TEST REPORT

REPORT NO. (65/2011)

- **CLIENT:** **ENERGYA CABLES ELSEWEDY.HELAL .**

- ***Report Date:*** *3/05 /2011.*

- ***Place:***
  - **EXTRA HIGH VOLTAGE RESEARCH CENTER.**

- ***Requirements:***
  - Type tests according to IEC 60502-2.

- ***Standard Specification:***
  - IEC (60502-2),(60228), (811-1-1),(811-1-2), (811-1-3), (811-3-1)

- ***Description of the Specimen :***
  - 18/30 kV Power cable with the following specification:
    - Manufacturer : Energya Cables Elsewedy.Helal, Egypt.
    - Type : 18/30 kV/AL/XLPE/Copper tape /STA/PVC - 3 × 240 mm^2
    - No. of Phases : 3
    - Insulation : XLPE
    - Conductor Material : Aluminum
    - Conductor cross-section : 240 mm^2
    - Screening Material : Copper
    - Sheath Material : PVC
    - Sheath Color : Black
    - Rated Frequency : 50 Hz
  - Internal code : TO – AC – 10 – 12 – 14 - 01

- ***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 – 20 kJ – Type SGSA 800-20.
  - Air oven up to 300 °C – Type BINDER - Serial No. 02-32772.
  - Universal testing machine 25 kN – Type TABLE TOP – Model APEX-T5000 Serial No. 2095.

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- ***Test Samples***:
  - Test sample were choose 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 and on Completed Cable:***

  2.1 Measurement of thickness of insulation
  2.2 Measurement of thickness of non-metallic sheath.
  2.3 Tests for determining the mechanical properties of insulation before and after ageing
  2.4 Tests for determining the mechanical properties of non-metallic sheaths before and after ageing
  2.5 Additional ageing test on pieces of completed cables.
  2.6 Test for resistance of PVC sheath to cracking (heat shock test).
  2.7 Hot set test for XLPE insulation.
  2.8 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 ambient temperature in accordance with clause 18.1.3 of IEC 60502-2 (2005). The test cable was bent around a test cylinder. The diameter of the cylinder was 2.3 m. The test cable was bent for one complete turn. It was then unwound. The process repeated, except that the bending of the cable was in the reverse direction. This cycle of operation was carried 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)
101	18.6	2511 - 2272	2300

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1.1.2 Partial discharge test:

- The test cable was subjected to a partial discharge test in accordance with clause 18.1.4 of IEC 60502-2 (2005). The test voltage was raised gradually to 1.73 U_o and the magnitude of the discharge was measured
- The measured value of the partial discharge level is shown in the following table

Applied voltage (kV)	Maximum partial discharge level (PC)	Measured partial discharge level (PC)		
		Red	Blue	Yellow
31	5	0.37	0.37	0.37

- The Figure of the PD- Scope is illustrated in page (10: 12) of this report.
- ***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 18.1.5 of IEC 60502-2 (2005). 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 10 kV at the temperature specified above.
- The measured value of Tan δ is shown in the following table

Applied voltage (kV)	Maximum allowable value for *tan* δ (x 10^{-4})	*Tan* δ (x 10^{-4}) [Measured value]		
		Red	Blue	Yellow
10	40	25	30	22

- ***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 18.1.6 of IEC 60502-2 (2005). 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.

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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 18.1.4 of IEC 60502-2 (2005). The measurement was carried out as mentioned above under item 1.1.
- The measured value of the partial discharge level is shown in the following table.

Applied voltage (kV)	Maximum partial discharge level (PC)	Measured partial discharge level (PC)		
		Red	Blue	Yellow
31	5	4.2	4.6	4.7

- The Figure of the PD- Scope is illustrate in page (13:15) of this report.
- ***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 18.1.7 of IEC 60502-2 (2005). 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 crest value of 170 kV without failure.
- The results were illustrated by the Figures in page No. (16:21) 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 63 kV for 15 min. in accordance with clause 18.1.7 of IEC 60502-2 (2005).
- The result of the voltage test is shown in the following table

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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 18.1.8 of IEC 60502-2 (2005). 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 48 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.***

1.6 Resistivity of semi-conducting screens:

- The measurement of the resistivity of the semi-conducting screens was carried out in accordance with clause 18.1.9 of IEC 60502-2 (2005). 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 (2005). The measurements were made at a temperature of 90 °C.
- The result of the Resistivity of semi-conducting screens are shown in the following table

Item	Unit	Requirement	Measured/ Determined		
			Red	Blue	Yellow
Conductor screen					
- Without ageing	Ωm	≤ 1000	12	22	15.6
- After ageing	Ωm	≤ 1000	4.2	6.9	5.3
Insulation screen					
- Without ageing	Ωm	≤ 500	0.85	1.5	1.2
- After ageing	Ωm	≤ 500	4.8	8.6	5.6

- ***The test results met the requirements.***

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2- Non-Electrical Type Tests on Cable Components and on Completed Cable:

2.1. Measurement of thickness of insulation

- The thickness of insulation was measured in accordance with clauses 19.1 of IEC 60502-2 (2005).
- The result of the measurements are shown in the following table

Thickness of insulation	Unit	Requirement	Measured / determined		
			Red	Blue	Yellow
- minimum - $(t_{max} - t_{min})/ t_{max}$	mm	≥ 7.1 ≤ 0.15	7.509 0.115	7.694 0.096	7.806 0.132

- ***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 19.2 of IEC 60502-2 (2005).
- The result of the measurements are shown in the following table

Thickness of non-metallic sheath	Unit	Requirement	Measured/ determined
- minimum	mm	≥ 3.3	4.152

- ***The test results met the requirements.***

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 19.3 of IEC 60502-2 (2005).
- The results of the mechanical properties of insulation before and after ageing are shown in the following table.

Item	Unit	Requirement	Measured/ Determined		
			Red	Blue	Yellow
Without ageing					
- Min. tensile strength	N/mm^2	12.5	20.58	24.21	24.74
- Min. elongation	%	200	367	393	389
After ageing in air oven					
-Min. tensile strength	N/mm^2	---	23.51	26.90	26.97
-Max. variation with samples without ageing	%	± 25	14.22	11.12	9.08
-Min. elongation	%	---	295.52	419	419
-Max. variation with samples without ageing	%	± 25	7.77	6.6	7.71

- ***The test results met the requirements.***

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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 19.4 of IEC 60502-2 (2005).
- The results of the mechanical properties of non-metallic sheaths before and after ageing are shown in the following table.

Item	Unit	Requirement	Measured/ Determined
Without ageing			
- Min. tensile strength	N/mm^2	12.5	19.60
- Min. elongation	%	150	166
After ageing in air oven			
-Min. tensile strength	N/mm^2	12.5	20.28
-Max. variation with samples without ageing	%	± 25	3.42
-Min. elongation	%	150	164
-Max. variation with samples without ageing	%	± 25	1.20

- ***The test results met the requirements.***

2.5. *Additional ageing Test on Pieces of Completed Cable:*

- Ageing tests on pieces of completed cable were carried out in accordance with clause 19.5 of IEC 60502-2 (2005).
- The results of the mechanical properties of completed cable are shown in the following table.

Item	Unit	Requirement	Measured/Determined		
			Red	Blue	Yellow
Insulation					
-Min. tensile strength	N/mm^2	---	21.92	19.85	22.15
-Max. variation with samples without ageing	%	± 25	6.50	-18	-10.4
-Min. elongation	%	---	362	355	361
-Max. variation with samples without ageing	%	± 25	-1.36	-7.2	- 7.2
Sheath					
-Min. tensile strength	N/mm^2	12.5	19.60		
-Max. variation with samples without ageing	%	± 25	- 0.01		
-Min. elongation	%	150	161.6		
-Max. variation with samples without ageing	%	± 25	-2.65		

- ***The test results met the requirements.***

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2.6. *Test for resistance of PVC sheath to cracking (heat shock test).*

- The test for resistance of PVC sheath to cracking (heat shock test) was carried out in accordance with clause 19.9 of IEC 60502-2 (2005).
- The result of the heat shock test for the PVC sheath is shown in the following table.

Over sheath thickness (average)	Mandrel diameter (mm)	Number of turns	Air oven temperature (°C)	Duration (hour)	Observations
4.125	10	2	150	1	No crack

- ***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 19.11 of IEC 60502-2 (2005).
- The results of the hot set test for the XLPE insulation are shown in the following table.

Item	Unit	Requirement	Measured		
			Red	Blue	Yellow
-Elongation under load	%	≤ 175	107	112	143
-Permanent elongation	%	≤ 15	5.2	12.5	10

- ***The test results met the requirements.***

2.8. *Shrinkage test for XLPE insulation:*

- A shrinkage test for XLPE insulation was carried out in accordance with clause 19.16 of IEC 60502-2 (2005).
- 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 (%)		
				Red	Blue	Yellow
200	130	1	4	0.75	0.5	1

- ***The test results met the requirements.***

- ***CONCLUSION :***

- The 18/30 kV/AL/XLPE/Copper tape /STA/PVC - 3 × 240 mm^2 manufactured by Energya Cables Elsewedy.Helal Company. Fulfilled the requirements of tests mentioned in this report according to IEC 60502-2 (2005-03).

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- ***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.

- ***TEST ENGINEERS:***

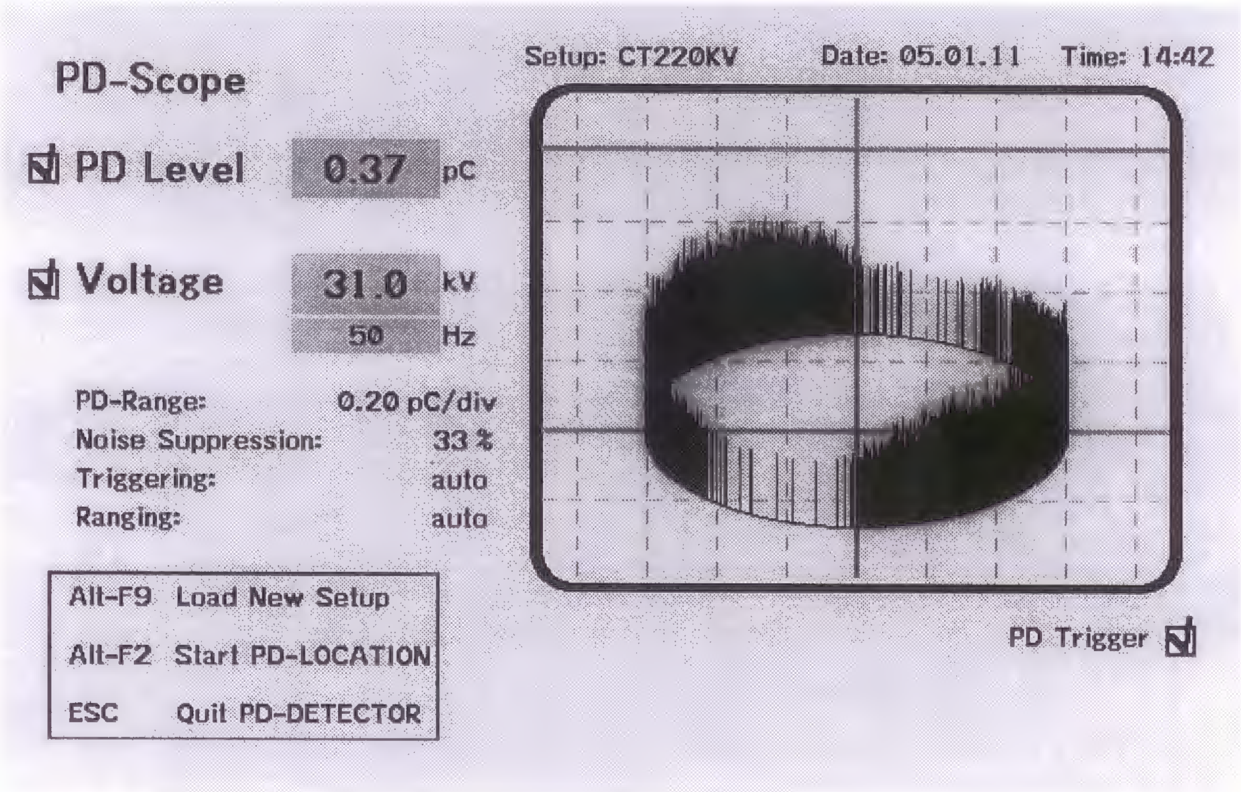
M. Ramzy

GENERAL MANGER

Fatma
4.5.2011

Azza .

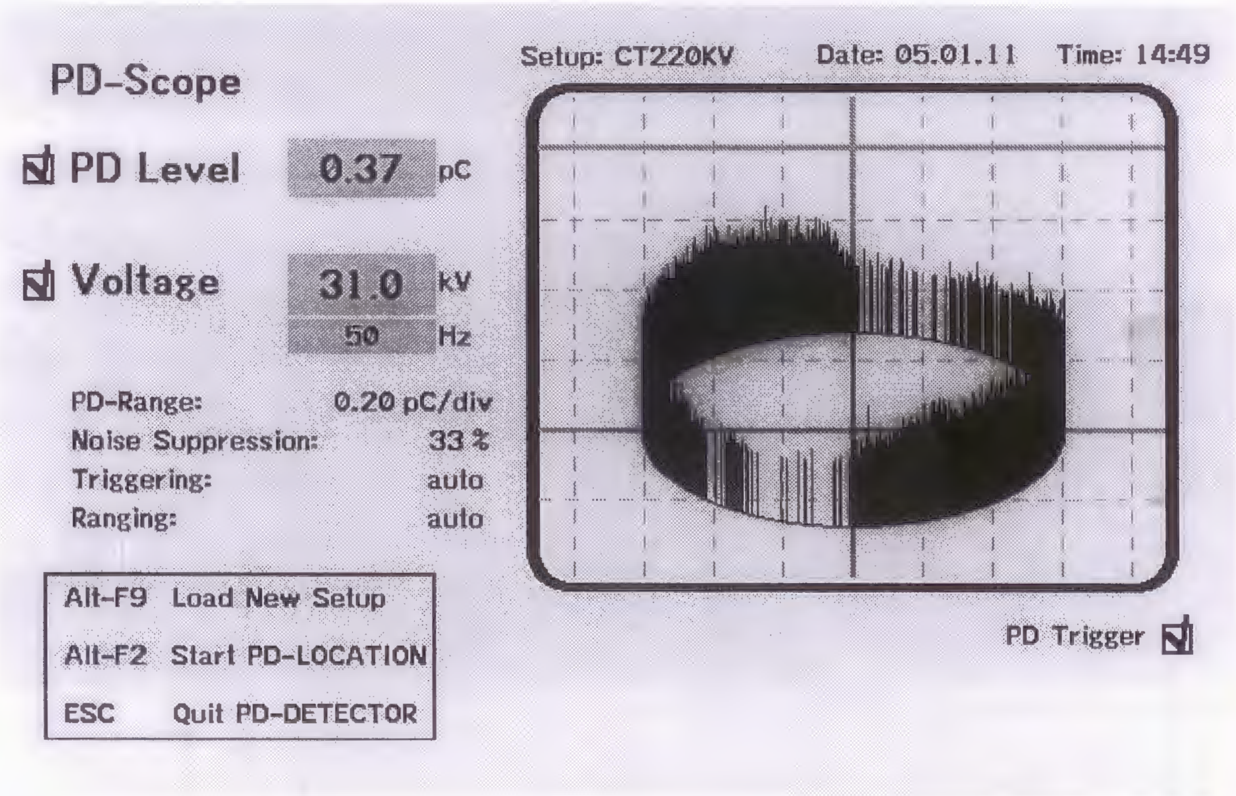
Measurement Results of Partial Discharge
For 18/30 kV power cable - 3 × 240 mm^2 – XLPE insulation
[Energya Cables Elsewedy.Helal]
Phase (Red)



- **Case: After bending test**
- **Ambient temperature : 18 °C**
- **Calibration at : 10 PC**

▪ ***TEST ENGINEERS:***

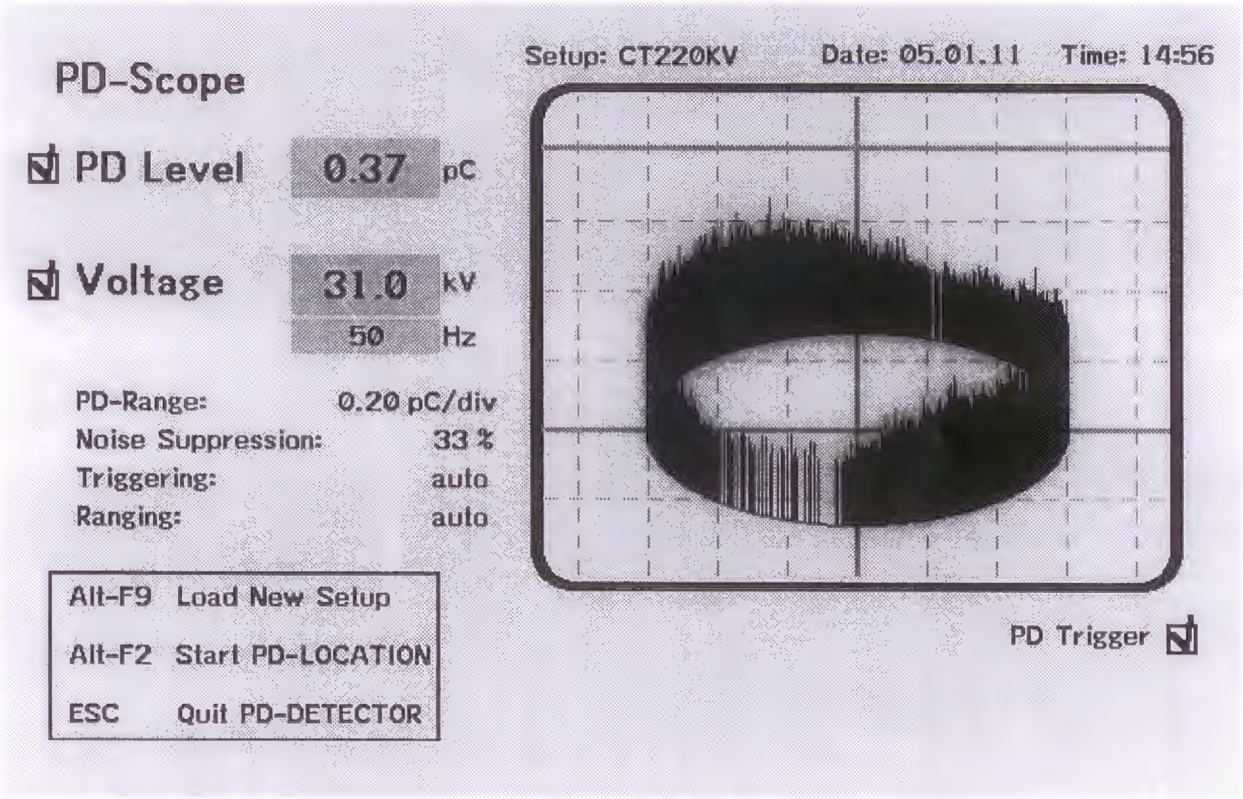
Measurement Results of Partial Discharge
For 18/30 kV power cable - 3 × 240 mm^2 – XLPE insulation
[Energya Cables Elsewedy.Helal]
Phase (Blue)



- **Case: After bending test**
- **Ambient temperature : 18 °C**
- **Calibration at : 10 PC**

- ***TEST ENGINEERS:***

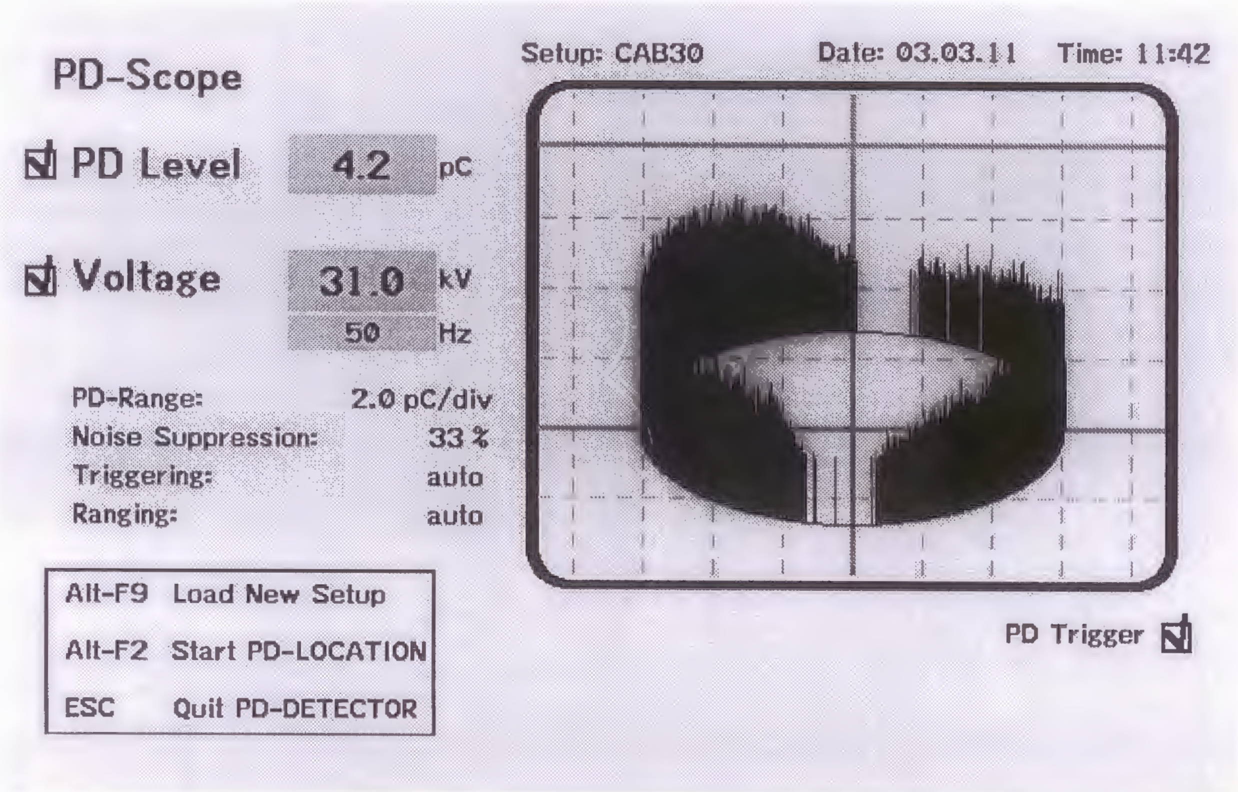
Measurement Results of Partial Discharge
For 18/30 kV power cable - 3 × 240 mm^2 – XLPE insulation
[Energya Cables Elsewedy.Helal]
Phase (Yellow)



- **Case: After bending test**
- **Ambient temperature : 18 °C**
- **Calibration at : 10 PC**

- ***TEST ENGINEERS:***

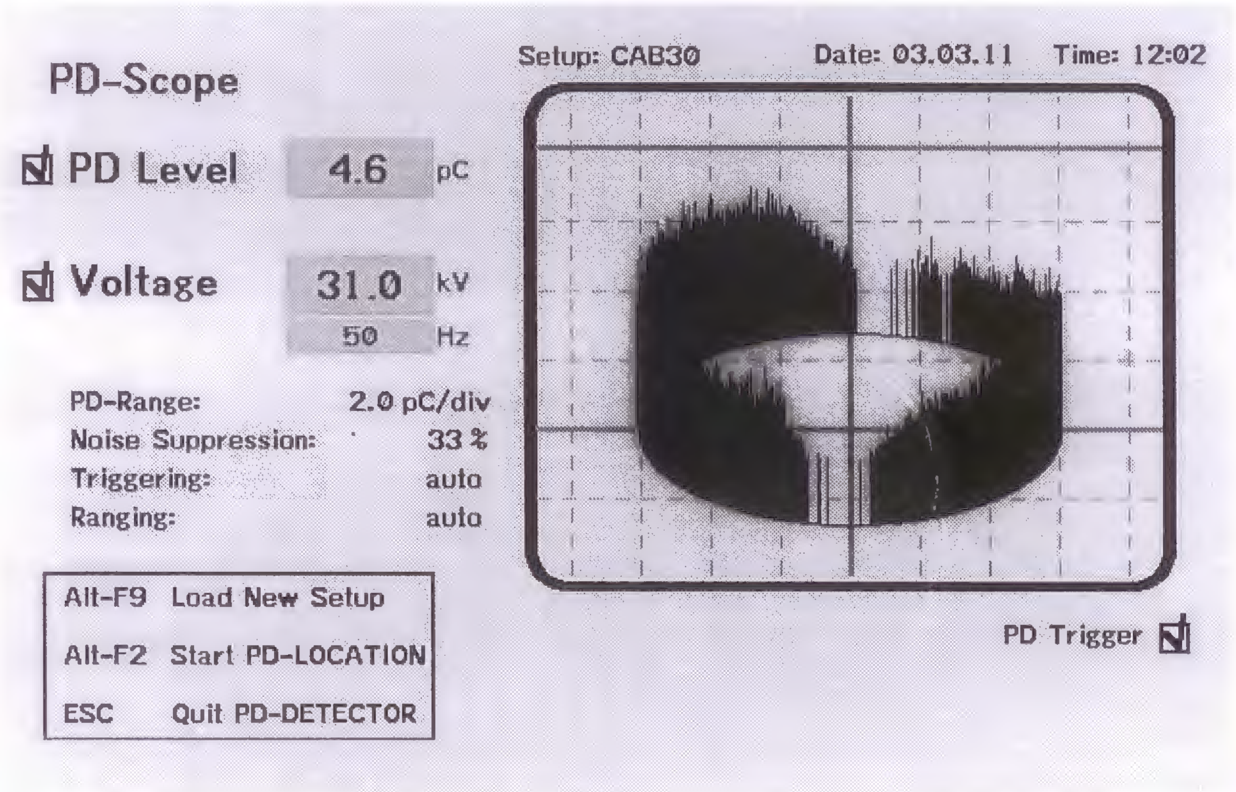
Measurement Results of Partial Discharge
For 18/30 kV power cable - 3 × 240 mm² – XLPE insulation
[Energya Cables Elsewedy.Helal]
Phase (Red)



- **Case: After heat cycle**
- **Ambient temperature : 22 °C**
- **Calibration at : 10 PC**

- ***TEST ENGINEERS:***

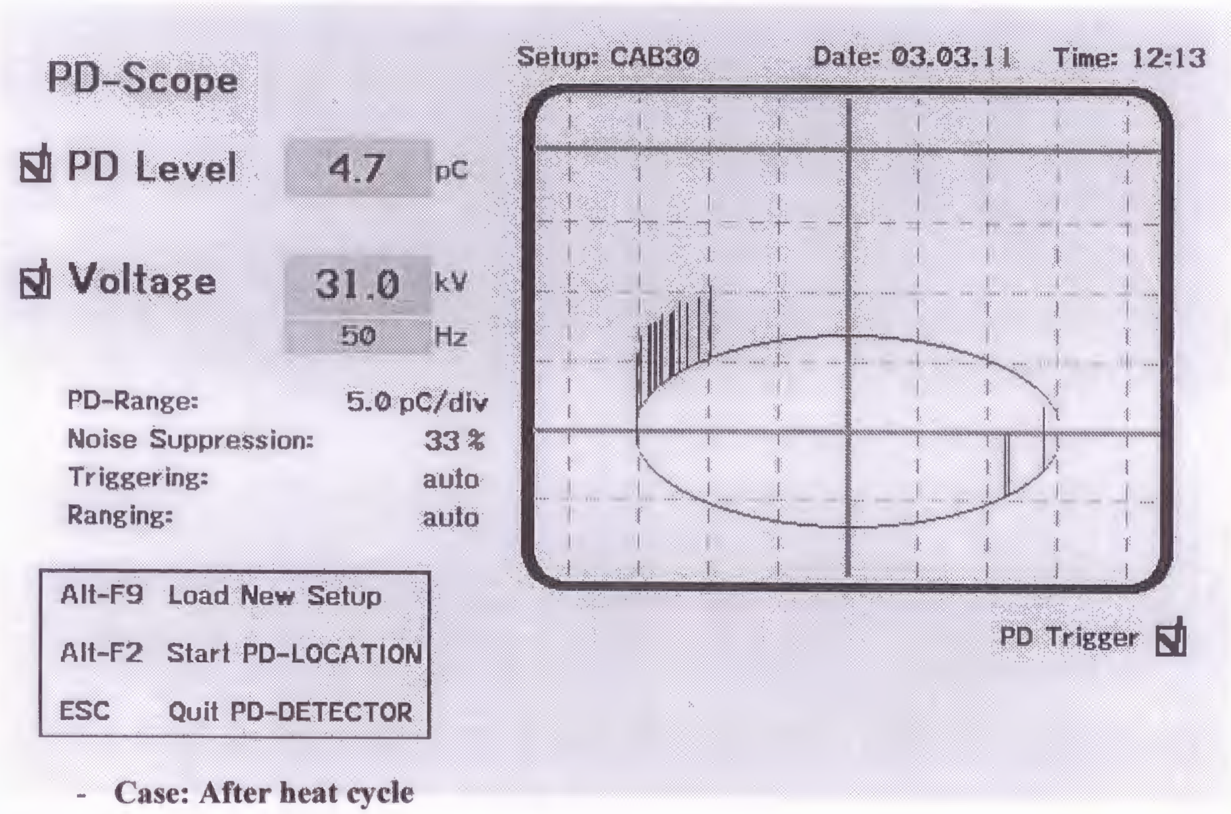
Measurement results of Partial Discharge
For 18/30 kV power cable - 3 × 240 mm^2 – XLPE insulation
[Energya Cables Elsewedy.Helal]
Phase (Blue)



- **Case: After heat cycle**
- **Ambient temperature : 22 °C**
- **Calibration at : 10 PC**

- ***TEST ENGINEERS:***

Measurement Results of Partial Discharge
For 18/30 kV power cable - 3 × 240 mm^2 – XLPE insulation
[Energya Cables Elsewedy.Helal]
Phase (Yellow)



- **Case: After heat cycle**
- **Ambient temperature : 22 °C**
- **Calibration at : 10 PC**

- ***TEST ENGINEERERS:***

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18/30 KV Power Cable 3*240 mm2,Energya Cables- Elsewedy Helal

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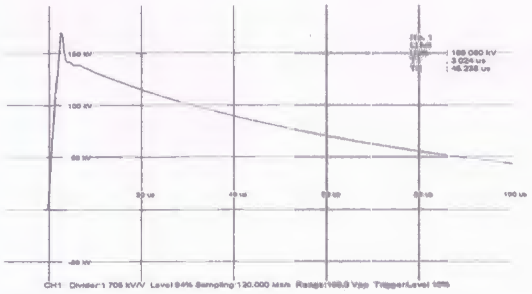

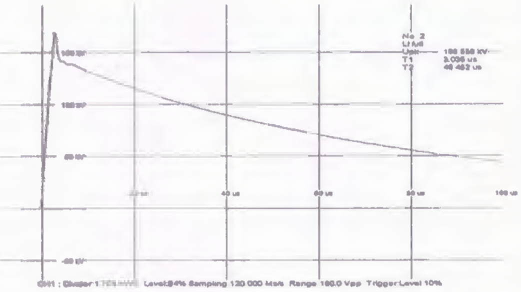

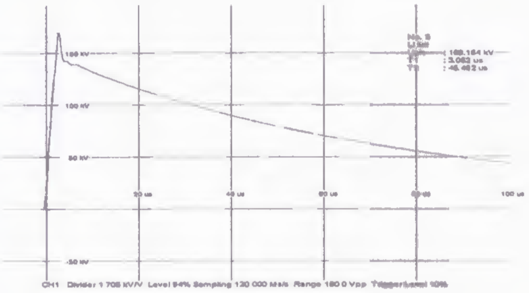

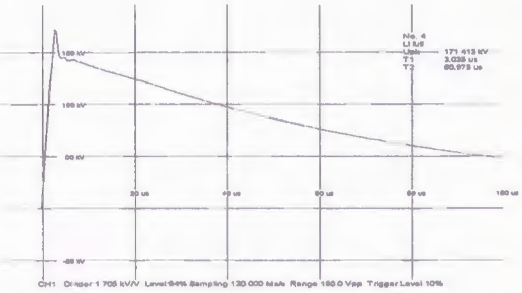

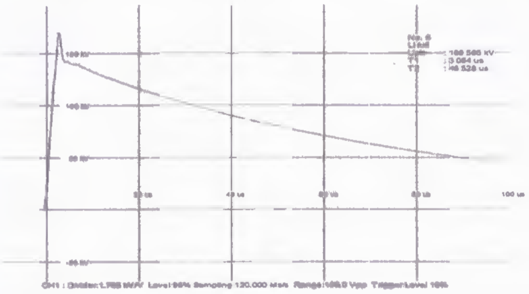

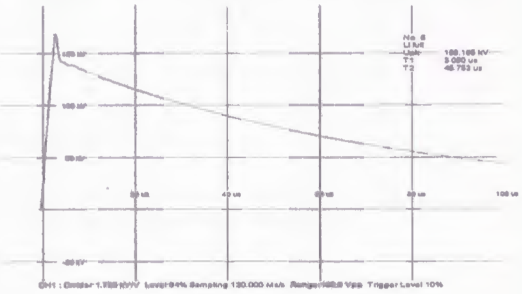

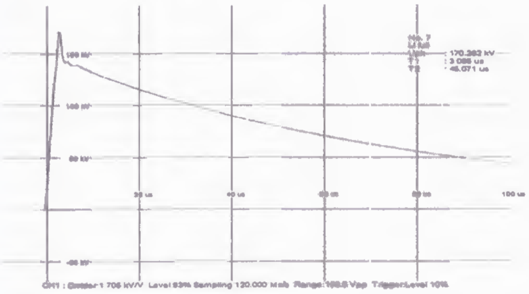

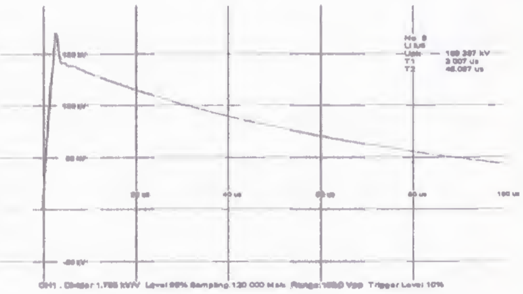

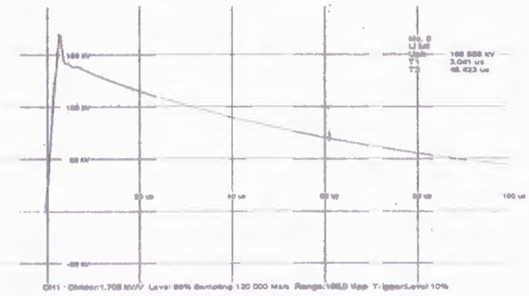

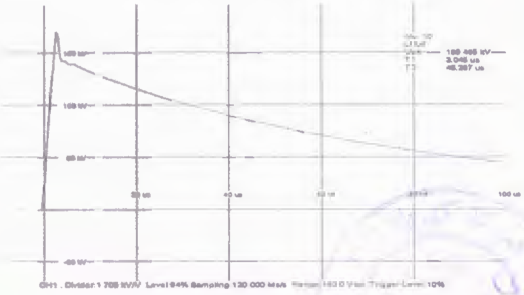

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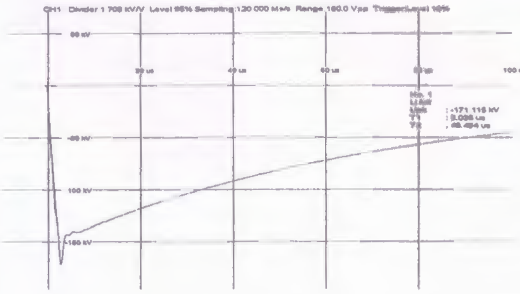
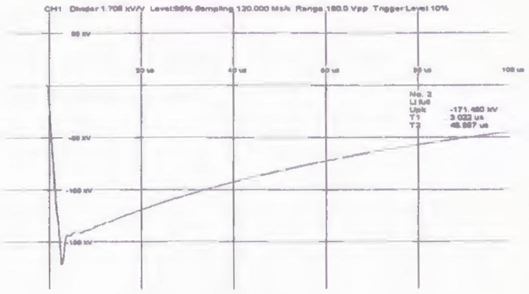
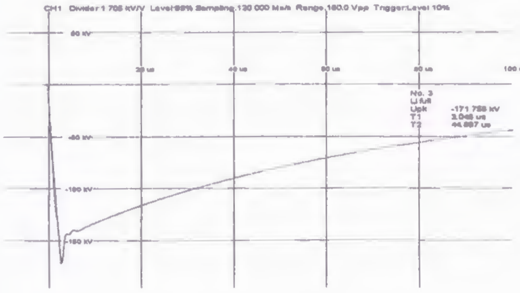
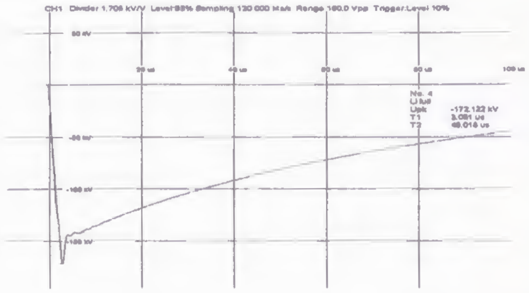
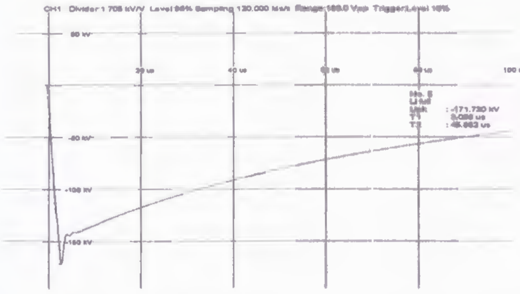
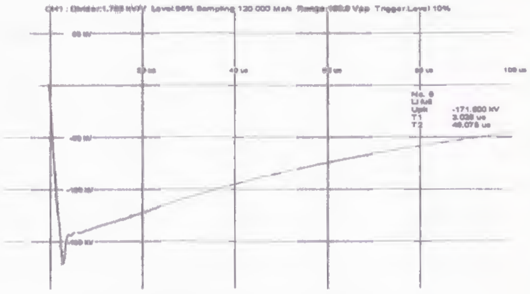
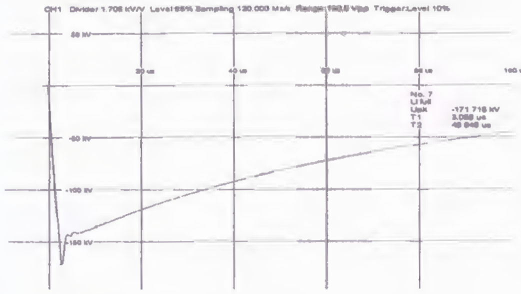
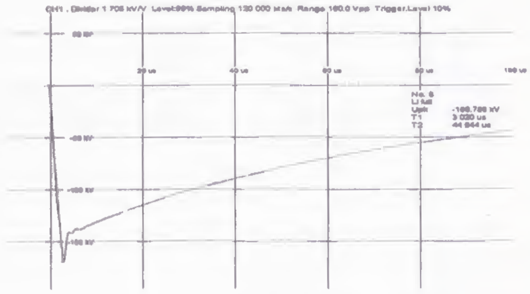
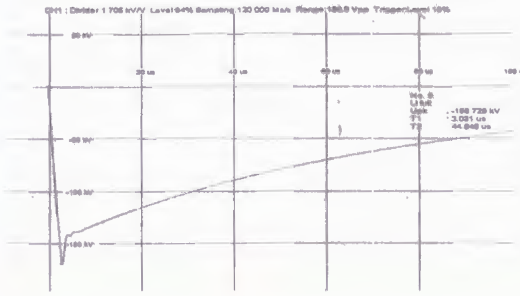
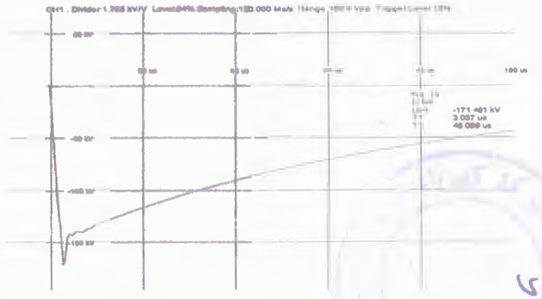

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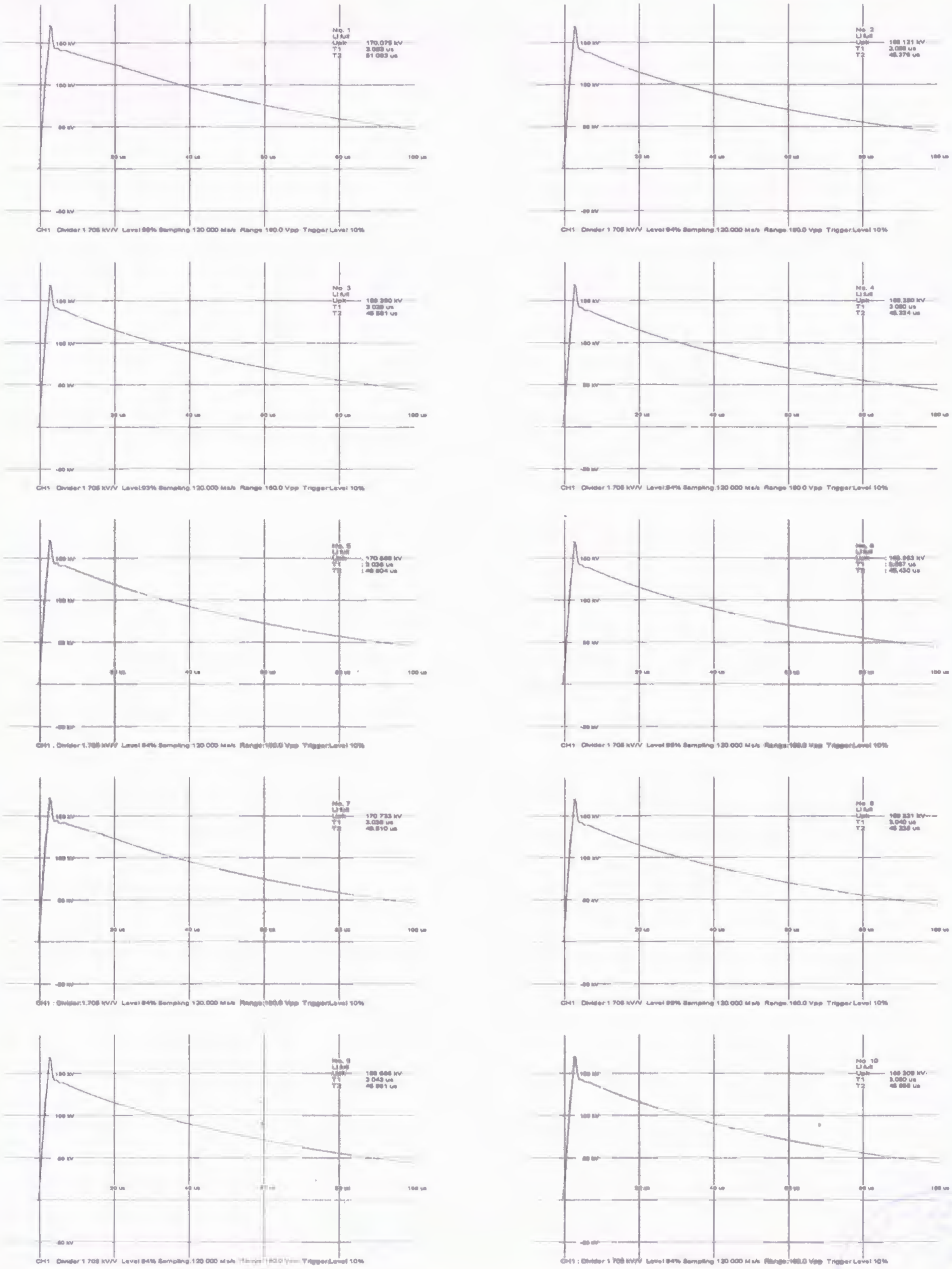

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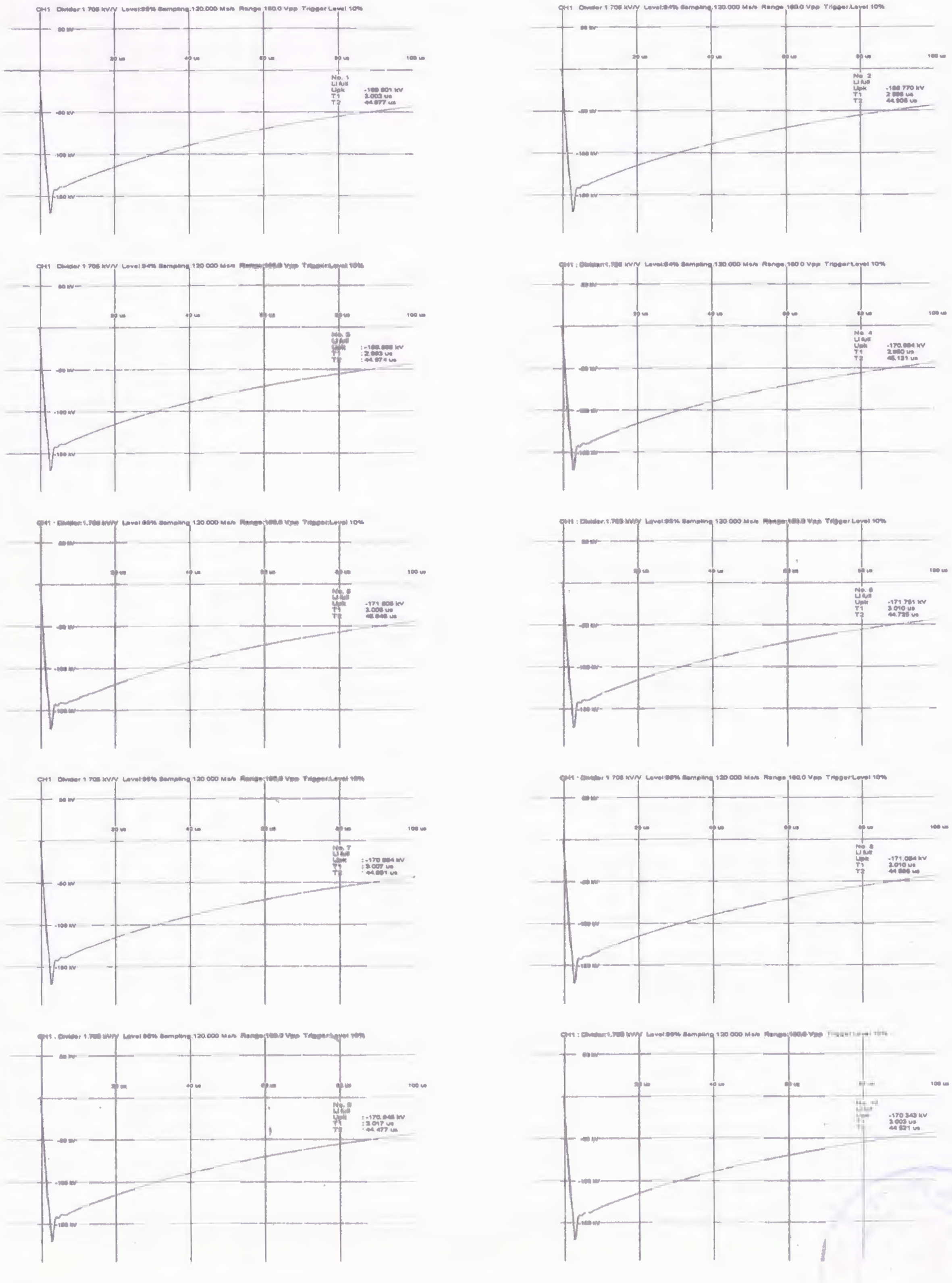

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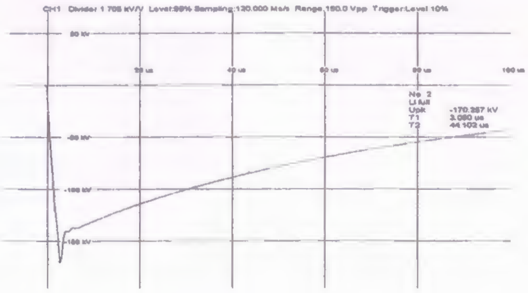

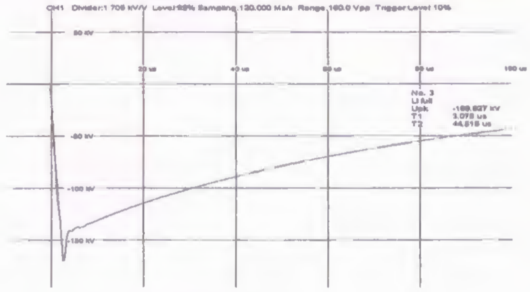

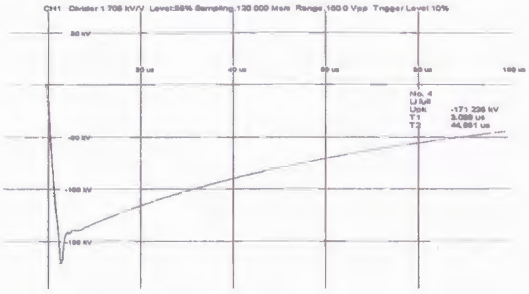

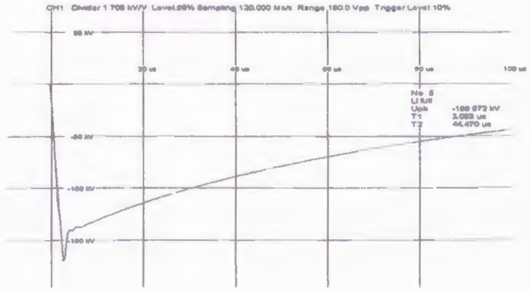

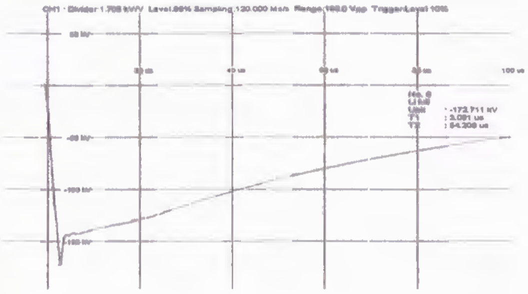

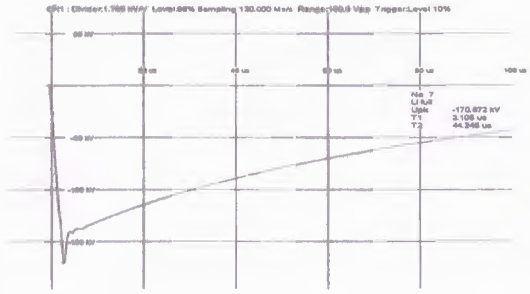

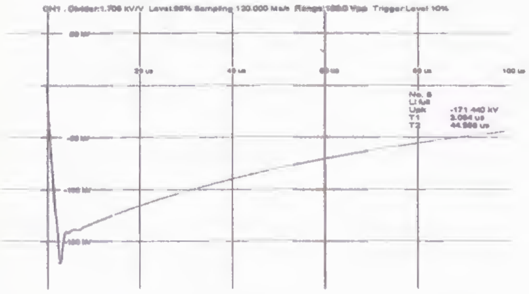

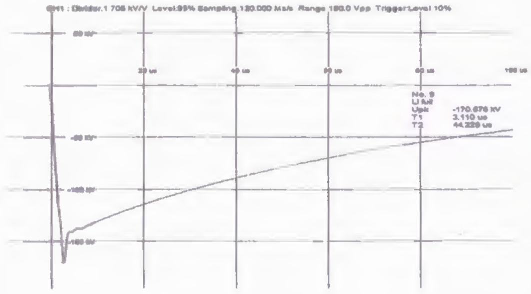

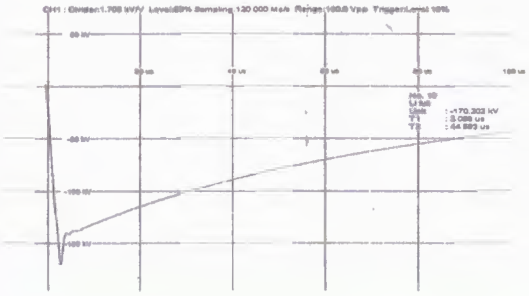

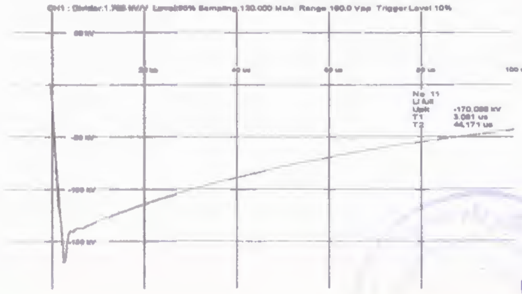

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