



DIN EN ISO 9001:2000
Zertifikat: 01 100 026214



LABORATORIES OF EXTRA HIGH
VOLTAGE RESEARCH CENTER SECTOR

kM 27 Cairo- Alex. Desert Road

Report No. (611/2019)

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TEST REPORT

REPORT No. (611/2019)

▪ **CLIENT : ELSEWEDY CABLES.**

10th of Ramadan City, Zone A3, Egypt.

▪ **Report Date:** 31/ 12 /2019

Expire Date : 6 /4 / 2022

▪ **Place:**

- Extra High Voltage Research Center.
- Internal Code : TO - AC -19 - 01 -14- 07.

▪ **Requirements:**

- Type tests according to IEC 60502-2 (2014).

▪ **Standard Specification:**

- IEC (60502-2)(2014): *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1.2$ kV) up to 30 kV ($U_m = 36$ kV)".*

▪ **Description of the Specimen :**

- 18/30 kV Power cable with the following specification:
 - Manufacturer : ELSEWEDY CABLES.
 - Type : 18/30 kV/AL/XLPE/ STA/PVC-3×400 mm²
 - No. of Phases : 3Phase.
 - Insulation : XLPE
 - Conductor Material : AL Wires
 - Conductor cross-section : 400 mm²
 - Screening Material : Copper tape.
 - Sheath Material : PVC
 - Sheath Color : Black.

▪ **Description of the Equipment:**

- High voltage reactor - 400 kV - 5000 KVA - 50 Hz - Type: (RSK) - Serial No. 204322/99.
- PD detector - Type: (TE57).
- Tan δ measurement devise - Type: dobel- M4000 - Serial No. 029700917.
- Impulse voltage generator 800 kV - 40 kJ - Type IP40/800M..
- Air oven up to 300 °C - Type BINDER - Serial No. 02-32772.
- Universal testing machine 100 kN-Type Lloyd - Model LR100Kplus Serial No. 108322.





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▪ Test Samples:

- Test sample were chosen under the responsibility of the client.

▪ Tests:

1- Electrical Type Tests on Completed Cable:

- 1.1 Bending test, followed by partial discharge test.
- 1.2 Tan δ measurement.
- 1.3 Heating cycle test followed by partial discharge test.
- 1.4 Impulse test followed by a voltage test.
- 1.5 Voltage test for 4 h.
- 1.6 Resistivity of semi-conducting screens.

2- Non-Electrical Type Tests on Cable Components:

1. Measurement of thickness of insulation
2. Measurement of thickness of non-metallic sheath.
3. Tests for determining the mechanical properties of insulation before and after ageing
4. Tests for determining the mechanical properties of non-metallic sheaths before and after ageing
5. Additional ageing test on pieces of completed cables.
6. Loss of mass test on PVC
7. Hot set test for XLPE insulation.
8. Shrinkage test for XLPE insulation.

▪ Test Method and Results:

1- Electrical Type Tests on Completed Cable:

1.1 Bending test, followed by partial discharge test:

1.1.1 Bending test:

- The test cable was subjected to a bending test at 2500 mmmin according with clause 18.2.4 in IEC (60502-2) at ambient temperature for at least one complete turn and unwound without axial rotation. These cyclescarried out three times.

Outer diameter of cable D (mm)	Diameter of conductor d (mm)	Requirement of bending diameter $<20(D+d)+5\%$ (mm)	Hub diameter of drum (mm)
110	23.2	2797	2500

1.1.2 Partial discharge test:

- The test cable was subjected to a partial discharge test in accordance with clause 18.2.5 of IEC 60502-2. The test voltage was raised gradually to and held at 2 U. for 10 s and then slowly reduced to 1.73 U. and the magnitude of the discharge was measured.



- The measured value of the partial discharge level is shown in the following table

Test voltage (kV)	Maximum partial discharge level (PC)	Measured partial discharge (PC)		
		R	S	T
31	5	1.98	2.16	2.23

- The test results met the requirements.

1.2 Tan δ measurement:

- Another sample of test cable was subjected to a Tan δ measurement in accordance with clause 18.2.6 of IEC 60502-2. The test cable was heated by passing a current through the conductor until it reached a steady temperature, which was 98 °C. The Tan δ was measured at a power frequency voltage of at least 2 kV at the temperature specified above.
- The measured value of Tan δ is shown in the following table

Test voltage (kV)	Maximum allowable value for tan δ (x 10 ⁻⁴)	Tan δ (x 10 ⁻⁴) [Measured value]		
		R	S	T
2	40	12	18	20

- The test results met the requirements.

1.3 Heating Cycle followed by partial discharge test:

1.3.1 Heating Cycle:

- The test cable was subjected to a heating cycle voltage test in accordance with clause 18.2.7 of IEC 60502-2. The test cable was heated by passing a current through the conductor until it reached a steady temperature, which was 98 °C. The heating was applied for 5 h. The conductor temperature was maintained within the stated temperature limits for 2 h of each heating period. This was followed by 3 h of natural cooling. The cycle of heating and cooling was carried out 20 times.
- The result of the heating cycle is shown in the following table:

No. of heating cycles	Required conductor temperature (°C)	Heating		Cooling time (h)
		Total heating time (h)	Duration of heating at 98 °C(h)	
20	95 ≤ t ≤ 100	5	2	3

- The test results met the requirements.

1.3.2 Partial discharge test

- After the last heat cycle, partial discharge was measured for the test cable at ambient temperature in accordance with clause 18.2.5 of IEC 60502-2. The measurement was carried out as mentioned above under item (1.1.2)



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- The measured value of the partial discharge level is shown in the following table:

Test voltage (kV)	Maximum partial discharge level (PC)	Measured partial discharge (PC)		
		R	S	T
31	5	2.74	2.82	2.91

- The test results met the requirements.

1.4 Impulse test followed by a voltage test:

1.4.1 Impulse Test:

- The test cable was subjected to a lightning impulse voltage withstand test in accordance with clauses 18.2.8 of IEC 60502-2 (2014). The test was performed on the sample at a conductor temperature of 98 °C. The cable withstood 10 positive and 10 negative voltage impulses with peak value of 170 kV without failure.
- The results were illustrated by the Figures in page No. (9:11) of this report.
- The test results met the requirements.

1.4.2 Voltage Test:

- After the impulse voltage test, the test cable was subjected to a voltage test of was 3.5 U_o. The voltage was increased gradually to 63kV and maintained for 15 min. in accordance with clause 18.2.8 of IEC 60502-2.
- The result of the voltage test is shown in the following table:

Applied voltage (kV)	Frequency (Hz)	Duration (min)	Observations
63	50	15	No breakdown

- The test results met the requirements.

1.5 Voltage test for 4 h:

- The test cable was subjected to the voltage test for 4 h in accordance with clauses 18.2.9 of IEC 60502-2. This test was made at ambient temperature. A power frequency voltage was applied for 4 h to the test cable between the conductor and screen. The test voltage was 4 U_o. The voltage was increased gradually to 72 kV and maintained for four hours.
- The result of the voltage test is shown in the following table:

Applied voltage (kV)	Frequency (Hz)	Duration (hour)	Observations
72	50	4	No breakdown

- The test results met the requirements.





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1.6 Resistivity of semi-conducting screens:

- The measurement of the resistivity of the semi-conducting screens was carried out in accordance with clause 18.2.10 of IEC 60502-2. The resistivity of extruded semi-conducting screens applied over the conductor and over the insulation was determined by measurements on test pieces taken from the core of a sample of cable as manufactured and a sample of cable which has been subjected to the ageing treatment to test the compatibility of component materials specified in IEC 60502-2. The measurements were made at a temperature of 90 ± 2 °C.
- The result of the Resistivity of semi-conducting screens are shown in the following table:

Item	Unit	Requirement	Measured Value
Conductor screen			
- without ageing	Ωm	≤ 1000	18.25
- after ageing	Ωm	≤ 1000	9.87
Insulation screen			
- without ageing	Ωm	≤ 500	11.67
- after ageing	Ωm	≤ 500	6.71

- The test results met the requirements.

2- Non-Electrical Type Tests on Cable Components:

2.1. Measurement of thickness of insulation

- The thickness of insulation was measured in accordance with clause 19.2 of IEC 60502-2.
- The result of the measurements are shown in the following table:

Thickness of insulation	Unit	Requirement	Measured Value		
			R	S	T
- minimum	mm	≥ 8	8.22	8.27	8.35
- $(t_{max} - t_{min}) / t_{max}$		≤ 0.15	0.07	0.07	0.06

- The test results met the requirements.

2.2. Measurement of thickness of non-metallic sheath:

- The thickness of non-metallic sheath was measured in accordance with clauses 19.3 of IEC 60502-2.
- The result of the measurements are shown in the following table:

Thickness of non-metallic sheath	Unit	Requirement	Measured Value
- minimum	mm	≥ 3.6	4.30

The test results met the requirements.





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2.3. Tests for determining the mechanical properties of insulation before and after ageing:

- The mechanical properties of insulation before and after ageing were determined in accordance with clause 19.5 of IEC 60502-2 :

Item	Unit	Requirement	Measured Value		
			R	S	T
Without ageing					
- Min. tensile strength	N/mm ²	12.5	20.15	21.74	19.47
- Min. elongation	%	200	532.14	602.73	592.40
After ageing in air oven					
-Min. tensile strength	N/mm ²	---	18.75	19.07	17.95
-Max. variation with samples with ageing	%	± 25	-7.04	-12.28	-7.80
-Min. elongation	%	---	618.42	684.14	658.1
-Max. variation with samples with ageing	%	± 25	16.21	13.50	11.09

- The test results met the requirements.

2.4. Tests for determining the mechanical properties of non-metallic sheaths before and after ageing:

- The mechanical properties of the outer sheath before and after ageing were determined in accordance with clause 19.6 of IEC 60502-2.
- The results of the mechanical properties of non-metallic sheaths before and after ageing are shown in the following table.

Item	Unit	Requirement	Measured Value
Without ageing			
- Min. tensile strength	N/mm ²	12.5	16.78
- Min. elongation	%	150	231.47
After ageing in air oven			
-Min. tensile strength	N/mm ²	12.5	15.07
-Max. variation with samples with ageing	%	± 25	-10.19
-Min. elongation	%	150	194.97
-Max. variation with samples with ageing	%	± 25	- 15.76

- The test results met the requirements.



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2.5. Additional ageing Test on Pieces of Completed Cable:

- Ageing tests on pieces of completed cable were carried out in accordance with clause 19.7 of IEC 60502-2 (2014).
- The results of the mechanical properties of completed cable are shown in the following table:

Item	Unit	Requirement	Measured Value		
			R	S	T
Insulation					
-Min. tensile strength	N/mm ²	12.5	19.01	18.97	20.14
-Max. variation with samples ageing	%	± 25	- 5.65	- 12.74	3.44
-Min. elongation	-	200	600.1	497.12	556.9
-Max. variation with samples ageing	%	± 25	12.77	- 17.52	-5.99
Sheath					
-Min. tensile strength	N/mm ²	12.5		18.04	
-Max. variation with samples ageing	%	± 25		7.68	
-Min. elongation	%	150		192.4	
-Max. variation with samples ageing	%	± 25		-16.87	

- The test results met the requirements.

2.6. Loss of mass test on PVC:

- A Loss of mass test on PVC sheath test was carried out in accordance with clause 19.8 of IEC 60502-2 .
- The results of the Loss of mass test on PVC sheath are shown in the following table:

Item	Unit	Requirement	Measured
-Maximum loss of mass	mg/cm ²	1.5	1.2

- The test results met the requirements.

2.7. Hot set test for XLPE insulation:

- A hot set test for the XLPE insulation was carried out in accordance with clause 19.13 of IEC 60502-2.
- The results of the hot set test for the XLPE insulation are shown in the following table:

Item	Unit	Requirement	Measured		
			R	S	T
- Elongation under load	%	≤ 175	115	124	110
- Permanent elongation	%	≤ 15	6.7	5.3	10.2

- The test results met the requirements.



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2.8. Shrinkage test for XLPE insulation:

- A shrinkage test for XLPE insulation was carried out in accordance with clause 19.18 of IEC 60502-2.
- The result of the shrinkage test for XLPE insulation is shown in the following table.

Distance L between marks (mm)	Air oven temperature (°C)	Duration (hour)	Maximum shrinkage (%)	Shrinkage measurement (%)		
				R	S	T
200	130	1	4	2.8	3.1	2.9

- The test results met the requirements.

CONCLUSION :

- The power cable ELSEWEDY CABLES 3×400 mm² 18/30 kV AL / XLPE/STA/PVC 2017 - manufactured by , achieved the requirements of tests mentioned in this report according to IEC 60502-2 (2014). The customer to check of carrying out other remaining tests specified in IEC standard and not included in this report.

Notes:

- Tests were carried out on the above specimen only without any responsibility concerning other untested specimens.
- The tests were carried out without any obligation on Egyptian Electricity Holding Company
- This test report shall not be reproduced except in full, without written approval of EHVRC.
- This report and results are related only to the tested specimen .
- This report is valid for the tested specimen and for a maximum three years unless there is a change in the design or specifications mentioned in this report.
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Dec 31, 2019

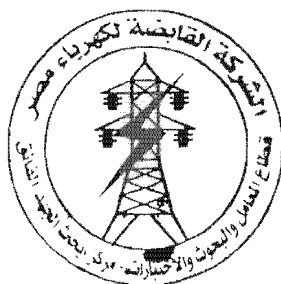
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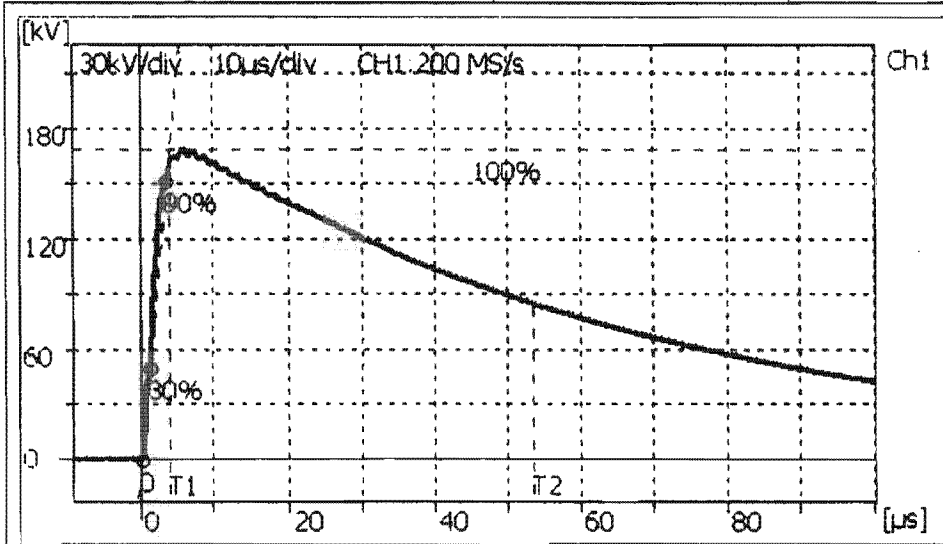
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Lightning impulse voltage test for Lightning impulse voltage test for 18/30 KV

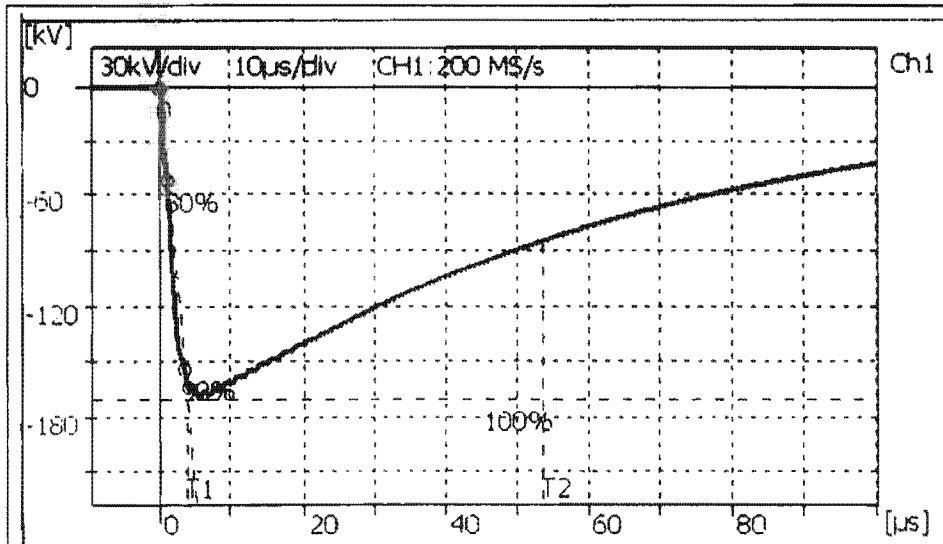
Power Cable 3x400mm², AL/XLPE/STA/PVC

Examples of the wave shapes



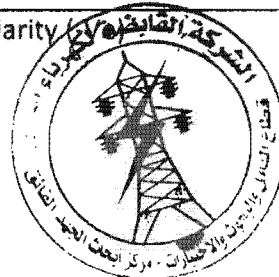
Ch1: 1
Up = 169.8 kV
T1 = 3.898 μs
T2 = 53.67 μs

Phase (R), Polarity (+Ve)



Ch1: 1
Up = -170.0 kV
T1 = 3.893 μs
T2 = 53.64 μs

Phase (R), Polarity (-Ve)



M. Khary



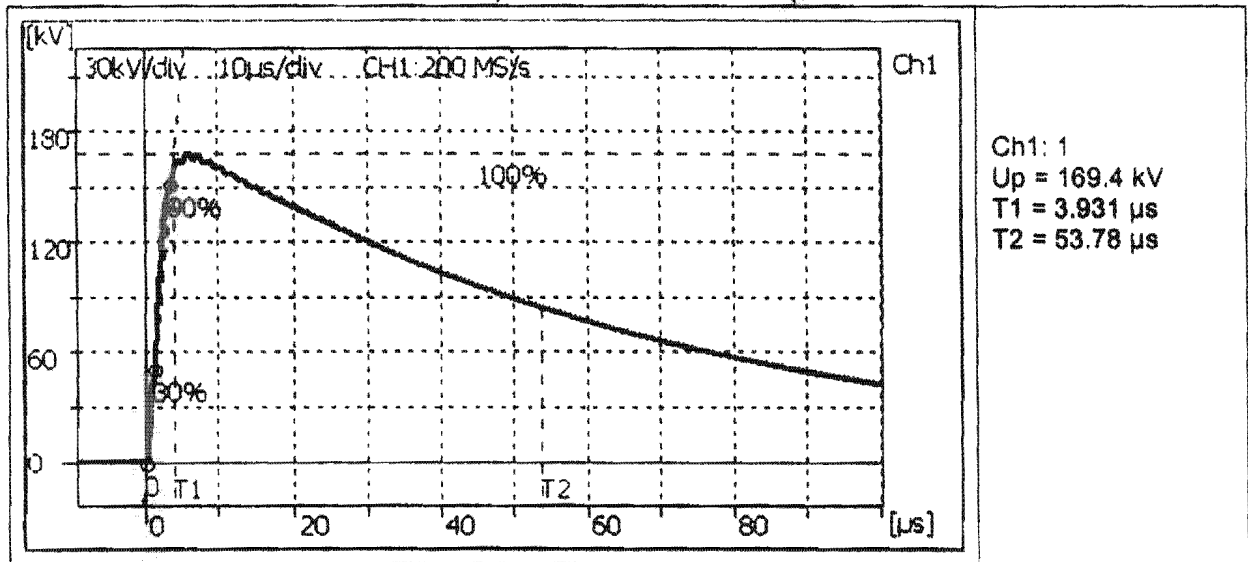
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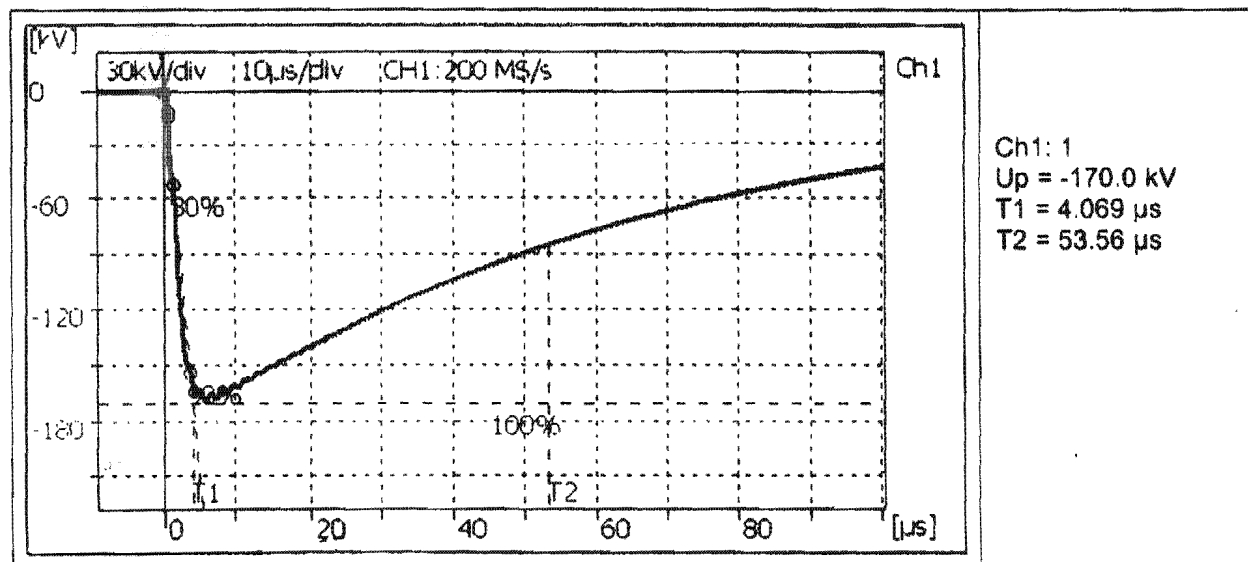
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Lightning impulse voltage test for Lightning impulse voltage test for 18/30 KV
Power Cable 3x400mm², AL/XLPE/STA/PVC

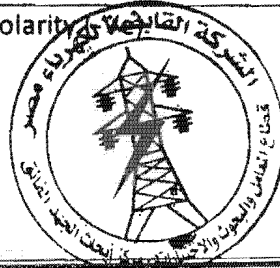
Examples of the wave shapes



Phase (S), Polarity (+Ve)



Phase (S), Polarity (-Ve)

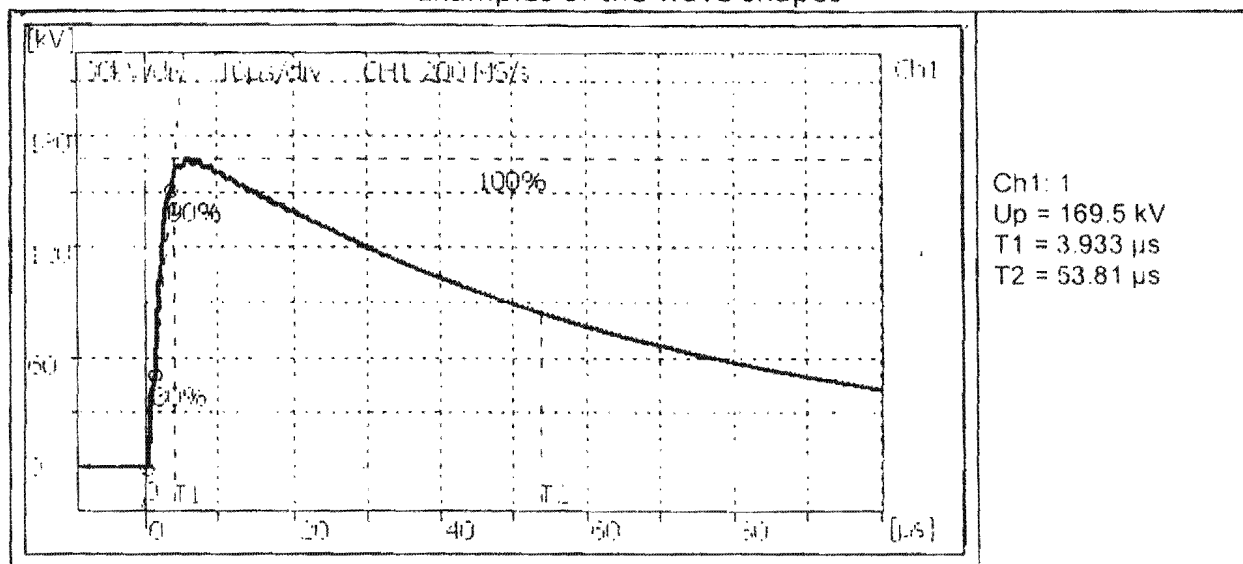


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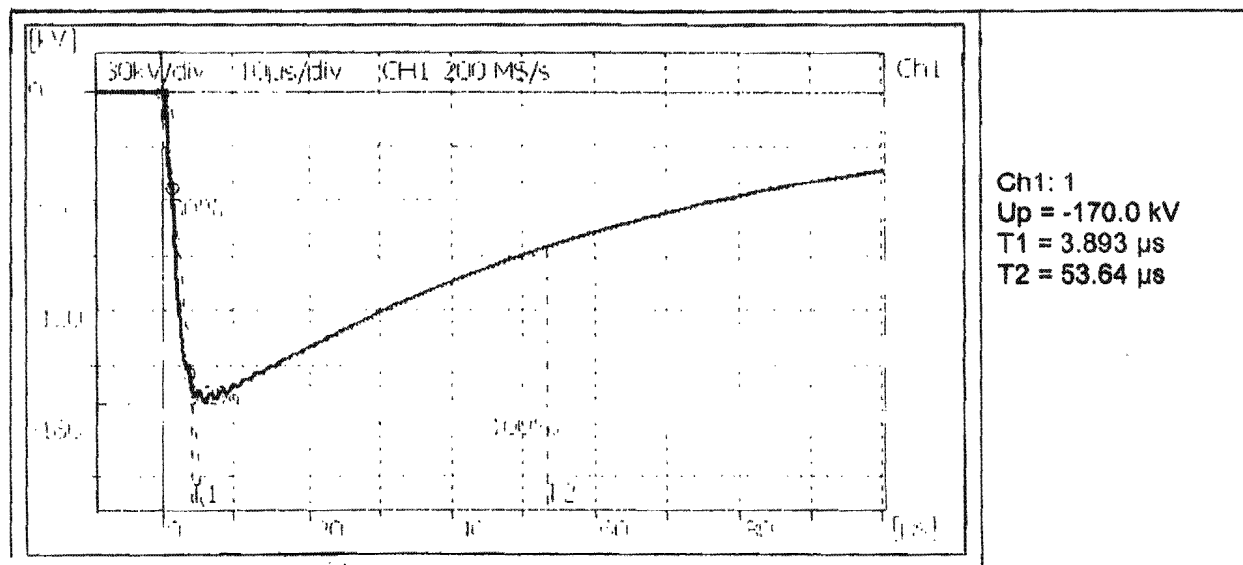
Lightning impulse voltage test for Lightning impulse voltage test for 18/30 KV

Power Cable 3x400mm², AL/XLPE/STA/PVC

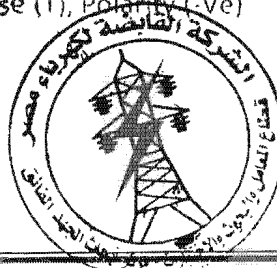
Examples of the wave shapes



Phase (T), Polarity (+Ve)



Phase (T), Polarity (-Ve)



M. Kheir