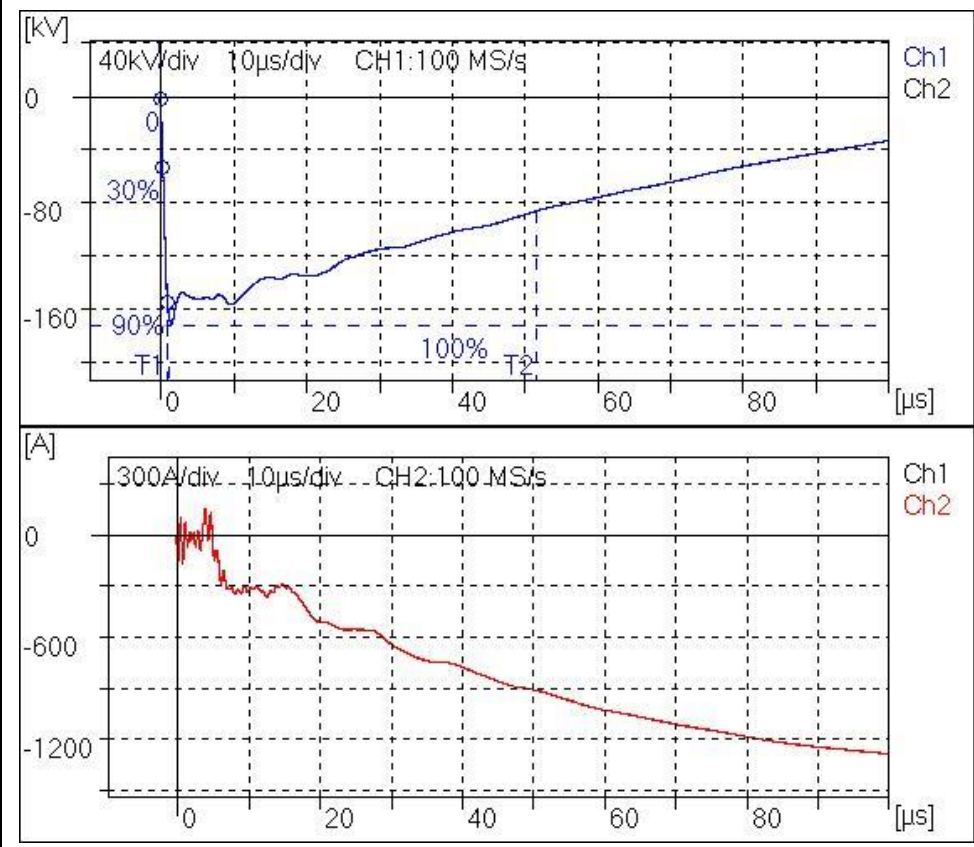


Fig. 4  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:17:01.328  
Up = -170.48 kV  
T1 = 1.1351 μs  
T2 = 51.727 μs

Ch2: 2  
2020-07-07  
18:17:01.328

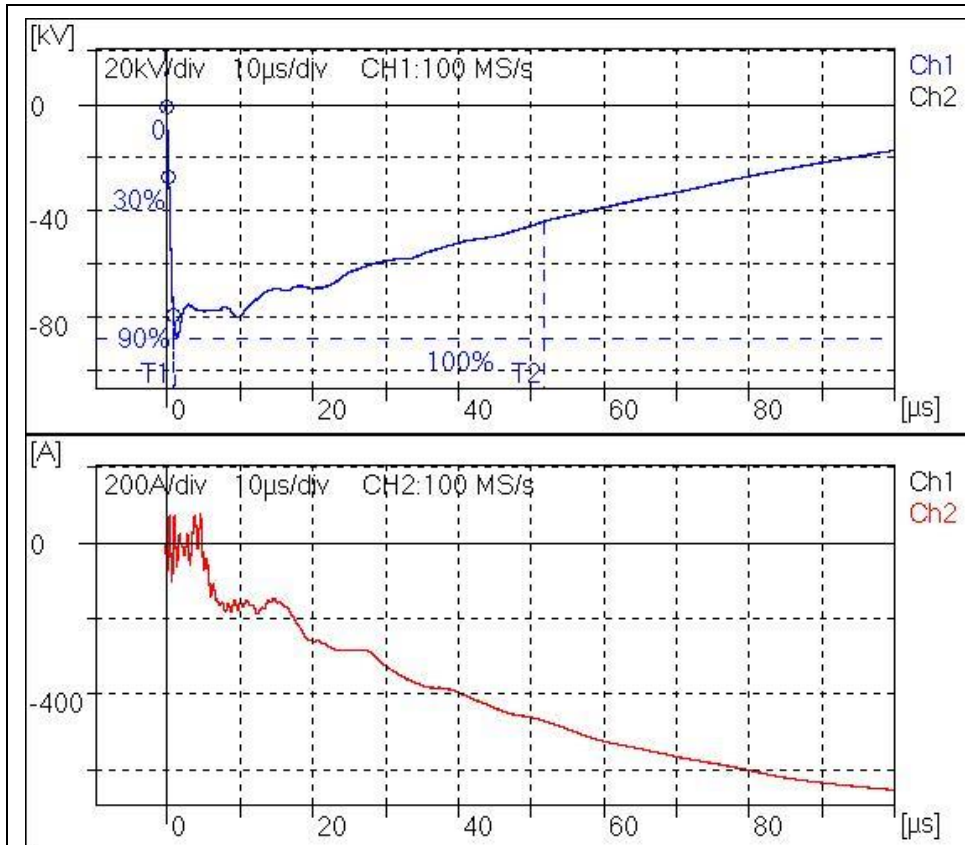


Fig. 5  
170 50% LI RW

Ch1: 1  
2020-07-07  
18:29:21.312  
Up = -87.293 kV  
T1 = 1.1327 μs  
T2 = 51.878 μs

Ch2: 2  
2020-07-07  
18:29:21.312

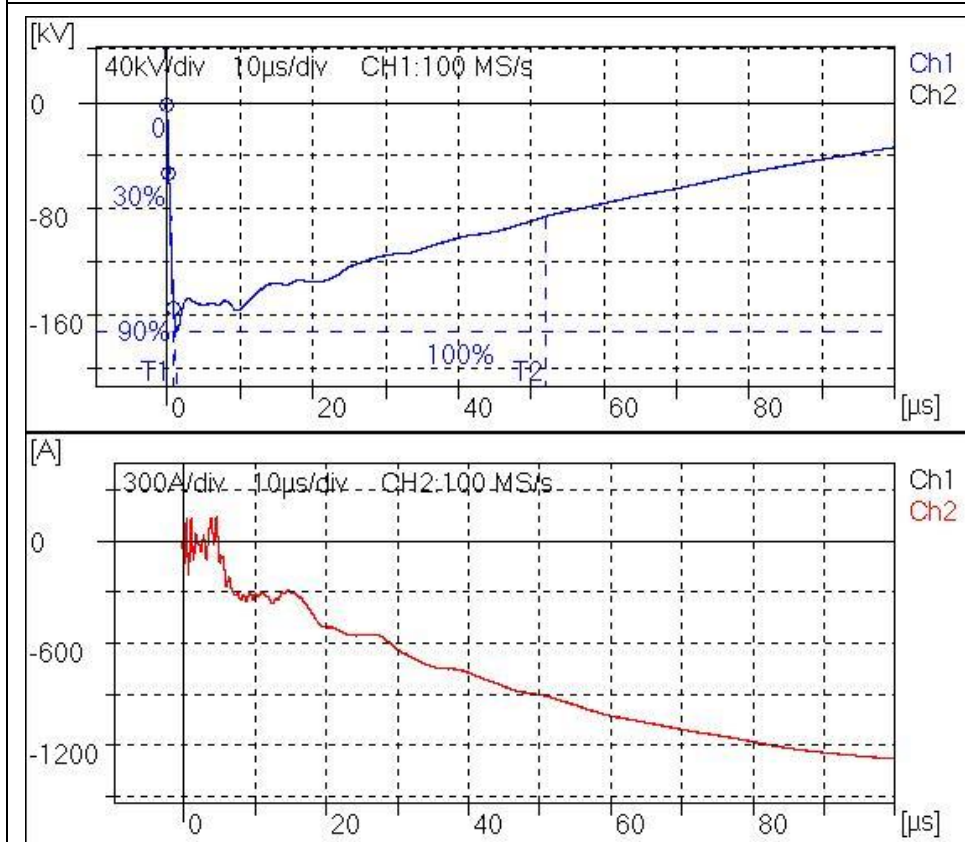


Fig. 6  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:30:56.703  
Up = -170.54 kV  
T1 = 1.1413 μs  
T2 = 52.028 μs

Ch2: 2  
2020-07-07  
18:30:56.703

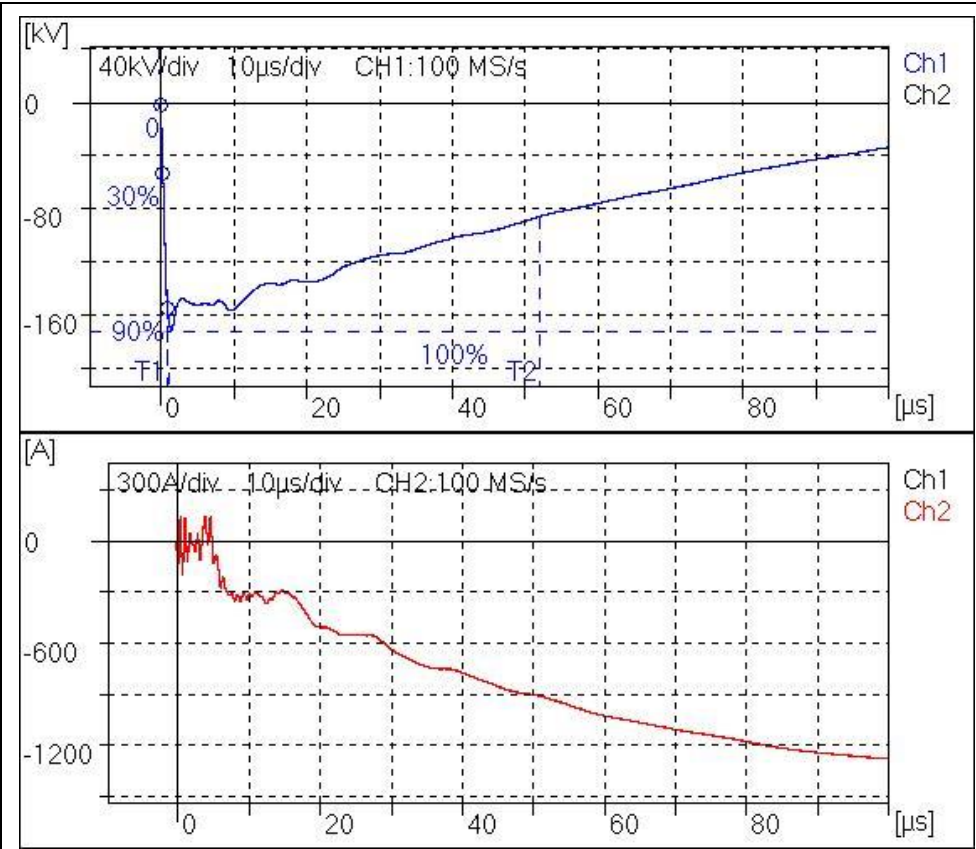


Fig. 7  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:32:00.500  
Up = -170.47 kV  
T1 = 1.1362 μs  
T2 = 52.022 μs

Ch2: 2  
2020-07-07  
18:32:00.500

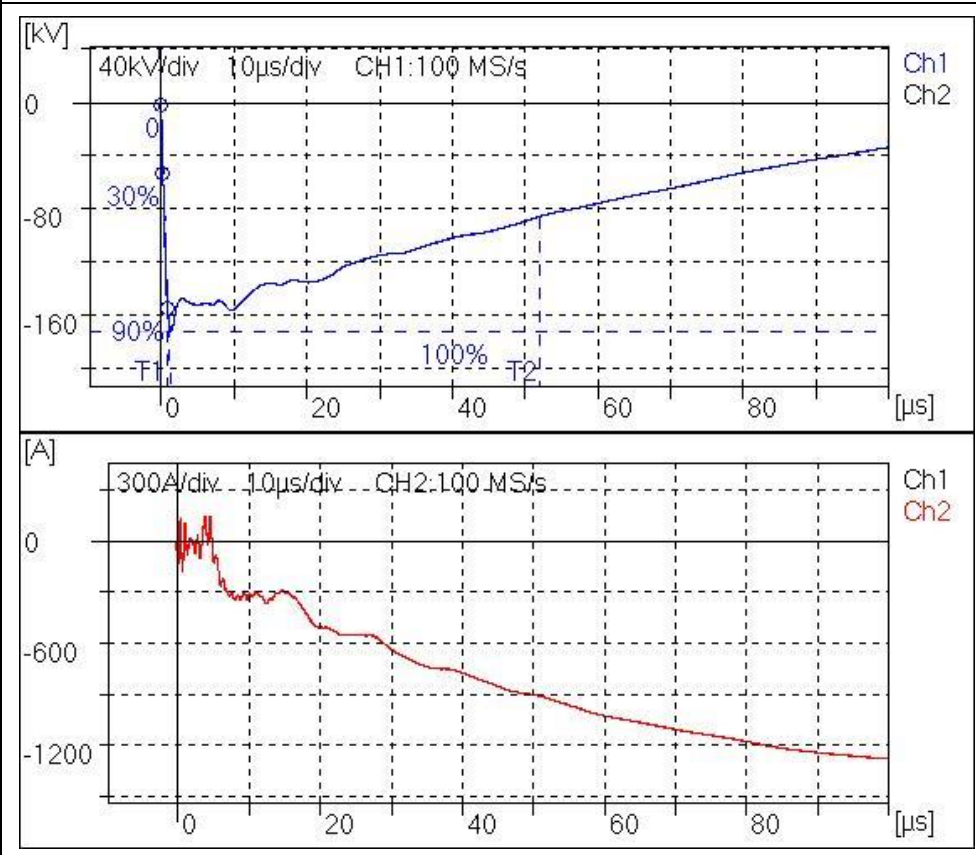


Fig. 8  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:33:04.093  
Up = -170.59 kV  
T1 = 1.1417 μs  
T2 = 52.009 μs

Ch2: 2  
2020-07-07  
18:33:04.093

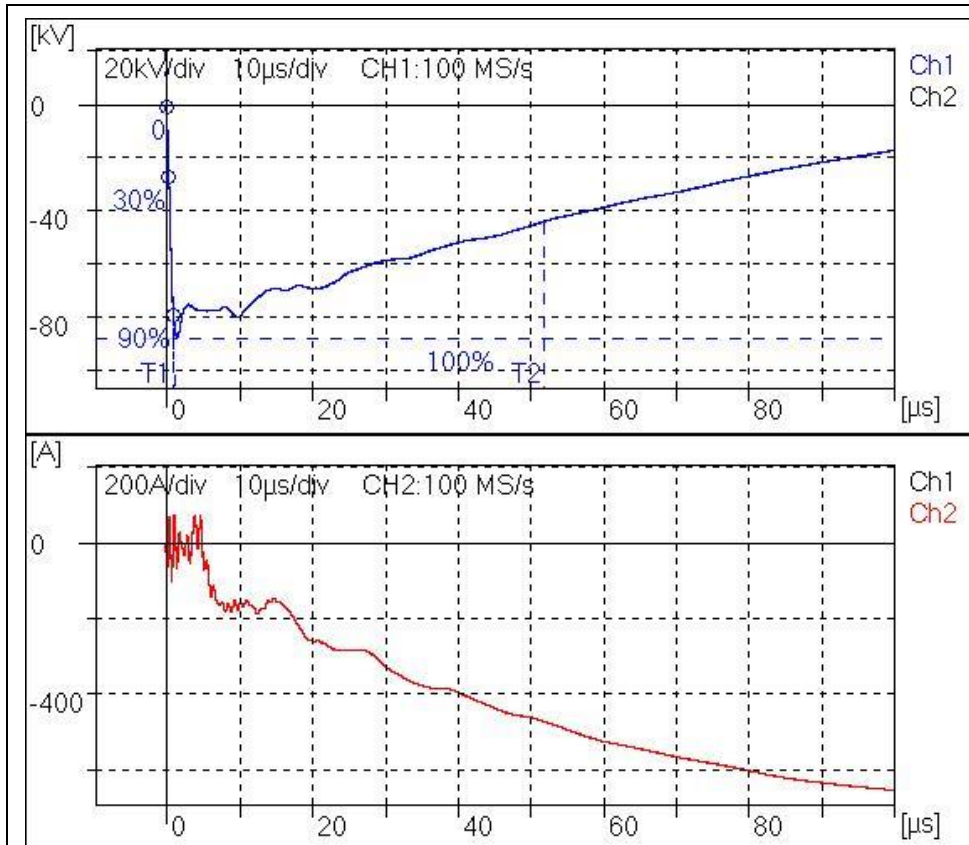


Fig. 9  
170 50% LI RW

Ch1: 1  
2020-07-07  
18:38:17.500  
Up = -87.313 kV  
T1 = 1.1321 μs  
T2 = 51.869 μs

Ch2: 2  
2020-07-07  
18:38:17.500

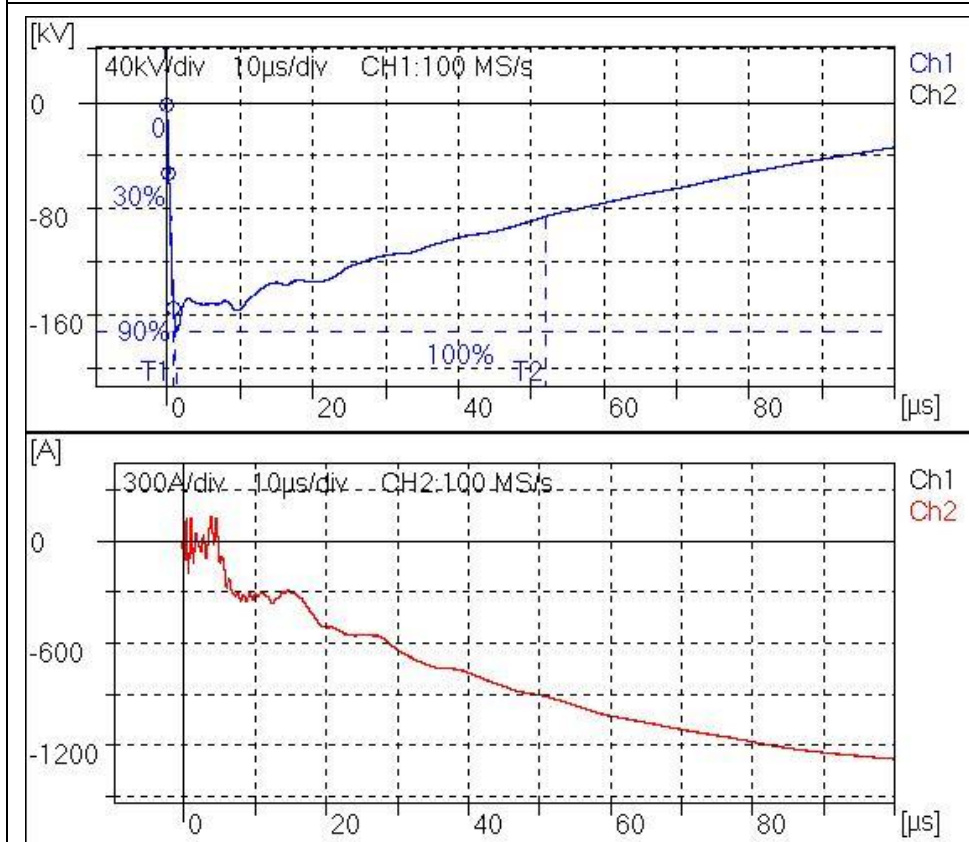


Fig. 10  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:39:47.484  
Up = -170.57 kV  
T1 = 1.1429 μs  
T2 = 51.995 μs

Ch2: 2  
2020-07-07  
18:39:47.484

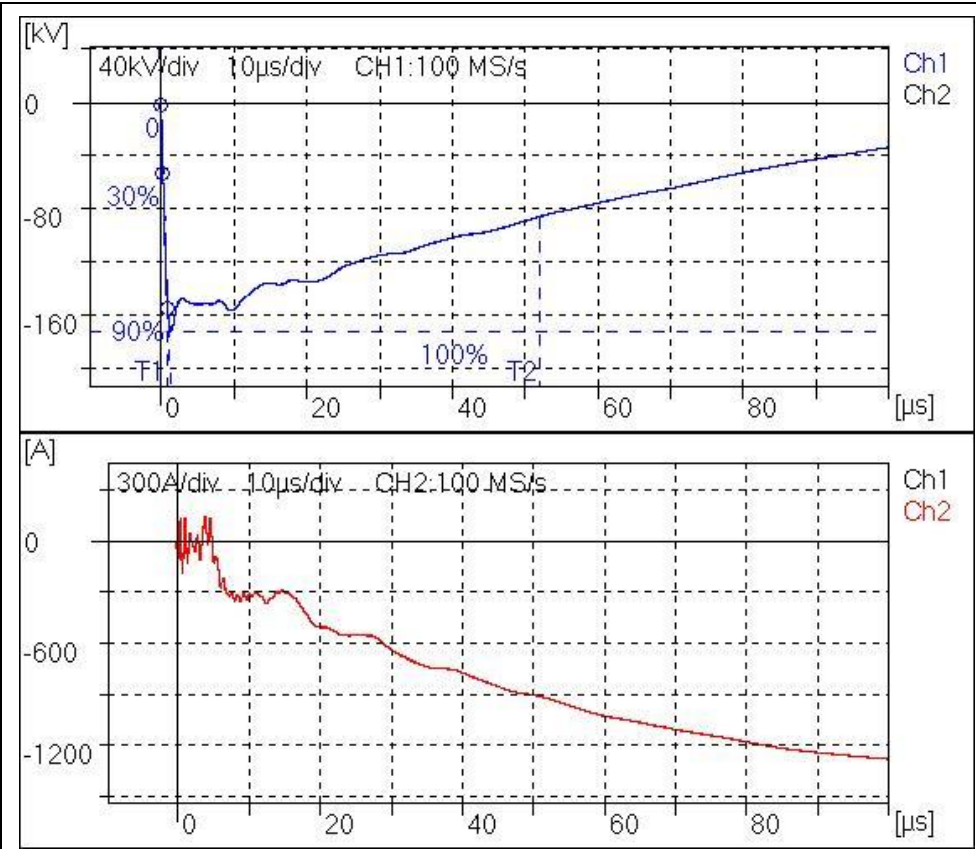


Fig. 11  
170 100% LI FW

Ch1: 1  
2020-07-07  
18:40:51.281  
Up = -170.54 kV  
T1 = 1.1419 μs  
T2 = 52.037 μs

Ch2: 2  
2020-07-07  
18:40:51.281

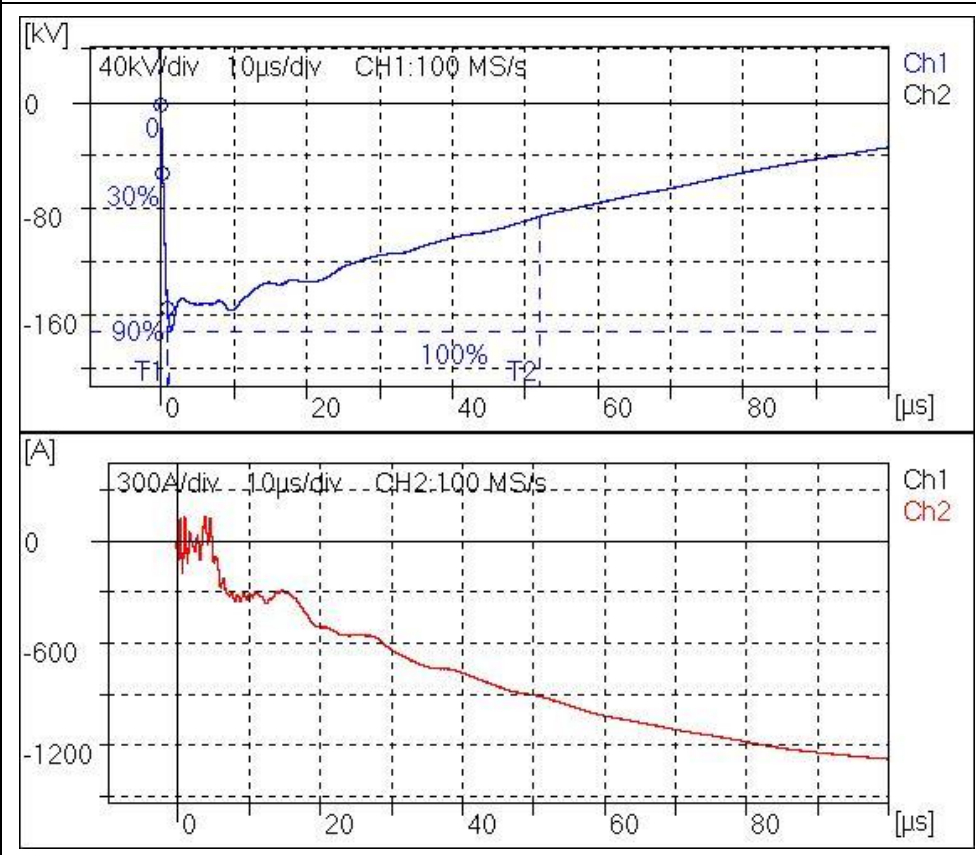


Fig. 12  
170 100% LI FW

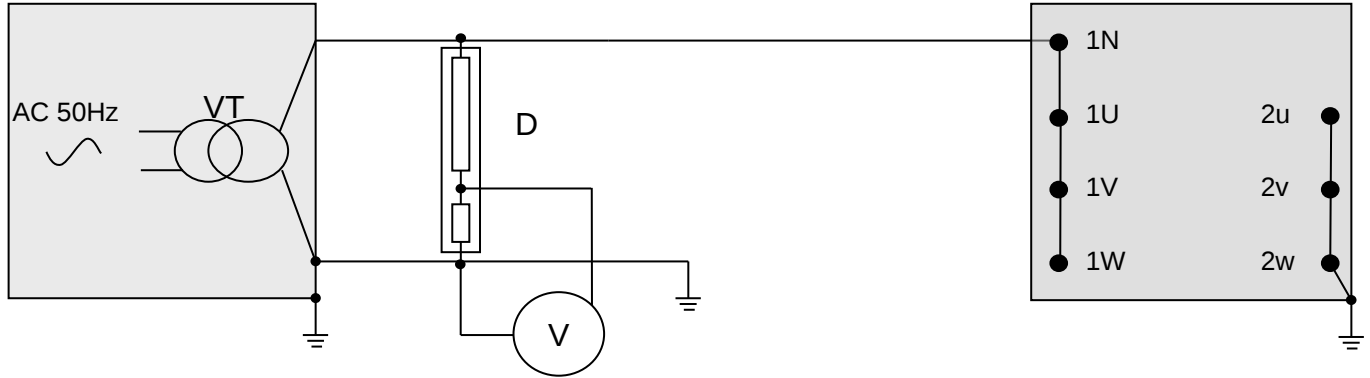
Ch1: 1  
2020-07-07  
18:42:07.468  
Up = -170.51 kV  
T1 = 1.1403 μs  
T2 = 52.022 μs

Ch2: 2  
2020-07-07  
18:42:07.468

Transformer

N° : 201421A/01

## Applied Voltage Test 50 Hz for 60 seconds

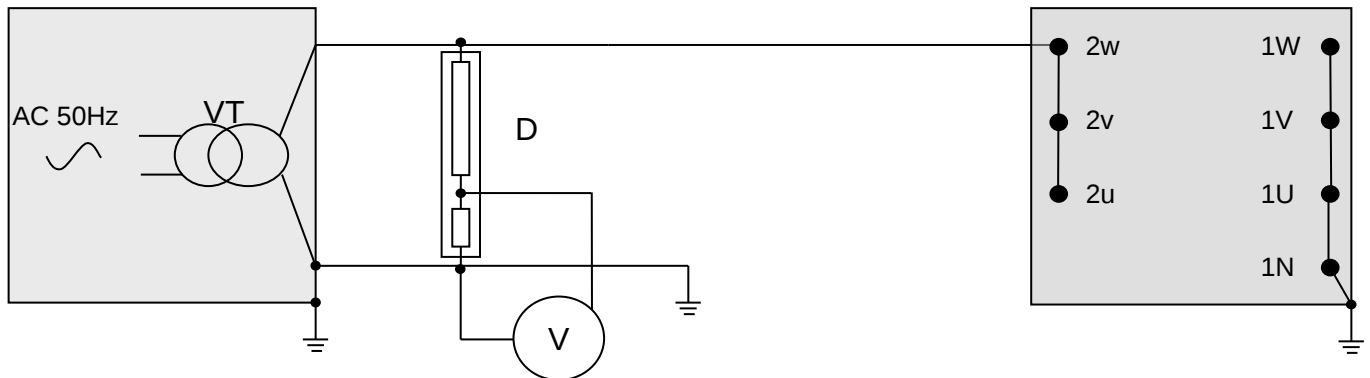


## Applied Voltage Test on HV

Tests Voltage : 70 kV

Result : SATISFACTORY.

## Applied Voltage Test 50 Hz for 60 seconds



## Applied Voltage Test on MV

Tests Voltage : 70 kV

Result : SATISFACTORY.

|    |   |        |                                                    |
|----|---|--------|----------------------------------------------------|
| VT | : | STM174 | Samgor technology type YDTCW-1000/2x250 n° 0907246 |
| D  | : | STM174 | Samgor technology type TRF-500/0,0005 n° 0907247   |
| V  | : | STM174 | Samgor technology system                           |

## References / Standards:

- IEC 60076-3 (2013), clause 10: "Applied Voltage Test"[3]

Drafted by: A.Bridi

Approved by: G.Zeni

Date

07/07/20

Customer

Restricted

Transformer

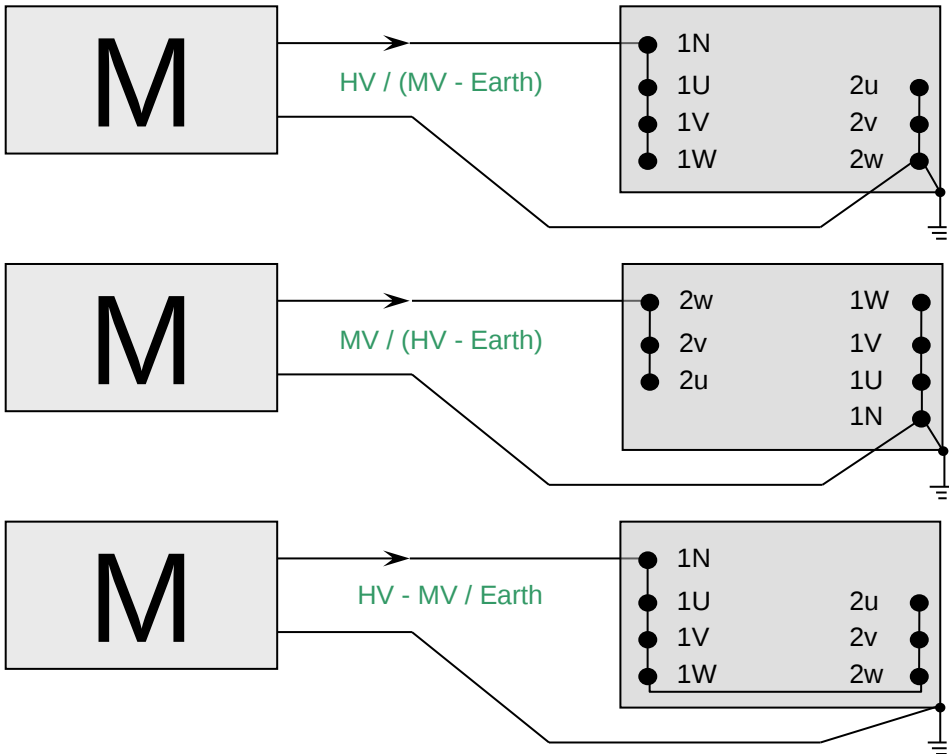
N°

:

201421A/01

Measurement of insulation resistance.

Test voltage: 5000 V DC for 60 seconds.



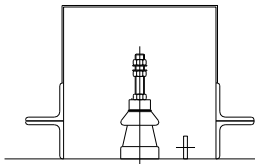
| 26,0 °C | 20,0 °C |
|---------|---------|
| [MOhm]  | [MOhm]  |
| 7410    | 11222   |

| [MOhm] | [MOhm] |
|--------|--------|
| 5560   | 8420   |

| [MOhm] | [MOhm] |
|--------|--------|
| 8020   | 12146  |

Measurement of insulation resistance of the core and core frames.

Test voltage: 2500 V DC for 60 seconds.



|                                | [MOhm] | [MOhm] |
|--------------------------------|--------|--------|
| Core / Core Frames and Earth = | 6620   | 10026  |
| Core Frames / Core and Earth = | 4980   | 7542   |

M :

STM222

MEGGER LIMITED, MIT1025

n° 101760237

Result : SATISFACTORY.

References / Standards:

- IEC 60076-1 Ed.3 (2011-04), clause 11.1: "General requirement for routine, type and special tests".

Drafted by: A.Bridi

08/07/20

Approved by: G.Zeni

Customer

Transformer

N°

:

201421A/01

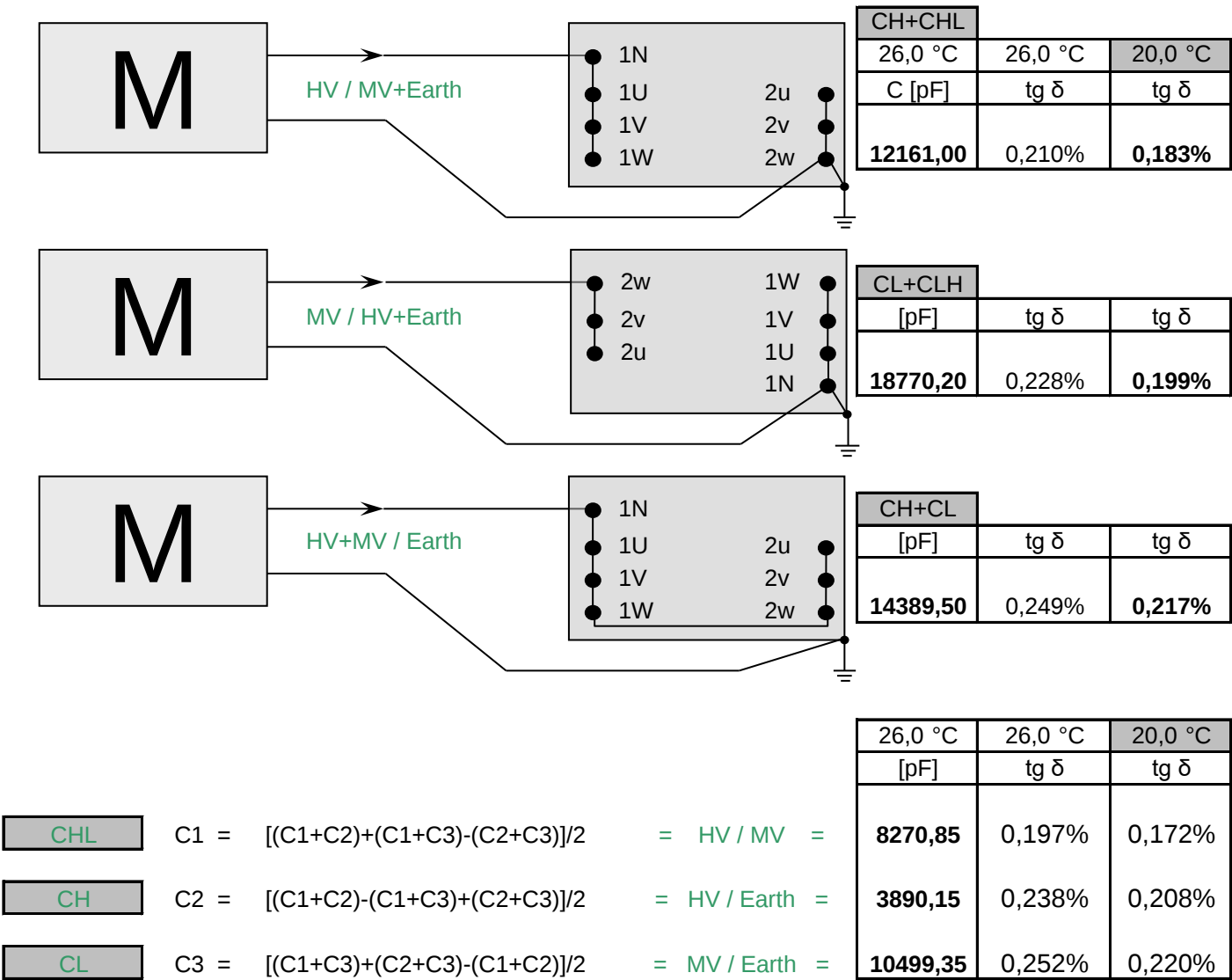
Winding capacitance measurement and tg Delta.

Transformer's Temperature [°C]:

26,0

Applied Voltage [kV] :

10,0



Instrument used:

STM157 OMICRON Type CPC 100

n° HF369M

References / Standards:

- IEC 60076-1 (2011), clause 11.1.2.2.c): "Measurement of the dissipation factor (tan d) of the insulation resistance capacitances".

Drafted by:

A.Bridi

Approved by:

G.Zeni

Date

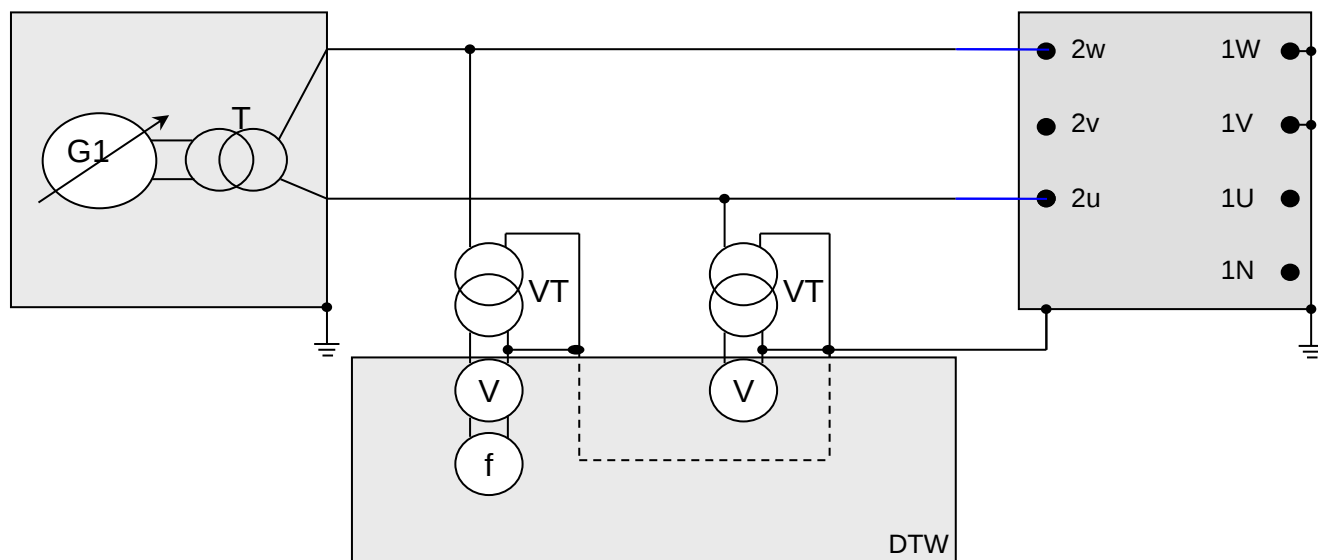
08/07/20

Customer

Transformer

N° : 201421A/01

## Line terminal AC withstand voltage test (LTAC)



|            |   |                                    |                                                 |
|------------|---|------------------------------------|-------------------------------------------------|
| <b>G1</b>  | : | Generator 100 Hz                   |                                                 |
| <b>T</b>   | : | Transformer                        |                                                 |
| <b>VT</b>  | : | Voltage Transformers               | 10000-20000-30000 / 100 10 VA CL.02 NMG VRC3/S: |
|            |   |                                    | STM124-125-126 n° 118674 - 118675 - 118676      |
| <b>DTW</b> | : | STM136 NORMA D6133T n° N5 38855 RR |                                                 |

## References / Standards:

- IEC 60076-3 (2013), clause 11: "Induced Voltage tests (IVW and IVPD)"[3]

Drafted by: G.Bert

Approved by: G.Zeni

Date

08/07/20

Customer

Transformer N° : 201421A/01

### Line terminal AC withstand voltage test (LTAC)

|          |          | $1U / \frac{1}{\sqrt{3}}$<br>[kV] | $1V / \frac{1}{\sqrt{3}}$<br>[kV] | $1W / \frac{1}{\sqrt{3}}$<br>[kV] |
|----------|----------|-----------------------------------|-----------------------------------|-----------------------------------|
| Um       | :        | 145,00                            | 145,00                            | 145,00                            |
| Position | <b>1</b> | 151,80                            | 151,80                            | 151,80                            |
| MV       | :        | UN / uv<br>33,000                 | VN / vw<br>33,000                 | WN / wu<br>33,000                 |

### Test Voltage ( phase to earth )

|    |   |        |        |        |
|----|---|--------|--------|--------|
|    |   | [kV]   | [kV]   | [kV]   |
| HV | : | 230,00 | 230,00 | 230,00 |

### Test Voltage ( neutral to earth )

|     |   |                 |                 |                 |
|-----|---|-----------------|-----------------|-----------------|
|     |   | [kV]            | [kV]            | [kV]            |
| NHV | : | 76,67 ± 3,000 % | 76,67 ± 3,000 % | 76,67 ± 3,000 % |

### Test Voltage ( phase to phase )

|    |   |       |       |       |
|----|---|-------|-------|-------|
|    |   | [kV]  | [kV]  | [kV]  |
| MV | : | 57,74 | 57,74 | 57,74 |

|      |                        |       |       |       |
|------|------------------------|-------|-------|-------|
|      |                        | [sec] | [sec] | [sec] |
| Time | 120 x (50 Hz / 100 Hz) | 60,00 | 60,00 | 60,00 |

**Result :** SATISFACTORY. SATISFACTORY. SATISFACTORY.

Drafted by: G.Bert

Approved by: G.Zeni

Date

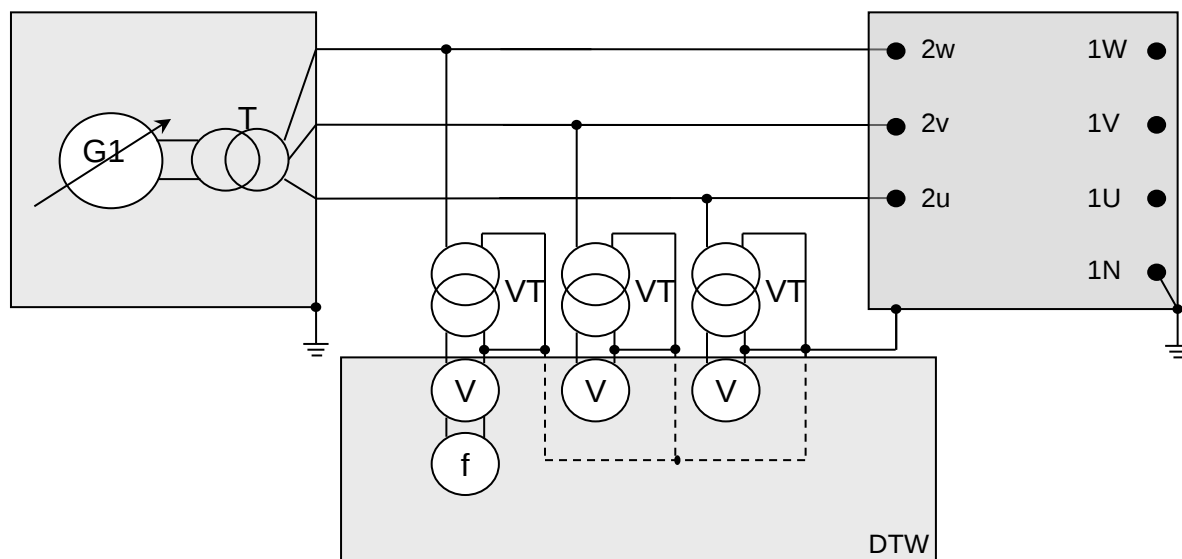
08/07/20

Customer

Transformer

N° : 201421A/01

## Induced voltage withstand test (IVW)



|            |   |                      |                                                 |
|------------|---|----------------------|-------------------------------------------------|
| <b>G1</b>  | : | Generator 100 Hz     |                                                 |
| <b>T</b>   | : | Transformer          |                                                 |
| <b>VT</b>  | : | Voltage Transformers | 10000-20000-30000 / 100 10 VA CL.02 NMG VRC3/S1 |
|            |   | STM124-125-126       | n° 118674 - 118675 - 118676                     |
| <b>DTW</b> | : | STM136 NORMA D6133T  | n° N5 38855 RR                                  |

## References / Standards:

- IEC 60076-3 (2013), clause 11: "Induced Voltage tests (IVW and IVPD)"[3]

Drafted by: G.Bert

Approved by: G.Zeni

Date

08/07/20

Customer

---



---

Transformer N° : 201421A/01

---



---

Ur : 145,00 kV

Position 13 : 132,000 kV

MV : 33,000 kV

### Induced voltage withstand test (IVW)

Test Voltage ( phase to phase ) HV : 264,0 kV

Test Voltage ( phase to phase ) MV : 66,00 ± 0,566 % kV

Time : 120 x (50 Hz / 100 Hz) 60 s

**Result : SATISFACTORY.**

---



---

Drafted by: G.Bert

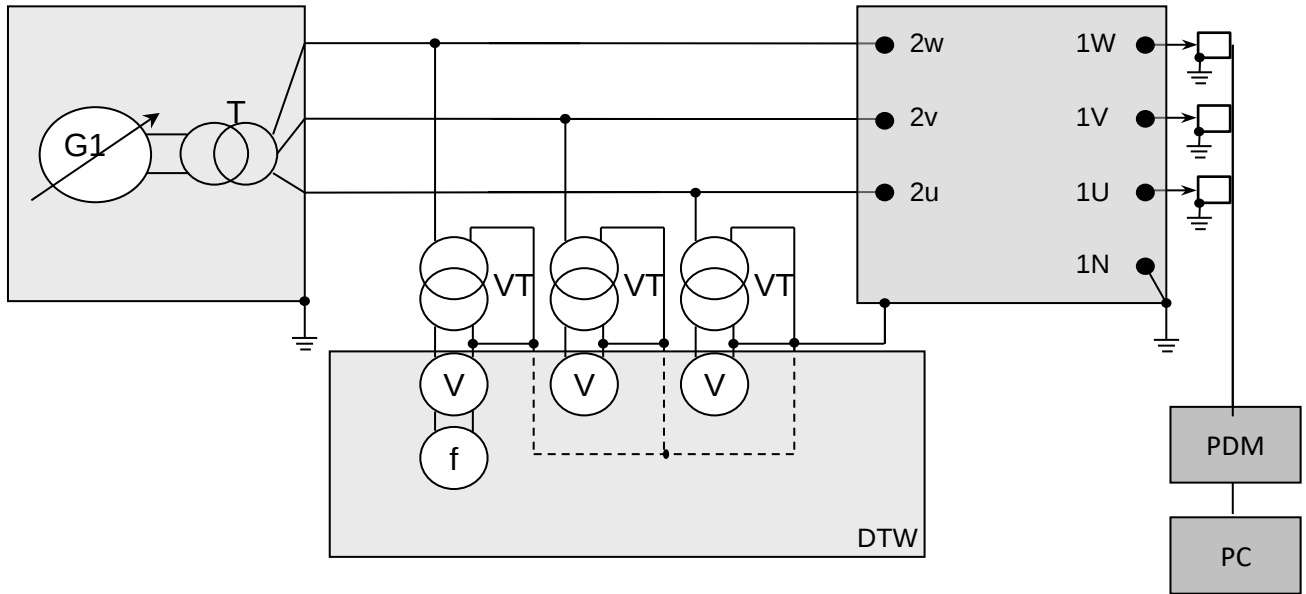
Approved by: G.Zeni

Date 08/07/20

Customer

Transformer N° : 201421A/01

Induced voltage tests with partial discharge measurement (IVPD).



|     |   |                                                                                                                    |
|-----|---|--------------------------------------------------------------------------------------------------------------------|
| G1  | : | Generator 100 Hz                                                                                                   |
| T   | : | Transformer                                                                                                        |
| VT  | : | Voltage Transformers 10000-20000-30000 / 100 10 VA CL.02 NMG VRC3/S1<br>STM124-125-126 n° 118674 - 118675 - 118676 |
| DTW | : | STM136 NORMA D6133T n° N5 38855 RR                                                                                 |
| PDM | : | STM158 Omicron Mtronix MPD 600                                                                                     |

References / Standards:

- IEC 60076-3 (2013), clause 11: "Induced Voltage tests (IVW and IVPD)"[3]

Drafted by: G.Bert

Approved by: G.Zeni

Date

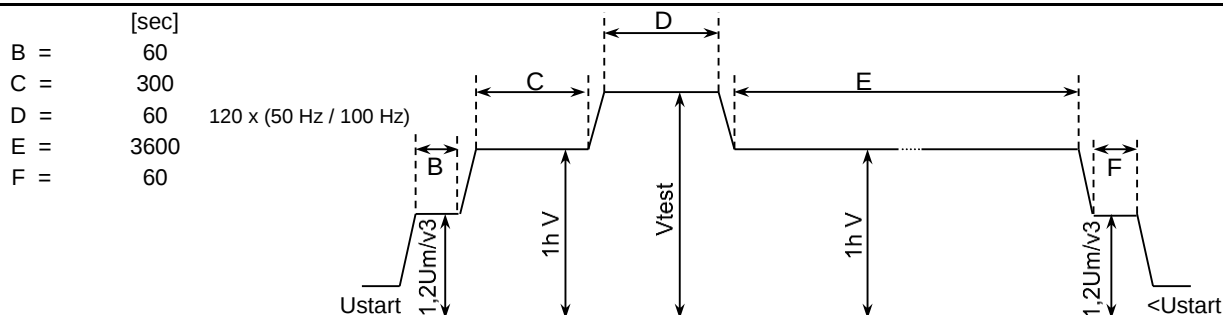
08/07/20

Customer

Transformer N° : 201421A/01

### Induced voltage tests with partial discharge measurement (IVPD).

Ur : 132,000 kV  
 Position **13** : 132,000 kV  
 MV : 33,000 kV



Background noise level = 5 pC

| Test Voltage ( phase to phase )         |              |              | Time | Max partial discharge measured after: |              |              | Guaranteed<br>-<br>[ pC ] |
|-----------------------------------------|--------------|--------------|------|---------------------------------------|--------------|--------------|---------------------------|
| x Um                                    | HV<br>[ kV ] | MV<br>[ kV ] |      | 1U<br>[ pC ]                          | 1V<br>[ pC ] | 1W<br>[ pC ] |                           |
| 0,40                                    | 52,8         | 13,20        | A    | -                                     | 8            | 9            | 250                       |
| 1,20                                    | 158,4        | 39,60        | B    | 1 min                                 | 10           | 10           |                           |
| 1,58                                    | 208,6        | 52,14        | C    | 5 min                                 | 12           | 7            |                           |
| 2,00                                    | <b>264,0</b> | 66,00        | D    | 60 sec                                | -            | -            |                           |
| 1,58                                    | 208,6        | 52,14        | E    | 5 min                                 | 11           | 7            |                           |
|                                         |              |              |      | 10 min                                | 10           | 7            |                           |
|                                         |              |              |      | 15 min                                | 9            | 7            |                           |
|                                         |              |              |      | 20 min                                | 8            | 6            |                           |
|                                         |              |              |      | 25 min                                | 7            | 6            |                           |
|                                         |              |              |      | 30 min                                | 7            | 6            |                           |
|                                         |              |              |      | 35 min                                | 7            | 6            |                           |
|                                         |              |              |      | 40 min                                | 7            | 6            |                           |
|                                         |              |              |      | 45 min                                | 7            | 6            |                           |
|                                         |              |              |      | 50 min                                | 7            | 6            |                           |
|                                         |              |              |      | 55 min                                | 7            | 6            |                           |
|                                         |              |              |      | 60 min                                | 7            | 6            |                           |
| 1,2                                     | 158,4        | 39,60        | F    | 1 min                                 | 6            | 5            | 100                       |
| 0,4                                     | 52,8         | 13,20        | G    | -                                     | 5            | 5            | 100                       |
| Uncertainty in the voltage measurement: |              |              |      | ± 0,566 %                             |              |              |                           |
| Instrument used:                        |              |              |      | Omicron Mtronix MPD 600               |              |              |                           |

Result : **SATISFACTORY.**

#### References / Standards:

- IEC 60076-3 (2013), Annex A: "Application guide for partial discharge measurements on transformers"[3]
- IEC 60270 (2000) "Partial discharge measurements"

Drafted by: G.Bert

Approved by: G.Zeni

Date

08/07/20

Customer

Transformer

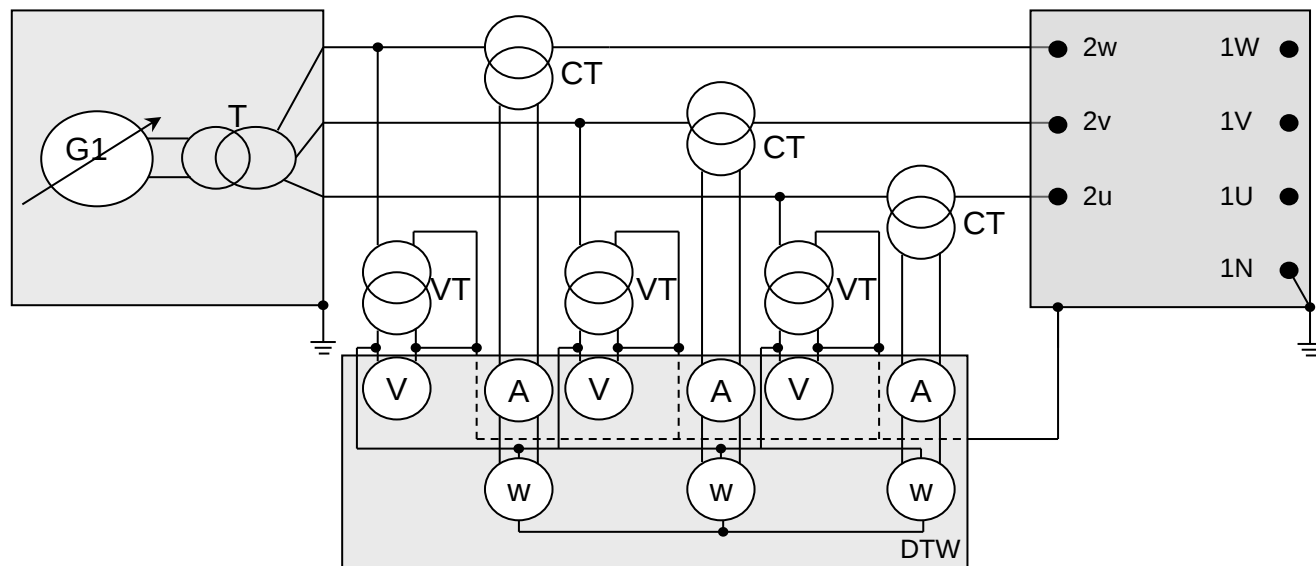
N°

:

201421A/01

Measurement of no-load loss and current.

ONAN: 110 MVA



G1 : Generator IF

T : Transformer

VT : Voltage Transformers 10000-20000-30000 / 100 10 VA CL.02 NMG VRC3/STM124-125-126 n° 118674 - 118675 - 118676

CT : Current Transformers 10-20 / 5 30 VA CL.02 CGS ASR36L STM025-026-027 n° 7825365 - 7825366 - 7825367

DTW : STM213 Threephase digital Wattmeter type Yokogawa WT 3000 n° 91L427548

**References / Standards:**

- IEC 60076-1 Ed.3 (2011-04), clause 10: "Table 1 - Tolerances", clause 11.1: "General requirement for routine, type and special tests", clause 10.5 "Measurement of no-load loss and current"[51]

- IEC 60076-8 (1997), clause 10: "Guide to the measurement of losses in power transformers"[6]

Drafted by: N.Mitu

Approved by: G.Zeni

Date

08/07/20

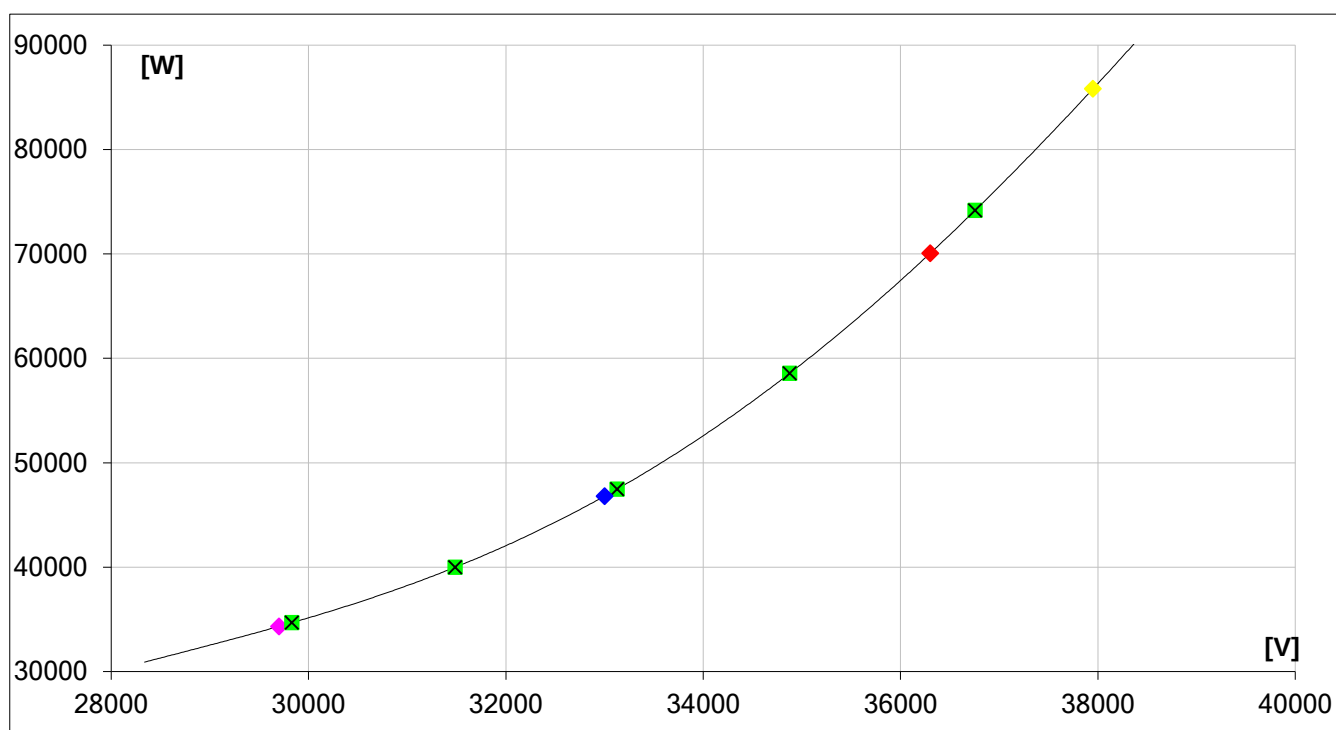
Customer

Transformer N° : 201421A/01

## Measurement of no-load loss and current. (ONAN: 110 MVA)

| Voltage average value |                 |                 |         | Losses         |                |                |       |
|-----------------------|-----------------|-----------------|---------|----------------|----------------|----------------|-------|
| V <sub>uv</sub>       | V <sub>vw</sub> | V <sub>wu</sub> | Average | W <sub>u</sub> | W <sub>v</sub> | W <sub>w</sub> | Total |
| [V]                   | [V]             | [V]             | [V]     | [W]            | [W]            | [W]            | [W]   |
| 36839                 | 36683           | 36743           | 36755   | 32620          | 9880           | 31670          | 74170 |
| 34928                 | 34801           | 34896           | 34875   | 21901          | 11088          | 25570          | 58559 |
| 33209                 | 33105           | 33064           | 33126   | 15666          | 10935          | 20871          | 47472 |
| 31568                 | 31466           | 31423           | 31486   | 13026          | 9662           | 17301          | 39989 |
| 29875                 | 29838           | 29775           | 29829   | 11294          | 8431           | 14951          | 34676 |

|                   |                   |                |            |              |
|-------------------|-------------------|----------------|------------|--------------|
| No-Load Losses at |                   | Measured       | Guaranteed |              |
|                   |                   | Vn [ W ]:      | 46802      | 48000 + 15 % |
|                   | No-Load Losses at | 0,90 Vn [ W ]: | 34327      | - -          |
|                   | No-Load Losses at | 1,10 Vn [ W ]: | 70062      | - -          |



Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date

08/07/20

Customer

Transformer

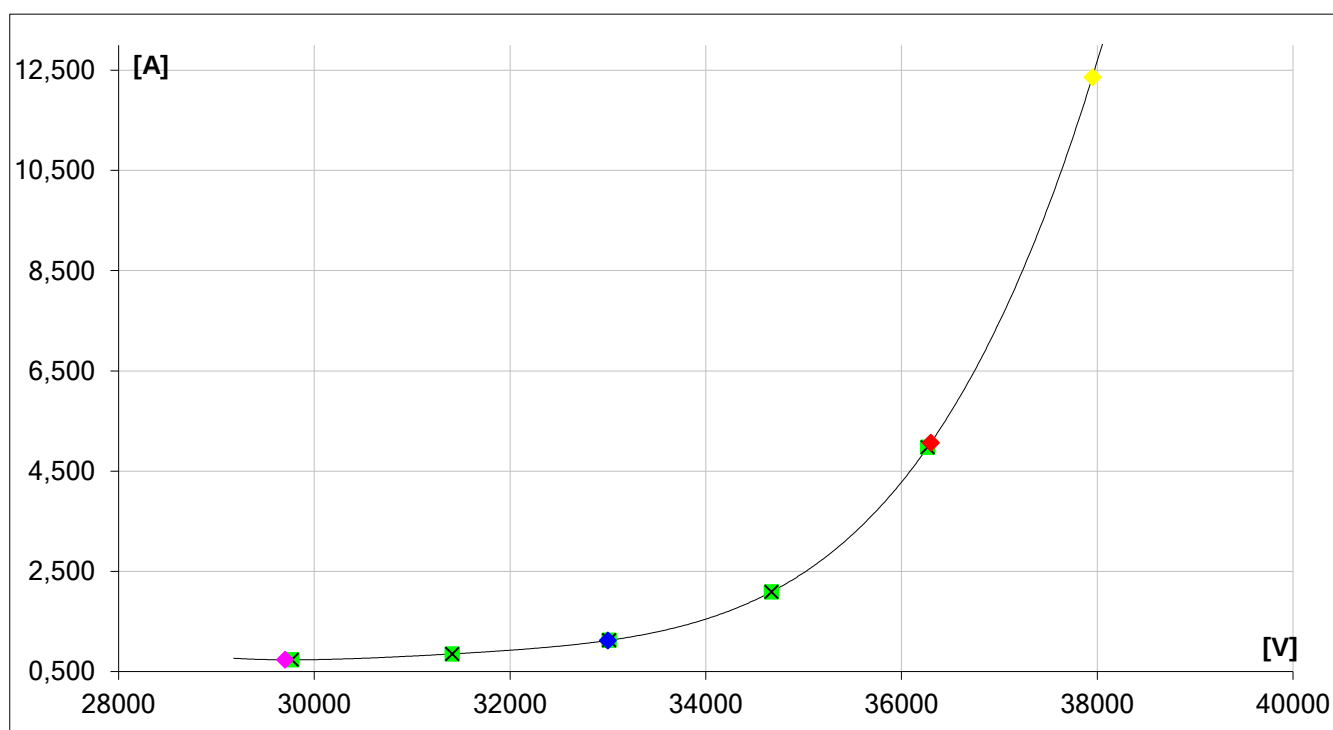
N° : 201421A/01

Measurement of no-load loss and current.

ONAN: 110 MVA

| Voltage r.m.s. value |                 |                 |         | Current        |                |                |         |
|----------------------|-----------------|-----------------|---------|----------------|----------------|----------------|---------|
| V <sub>uv</sub>      | V <sub>vw</sub> | V <sub>wu</sub> | Average | I <sub>u</sub> | I <sub>v</sub> | I <sub>w</sub> | Average |
| [V]                  | [V]             | [V]             | [V]     | [A]            | [A]            | [A]            | [A]     |
| 36362                | 36184           | 36257           | 36268   | 4,609          | 4,741          | 5,584          | 4,978   |
| 34717                | 34607           | 34684           | 34669   | 1,870          | 1,928          | 2,470          | 2,089   |
| 33079                | 32947           | 33010           | 33012   | 0,991          | 1,000          | 1,381          | 1,124   |
| 31469                | 31347           | 31410           | 31409   | 0,773          | 0,717          | 1,067          | 0,852   |
| 29824                | 29728           | 29761           | 29771   | 0,686          | 0,593          | 0,922          | 0,734   |

|                                             | Measured | Value [%]     | Guaranteed [%] |
|---------------------------------------------|----------|---------------|----------------|
| No-Load current at V <sub>n</sub> [A]:      | 1,121    | <b>0,058%</b> | -              |
| No-Load current at 0,90 V <sub>n</sub> [A]: | 0,734    | <b>0,038%</b> | -              |
| No-Load current at 1,10 V <sub>n</sub> [A]: | 5,069    | <b>0,263%</b> | -              |



Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date

08/07/20

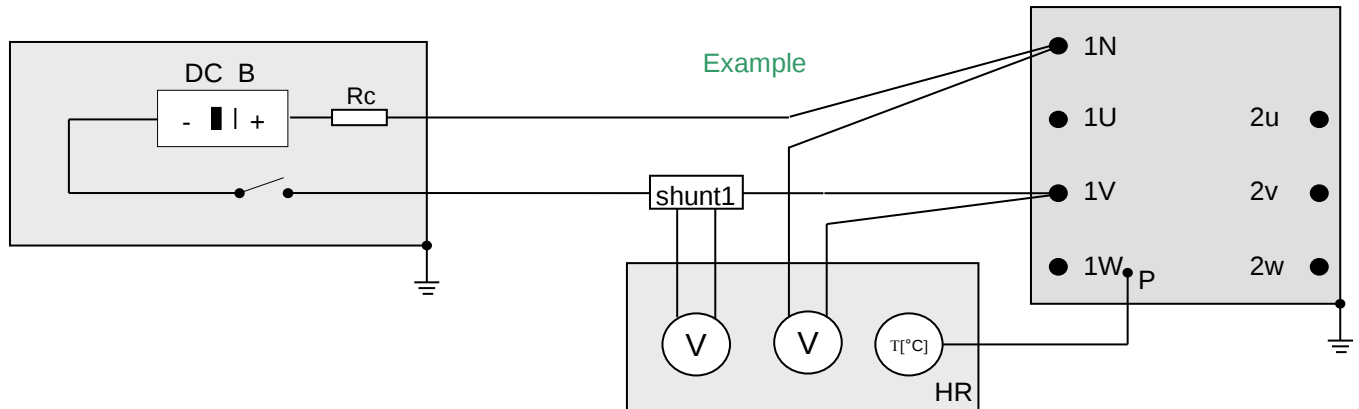
Customer

Restricted

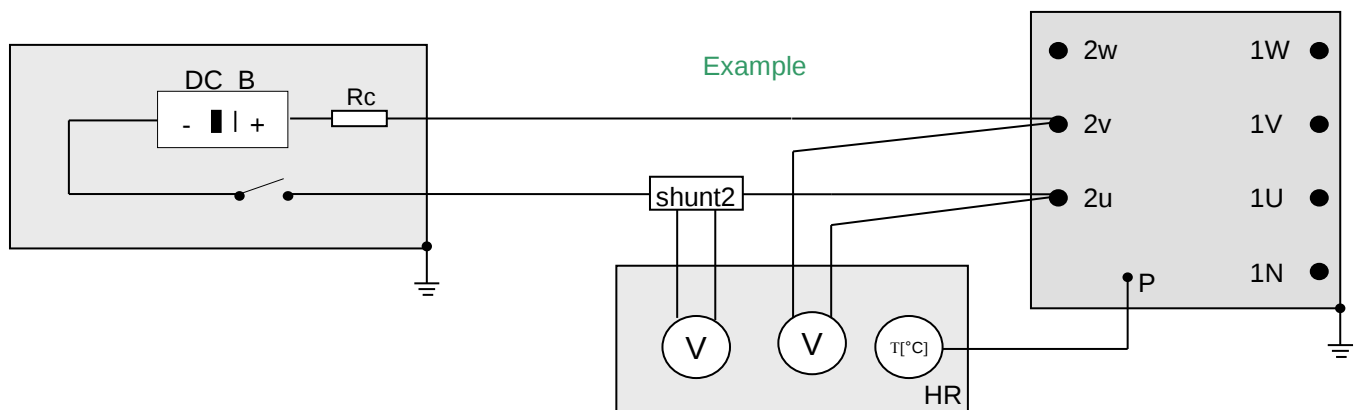
Transformer

N° : 201421A/01

## Measurement of winding resistance on side HV



## Measurement of winding resistance on side MV



DC B : DC feeder  
 Rc : References Resistance  
 P : Thermometric Pocket  
 HR : STM219 HAEFELY Test AG Type 2293 SN:185858

## References / Standards:

- IEC 60076-1 Ed.3 (2011-04), clause 11.2: "Measurement of winding resistance"[1]

Drafted by: M.Norena

Approved by: G.Zeni

Date

08/07/20

Customer

Transformer

N°

:

201421A/01

Transformer oil temperature : **26,0 °C**  $\pm 0,002$  % $K_t = 1,188$ 

## Measurement of winding resistance on side HV

| $R = (V_m \times k_V) : (C_m \times k_A)$ with: $k_V = 1,0$ $k_A = 1,0$ |                           |                           |                                            |                           |                           |                                            |                           |                           |                                            |
|-------------------------------------------------------------------------|---------------------------|---------------------------|--------------------------------------------|---------------------------|---------------------------|--------------------------------------------|---------------------------|---------------------------|--------------------------------------------|
| Position                                                                | 1U - 1N                   |                           |                                            | 1V - 1N                   |                           |                                            | 1W - 1N                   |                           |                                            |
|                                                                         | Voltage<br>$V_m$ [ div. ] | Current<br>$C_m$ [ div. ] | Resistance<br>$R$ [ $\Omega$ ]             | Voltage<br>$V_m$ [ div. ] | Current<br>$C_m$ [ div. ] | Resistance<br>$R$ [ $\Omega$ ]             | Voltage<br>$V_m$ [ div. ] | Current<br>$C_m$ [ div. ] | Resistance<br>$R$ [ $\Omega$ ]             |
| 13                                                                      | 0,789                     | 3,96                      | 0,1993<br>$\Delta 0,38\%$                  | 0,789                     | 3,96                      | 0,1993<br>$\Delta 0,36\%$                  | 0,786                     | 3,96                      | 0,1985<br>$\Delta 0,00\%$                  |
| 1                                                                       | 0,956                     | 3,96                      | 0,2413<br>$\Delta 0,09\%$                  | 0,956                     | 3,96                      | 0,2415<br>$\Delta 0,16\%$                  | 0,955                     | 3,96                      | 0,2411<br>$\Delta 0,00\%$                  |
| 25                                                                      | 0,676                     | 3,96                      | 0,1708<br>$\Delta 0,29\%$<br>$\pm 0,28 \%$ | 0,676                     | 3,960                     | 0,1708<br>$\Delta 0,32\%$<br>$\pm 0,28 \%$ | 0,674                     | 3,960                     | 0,1703<br>$\Delta 0,00\%$<br>$\pm 0,28 \%$ |

## Measurement of winding resistance on side MV

| $R = (V_m \times k_V) : (C_m \times k_A)$ with: $k_V = 1,0$ $k_A = 1,0$ |                           |                           |                                              |                           |                           |                                              |                           |                           |                                              |
|-------------------------------------------------------------------------|---------------------------|---------------------------|----------------------------------------------|---------------------------|---------------------------|----------------------------------------------|---------------------------|---------------------------|----------------------------------------------|
| Position                                                                | 2u - 2v                   |                           |                                              | 2v - 2w                   |                           |                                              | 2w - 2u                   |                           |                                              |
|                                                                         | Voltage<br>$V_m$ [ div. ] | Current<br>$C_m$ [ div. ] | Resistance<br>$R$ [ $\Omega$ ]               | Voltage<br>$V_m$ [ div. ] | Current<br>$C_m$ [ div. ] | Resistance<br>$R$ [ $\Omega$ ]               | Voltage<br>$V_m$ [ div. ] | Current<br>$C_m$ [ div. ] | Resistance<br>$R$ [ $\Omega$ ]               |
| -                                                                       | 0,3278                    | 11,9000                   | 0,027545<br>$\Delta 0,00\%$<br>$\pm 0,28 \%$ | 0,3279                    | 11,9000                   | 0,027557<br>$\Delta 0,04\%$<br>$\pm 0,28 \%$ | 0,3280                    | 11,9000                   | 0,027559<br>$\Delta 0,05\%$<br>$\pm 0,28 \%$ |

Drafted by: M.Norena

Approved by: G.Zeni

Date

08/07/20

Customer

Transformer

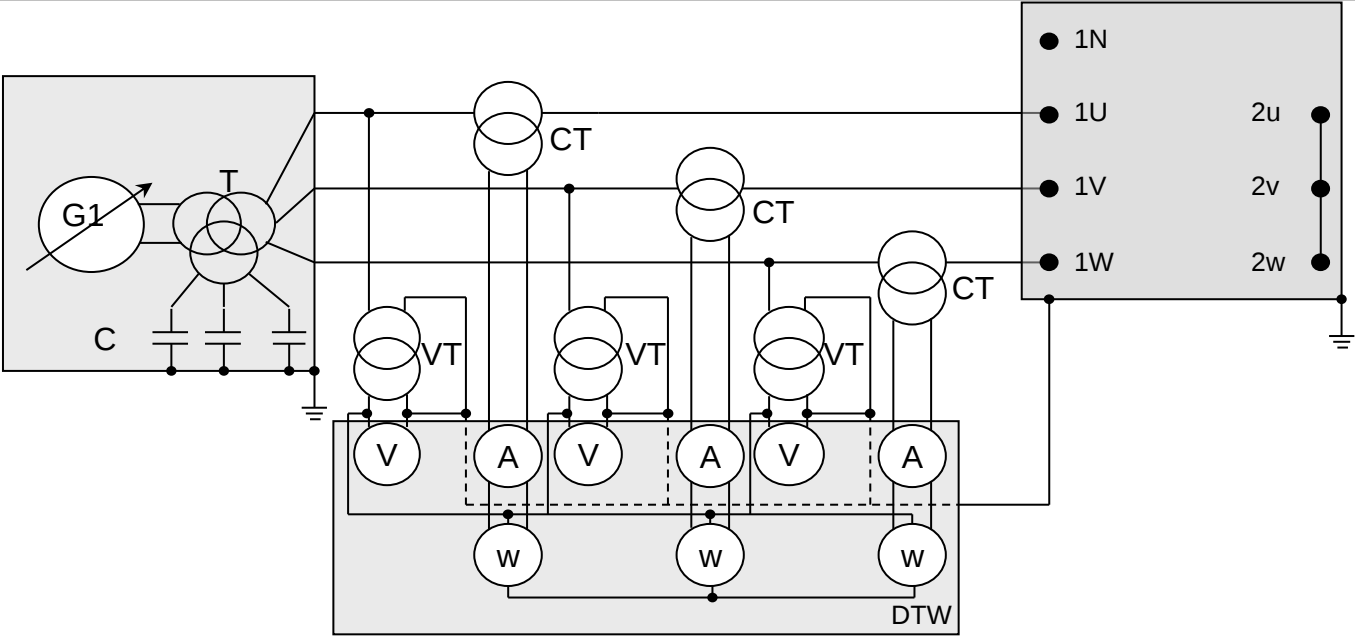
N°

:

201421A/01

Measurement of short-circuit impedance and load loss.

HV / MV



|     |   |                      |                                                                                        |
|-----|---|----------------------|----------------------------------------------------------------------------------------|
| G1  | : | Generator IF         |                                                                                        |
| T   | : | Transformer          |                                                                                        |
| VT  | : | Voltage Transformers | 30.000/200 50 VA CL.02 CGS VSR 36L<br>STM053-054-055 n° 7825368 - 7825369 - 7825370    |
| CT  | : | Current Transformers | 100-300-600/5 10 VA CL.02 NMG ARM6/N1<br>STM150-151-152 n° 0683912 - 0683913 - 0683914 |
| C   | : | Capacitors           |                                                                                        |
| DTW | : | STM136               | NORMA D6133T n° N5 38855 RR                                                            |

References / Standards:

- IEC 60076-1 Ed.3 (2011-04), clause 10: "Table 1 - Tolerances", clause 11.1: "General requirement for routine, type and special tests", clause 11.4: "Measurement of short-circuit impedance and load loss"[1]
- IEC 60076-8 (1997), clause 10: "Guide to the measurement of losses in power transformers"[6]

Drafted by: N.Mitu

Approved by: G.Zeni

Date 09/07/20

Customer

Transformer

N°

:

201421A/01

## Measurement of short-circuit impedance and load loss.

HV / MV

ONAN: 110 MVA

Position

13

132,000 kV

Nominal current HV [ A ] : 481,13

Nominal current MV [ A ] : 1924,50

## Windings resistance

Transformer oil temperature :

26,0

Kt =

1,188

1U - 1N

1V - 1N

1W - 1N

2u - 2v

2v - 2w

2w - 2u

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

0,199

0,199

0,199

0,02755

0,02756

0,02756

Average

0,199

Ω

Average

0,02755

Ω

## Ohmic Losses

Ohmic Losses HV

26,0 °C

138211 W

Ohmic Losses MV

26,0 °C

153076 W

Total Ohmic Losses

26,0 °C

291287 W

Total Ohmic Losses

75,0 °C

345973 W

## Measurement of short-circuit impedance and load loss.

Transformer oil temperature :

26,0 °C

Kt =  
CT and VT1,188  
0

[ A ]

[ V ]

I1 480,60

V1 19196

W1 108800

I2 488,40

V2 19436

W2 125800

I3 488,40

V3 19170

W3 116500

Average 485,80

Average 19267

Total 351100

-

-

-

In 481,13

Voltage 19082

Losses 344375

## Stray Losses

ZI % 26,0 °C

14,456

RI % 26,0 °C

0,313

XI % 14,453

ZI % 75,0 °C

14,457

RI % 75,0 °C

0,355

cosficc 0,025

Stray Losses 26,0 °C

53089 W

Stray Losses

75,0 °C

44697 W

## Summary Results

Guaranteed

Tolerances

Measured

-

-

Load Loss

75,0 °C

[ W ]

354000

+ 15 %

[ W ]

390670

Short circuit impedance

75,0 °C

[ % ]

14,50

± 7,5 %

[ % ]

14,457

Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date 09/07/20

Customer

Transformer

N°

:

201421A/01

## Measurement of short-circuit impedance and load loss.

HV / MV

ONAF: 120 MVA

Position

13

132,000

kV

Nominal current HV [ A ] : 524,86

Nominal current MV [ A ] : 2099,46

## Windings resistance

Transformer oil temperature :

26,0

Kt =

1,188

1U - 1N

1V - 1N

1W - 1N

2u - 2v

2v - 2w

2w - 2u

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

0,199

0,199

0,199

0,02755

0,02756

0,02756

Average

0,199

Ω

Average

0,02755

Ω

## Ohmic Losses

Ohmic Losses HV

26,0 °C

164482 W

Ohmic Losses MV

26,0 °C

182173 W

Total Ohmic Losses

26,0 °C

346655 W

Total Ohmic Losses

75,0 °C

411736 W

## Measurement of short-circuit impedance and load loss.

Transformer oil temperature :

26,0 °C

Kt =

1,188

I1

[ A ]

480,60

V1

[ V ]

19196

W1

[ W ]

108800

I2

488,40

V2

19436

W2

125800

I3

488,40

V3

19170

W3

116500

Average

485,80

Average

19267

Total

351100

-

-

-

In

524,86

Voltage

20817

Losses

409835

## Stray Losses

ZI %

26,0 °C

15,770

RI %

26,0 °C

0,342

XI %

15,766

ZI %

75,0 °C

15,771

RI %

75,0 °C

0,387

cosficc

0,025

Stray Losses

26,0 °C

63180 W

Stray Losses

75,0 °C

53194 W

## Summary Results

Guaranteed

Tolerances

Measured

-

-

Load Loss

75,0 °C

[ W ]

-

+ 15 %

[ W ]

464929

Short circuit impedance

75,0 °C

[ % ]

-

± 7,5 %

[ % ]

15,771

Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date

09/07/20

Customer

Transformer

N°

:

201421A/01

## Measurement of short-circuit impedance and load loss.

HV / MV

ONAN: 110 MVA

Position

1

151,800 kV

Nominal current HV [ A ] : 418,37

Nominal current MV [ A ] : 1924,50

## Windings resistance

Transformer oil temperature :

26,0

Kt =

1,188

1U - 1N

1V - 1N

1W - 1N

2u - 2v

2v - 2w

2w - 2u

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

0,241

0,242

0,241

0,02755

0,02756

0,02756

Average

0,241

Ω

Average

0,02755

Ω

## Ohmic Losses

Ohmic Losses HV

26,0 °C

126714 W

Ohmic Losses MV

26,0 °C

153076 W

Total Ohmic Losses

26,0 °C

279790 W

Total Ohmic Losses

75,0 °C

332317 W

## Measurement of short-circuit impedance and load loss.

Transformer oil temperature :

26,0 °C

Kt =  
CT and VT1,188  
0

[ A ]

[ V ]

I1 395,10

V1 23092

W1 89600

I2 402,60

V2 23418

W2 110500

I3 401,70

V3 22966

W3 114800

Average 399,80

Average 23159

Total 314900

-

-

-

In 418,37

Voltage 24234

Losses 344832

## Stray Losses

ZI % 26,0 °C

15,965

RI % 26,0 °C

0,313

XI % 15,962

ZI % 75,0 °C

15,965

RI % 75,0 °C

0,352

cosficc 0,022

Stray Losses 26,0 °C

65043 W

Stray Losses

75,0 °C

54762 W

## Summary Results

Guaranteed

Tolerances

Measured

-

-

Load Loss

75,0 °C

[ W ]

-

-

[ W ]

387079

Short circuit impedance

75,0 °C

[ % ]

-

-

[ % ]

15,965

Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date 09/07/20

Customer

Transformer

N°

:

201421A/01

## Measurement of short-circuit impedance and load loss.

HV / MV

ONAF: 120 MVA

Position

1

151,800 kV

Nominal current HV [ A ] : 456,40

Nominal current MV [ A ] : 2099,46

## Windings resistance

Transformer oil temperature :

26,0

Kt =

1,188

1U - 1N

1V - 1N

1W - 1N

2u - 2v

2v - 2w

2w - 2u

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

0,241

0,242

0,241

0,02755

0,02756

0,02756

Average

0,241

Ω

Average

0,02755

Ω

## Ohmic Losses

Ohmic Losses HV

26,0 °C

150800 W

Ohmic Losses MV

26,0 °C

182173 W

Total Ohmic Losses

26,0 °C

332973 W

Total Ohmic Losses

75,0 °C

395485 W

## Measurement of short-circuit impedance and load loss.

Transformer oil temperature :

26,0 °C

Kt =

1,188

I1

[ A ]

395,10

V1

[ V ]

23092

W1

[ W ]

89600

I2

402,60

V2

23418

W2

110500

I3

401,70

V3

22966

W3

114800

Average

399,80

Average

23159

Total

314900

-

-

-

In

456,40

Voltage

26437

Losses

410379

## Stray Losses

ZI %

26,0 °C

17,416

RI %

26,0 °C

0,342

XI %

17,413

ZI %

75,0 °C

17,417

RI %

75,0 °C

0,384

cosficc

0,022

Stray Losses

26,0 °C

77406 W

Stray Losses

75,0 °C

65171 W

## Summary Results

Guaranteed

Tolerances

Measured

-

-

Load Loss

75,0 °C

[ W ]

-

-

[ W ]

460656

Short circuit impedance

75,0 °C

[ % ]

-

-

[ % ]

17,417

Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date 09/07/20

Customer

Transformer

N°

:

201421A/01

## Measurement of short-circuit impedance and load loss.

HV / MV

ONAN: 110 MVA

Position

25

112,200

kV

Nominal current HV [ A ] : 566,03

Nominal current MV [ A ] : 1924,50

## Windings resistance

Transformer oil temperature :

26,0

Kt =

1,188

1U - 1N

1V - 1N

1W - 1N

2u - 2v

2v - 2w

2w - 2u

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

0,171

0,171

0,170

0,02755

0,02756

0,02756

Average

0,171

Ω

Average

0,02755

Ω

## Ohmic Losses

Ohmic Losses HV

26,0 °C

164001 W

Ohmic Losses MV

26,0 °C

153076 W

Total Ohmic Losses

26,0 °C

317077 W

Total Ohmic Losses

75,0 °C

376605 W

## Measurement of short-circuit impedance and load loss.

Transformer oil temperature :

26,0 °C

Kt =  
CT and VT1,188  
0

[ A ]

[ V ]

I1 562,70

V1 14879

W1 118400

I2 566,40

V2 15053

W2 130100

I3 571,60

V3 15015

W3 118100

Average 566,90

Average 14982

Total 366600

-

-

-

In 566,03

Voltage 14959

Losses 365475

## Stray Losses

ZI % 26,0 °C

13,333

RI % 26,0 °C

0,332

XI % 13,329

ZI % 75,0 °C

13,334

RI % 75,0 °C

0,379

cosficc 0,028

Stray Losses 26,0 °C

48398 W

Stray Losses

75,0 °C

40748 W

## Summary Results

Guaranteed

Tolerances

Measured

-

-

Load Loss

75,0 °C

[ W ]

-

-

[ W ]

417353

Short circuit impedance

75,0 °C

[ % ]

-

-

[ % ]

13,334

Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date 09/07/20

Customer

Transformer

N°

:

201421A/01

## Measurement of short-circuit impedance and load loss.

HV / MV

ONAF: 120 MVA

Position

25

112,200 kV

Nominal current HV [ A ] : 617,49

Nominal current MV [ A ] : 2099,46

## Windings resistance

Transformer oil temperature :

26,0

Kt =

1,188

1U - 1N

1V - 1N

1W - 1N

2u - 2v

2v - 2w

2w - 2u

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

[ Ω ]

0,171

0,171

0,170

0,02755

0,02756

0,02756

Average

0,171

Ω

Average

0,02755

Ω

## Ohmic Losses

Ohmic Losses HV

26,0 °C

195175 W

Ohmic Losses MV

26,0 °C

182173 W

Total Ohmic Losses

26,0 °C

377348 W

Total Ohmic Losses

75,0 °C

448191 W

## Measurement of short-circuit impedance and load loss.

Transformer oil temperature :

26,0 °C

Kt =

1,188

I1

[ A ]

562,70

V1

[ V ]

14879

W1

[ W ]

118400

I2

566,40

V2

15053

W2

130100

I3

571,60

V3

15015

W3

118100

Average

566,90

Average

14982

Total

366600

-

-

-

In

617,49

Voltage

16319

Losses

434946

## Stray Losses

ZI %

26,0 °C

14,545

RI %

26,0 °C

0,362

XI %

14,540

ZI %

75,0 °C

14,546

RI %

75,0 °C

0,414

cosficc

0,028

Stray Losses

26,0 °C

57598 W

Stray Losses

75,0 °C

48494 W

## Summary Results

Guaranteed

Tolerances

Measured

-

-

Load Loss

75,0 °C

[ W ]

-

-

[ W ]

496685

Short circuit impedance

75,0 °C

[ % ]

-

-

[ % ]

14,546

Result : SATISFACTORY.

Drafted by: N.Mitu

Approved by: G.Zeni

Date 09/07/20

Customer

---



---

Transformer N° : 201421A/01

---



---

## Efficiencies determinations

120,000

MVA

HV / MV

Nominal Voltages : 132,000 33,000 kV

No-Load Losses (Vn) = 46,802 kW

Load Losses at 75 °C = 464,929 kW

## EFFICIENCY

%

Load 125 % cos(phi) 1 99,487

Load 100 % cos(phi) 1 99,575

Load 75 % cos(phi) 1 99,659

Load 50 % cos(phi) 1 99,729

Load 25 % cos(phi) 1 99,748

Load 125 % cos(phi) 0,9 99,430

Load 100 % cos(phi) 0,9 99,528

Load 75 % cos(phi) 0,9 99,621

Load 50 % cos(phi) 0,9 99,699

Load 25 % cos(phi) 0,9 99,720

Load 125 % cos(phi) 0,8 99,360

Load 100 % cos(phi) 0,8 99,470

Load 75 % cos(phi) 0,8 99,574

Load 50 % cos(phi) 0,8 99,661

Load 25 % cos(phi) 0,8 99,685

Drafted by: N.Mitu

Approved by: G.Zeni

Date

09/07/20

Customer

---



---

Transformer N° : 201421A/01

---



---

### On-load tap changer.

|             |                            |         |         |
|-------------|----------------------------|---------|---------|
| Trade mark  | MASCHINENFABRIK REINHAUSEN |         |         |
| Type        | VMIII650Y-72,5/B-142516    | Number  | 2200539 |
| Motor drive | ED100S                     | Diagram | 7365485 |

### Test on on-load tap changer.

With the tap-changer fully assembled on the transformer, the following sequence of operations has been performed without failure:

- a) With the transformer de-energized, eight complete cycles of operation (a cycle of operation goes from one end of the tapping range to the other, and back again).
- b) With the transformer de-energized, and with the auxiliary voltage reduced to 85% of its rated value, one complete cycle of operation.
- c) With the transformer energized at rated voltage and frequency at no load, one complete cycle of operation.
- d) With one winding short-circuited and, as far as practicable, rated current in tapped winding, 10 cycle of tap-change operations across the range of two steps on each side from where a coarse or reversing changeover selector operates, or otherwise from the middle tapping (the tapchanger will pass 20 times through the changeover position).

Result : **SATISFACTORY.**

#### References / Standards:

- IEC 60076-1 Ed.3 (2011-04), clause 11.7: "Tests on on-load tap-changers - Operation test"[1]

---

Drafted by: M.Norena

Approved by: G.Zeni

Date 08/07/20

Customer

---

---

Transformer N° : 201421A/01

---

---

Dielectric strength test for oil.

|                        |        |             |
|------------------------|--------|-------------|
| Test 1                 | [ kV ] | 73,0        |
| Test 2                 | [ kV ] | 79,8        |
| Test 3                 | [ kV ] | 78,7        |
| Test 4                 | [ kV ] | 55,9        |
| Test 5                 | [ kV ] | 75,2        |
| Test 6                 | [ kV ] | 74,0        |
| Average                | [ kV ] | <b>72,8</b> |
| Minimum Accepted Value | [ kV ] | 60,0        |

**Result :** **SATISFACTORY.**

Instrument used: BAUR type DTA 100C n° 1001807004

**References / Standards:**

- IEC 60422 (2005), clause 9: "Evaluation of mineral insulating oil in new equipment".
- IEC 60156

---

Drafted by: G.Grillo

Approved by: G.Zeni

Date 08/07/20

Customer

Transformer N° : 201421A/01

### Dimensional, auxiliary equipments and accessories checks.

Tested and verified according to the assembling drawing :

**Result :**

C201421/A /05      revision      01      Date      05/04/20      **SATISFACTORY.**

### Auxiliary circuit checks.

Functional tests according to schematic diagrams :

C201421/A /06      revision      02      Date      05/04/20      **SATISFACTORY.**

C201421/A /07      revision      00      Date      22/04/20      **SATISFACTORY.**

|                                                   |          |                      |
|---------------------------------------------------|----------|----------------------|
| Power frequency withstand of 2 kV r.m.s.to earth. | 30/06/20 | <b>SATISFACTORY.</b> |
|---------------------------------------------------|----------|----------------------|

Instrument used: STM130 Risatti E4/A n° 94325

## Name-plates checks.

Verified according to the drawing :

C201421/A /08      revision      01      Date      05/04/20      **SATISFACTORY.**

### References / Standards:

- IEC 60076-3 (2013), clause 9: "Insulation of auxiliary wiring (AuxW)"[3]

Drafted by: M.Norena

Approved by: G.Zeni

Date 07/07/20

Customer

Transformer

N° : 201421A/01

## Ratio and polarity checks on CTs

| Terminal | CT Number | CT Type | Wiring Number | Polarity | Mesured Ratio         |
|----------|-----------|---------|---------------|----------|-----------------------|
| 1U       | CT1       | 600/1A  | X4 1 ÷ 2      | OK       | S2 - S1 600 : 0,9964  |
| 1U       | CT2       | 600/5A  | X4 4 ÷ 5      | OK       | S2 - S1 600 : 5,0037  |
| 1U       | CT3       | 1250/1  | X4 7 ÷ 8      | OK       | S2 - S1 1250 : 0,9957 |
| 1V       | CT4       | 600/1A  | X4 10 ÷ 11    | OK       | S2 - S1 600 : 0,9963  |
| 1V       | CT5       | 600/5A  | X4 13 ÷ 14    | OK       | S2 - S1 600 : 5,0044  |
| 1V       | CT6       | 1250/1  | X4 16 ÷ 17    | OK       | S2 - S1 1250 : 0,9998 |
| 1W       | CT7       | 600/1A  | X4 19 ÷ 20    | OK       | S2 - S1 600 : 0,9962  |
| 1W       | CT8       | 600/5A  | X4 22 ÷ 23    | OK       | S2 - S1 600 : 5,0043  |
| 1W       | CT9       | 1250/1A | X4 25 ÷ 26    | OK       | S2 - S1 1250 : 0,9985 |
| 1V       | CT10      | 618/2A  | X4 28 ÷ 29    | OK       | S2 - S1 618 : 1,9865  |
| 1N       | CT11      | 600/1A  | X4 31 ÷ 32    | OK       | S2 - S1 600 : 0,9985  |
| 2v       | CT12      | 2100/1A | X4 34 ÷ 35    | OK       | S2 - S1 2100 : 0,9987 |

Instrument used: STM181 OMICRON CT Analyzer

n° FM465A

Result : SATISFACTORY.

Drafted by: M.Norena

Approved by: G.Zeni

Date 07/07/20

Customer

---

---

Transformer N° : **201421A/01**

---

---

**Tank Pressure test**

The test was performed with transformer full of oil and all accesories installed.

Ambient temperature : **26** °C

Static pressure : **0,4** bar

test Pressure : **0,7** bar

Duration of the test : **24** Hours

During the test, no leakage has been detected

Result : **SATISFACTORY.**

---

---

Drafted by: F.Boudhraa

Approved by: G.Zeni

Date 10/07/20

Customer