Phaseback Arc Flash Test Summary

Testing and Waveform Data Provided By KEMA Laboratories

The Phaseback Voltage Stabilizing Ground Reference (VSGR) is a device that serves as a surge suppressor, voltage regulator, and harmonic filter. It has mitigated equipment damage and has successfully prevented arc flash events in many power systems.

The objective of the procedure is as follows: test the voltage withstand of a 480 volt three-phase power system operating a three-phase load, protected by the Phaseback VSGR, The objective of the procedure is as follows: test the voltage withstand of a 480 volt three-phase power system operating a three-phase load, protected by the Phaseback VSGR, with high voltage (2.5kV and 6kV) connecting to phase C for about 390ms.

The resulting voltage waveforms produced by KEMA Laboratories are contained in pages 9 through 12.

The tests included connecting 2,500 and 6,000 volts to Phase C while recording the voltages. Two types of circuits were tested: three-phase three-wire, and three-phase four-wire power systems.

A summary of the four (4) three-phase waveforms is included. The summary shows minimal voltage changes, no arc flash, and no damaged equipment. Phase voltages did not exceed line voltage values during the high voltage testing, and no equipment damage or loss occurred during the entire battery of tests.

The people at the high power test facility were professional throughout this process, and they were technically competent in the performance of their duties. KEMA Laboratories was selected over other testing facilities for numerous reasons, especially because this lab has performed power tests for the US Government, including arc flash testing.

There was an expectation held by the testing crew that the customer's equipment would fail and cause an arc flash event, as is typically the result from the high power test generator reaching its maximum test voltage. One witness of these tests stated that it was "quite boring", as there wasn't even a spark. Presently, an average of two people per day are killed due to arc flash events in America, and dozens are injured. After extensive study, it has been determined that 80 to 85% of arc flash events are started by arcing ground faults.

When there is arcing, the air becomes ionized (conductive). Because of their unpredictable nature, arc flash events can quickly become catastrophic. Adding a Phaseback can cause a reduction in both the likelihood and the severity of arc flash events. This may only cause a reduction to the injury rate by 50 to 80%, but there are other factors to consider.

A Phaseback VSGR will quickly pay for itself in energy savings (typically within a year or less).

Other considerations for installing Phaseback VSGR:

- It will pay for itself in energy savings, by balancing the phase voltages continuously.
- This payback may be accelerated by reducing or eliminating down-time and equipment damage from Power Quality issues, including harmonics, single phase events, and ground fault events.
- This payback may be accelerated by the elimination of other equipment typically required in the system such as TVSS (SPD), HRG, NGR, Relays to prevent single phase,
- It will provide continuous voltage spike prevention, and it will prevent most other issues caused by electrical noise.
- Each VSGR carries a lifetime warranty and does not contain sacrificial solid state components.

Respectfully submitted,
William Hinton
Director of Engineering
Applied Energy LLC.

DNV·GL

KEMA TEST REPORT

17013-K

Object	Voltage Stabilizing Device
Type	Phaseback – VSGR (Voltage Stabilizing Ground Reference) **Serial No.** N/A
	480 V, rms – 3 phase – 60 Hz
Client	Borg General Sales, LLC Elk Grove Village, IL, USA
Tested by	KEMA Powertest LLC, 4379 County Line Road Chalfont, PA 18914 USA
Date of tests	13 January 2017
Test specification	The tests have been carried out in accordance with the client's instructions.
Remarks	The test object was subjected to phase to ground overvoltage withstand.

This report applies only to the object tested. The responsibility for conformity of any object having the same type references as that tested rests with the Manufacturer.

This report consists of 47 pages in total.

KEMA-Powertest, LLC.

Victor Savulyak
Head of Department, Operations

KEMA Laboratories

Chalfont, _____

INFORMATION SHEET

1 KEMA Type Test Certificate

A KEMA Type Test Certificate contains a record of a series of (type) tests carried out in accordance with a recognized standard. The equipment tested has fulfilled the requirements of this standard and the relevant ratings assigned by the manufacturer are endorsed by DNV GL. In addition, the test object's technical drawings have been verified and the condition of the test object after the tests is assessed and recorded. The Certificate contains the essential drawings and a description of the equipment tested. A KEMA Type Test Certificate signifies that the object meets all the requirements of the named subclauses of the standard. It can be identified by gold-embossed lettering on the cover and a gold seal on its front sheet.
The Certificate is applicable to the equipment tested only. DNV GL is responsible for the validity and the contents of the Certificate. The responsibility for conformity of any object having the same type references as the one tested rests with the manufacturer.
Detailed rules on types of certification are given in DNV GL's Certification procedure applicable to KEMA Laboratories.

2 KEMA Report of Performance

A KEMA Report of Performance is issued when an object has successfully completed and passed a subset (but not all) of test programs in accordance with a recognized standard. In addition, the test object's technical drawings have been verified and the condition of the test object after the tests is assessed and recorded. The report is applicable to the equipment tested only. A KEMA Report of Performance signifies that the object meets the requirements of the named subclauses of the standard. It can be identified by silver-embossed lettering on the cover and a silver seal on its front sheet.
The sentence on the front page of a KEMA Report of Performance will state that the tests have been carried out in accordance with ..... The object has complied with the relevant requirements.

3 KEMA Test Report

A KEMA Test Report is issued in all other cases. Reasons for issuing a KEMA Test Report could be:

- Tests were performed according to the client's instructions.
- Tests were performed only partially according to the standard.
- No technical drawings were submitted for verification and/or no assessment of the condition of the test object after the tests was performed.
- The object failed one or more of the performed tests.

The KEMA Test Report can be identified by the grey-embossed lettering on the cover and grey seal on its front sheet.
In case the number of tests, the test procedure and the test parameters are based on a recognized standard and related to the ratings assigned by the manufacturer, the following sentence will appear on the front sheet. The tests have been carried out in accordance with the client's instructions. Test procedure and test parameters were based on ..... If the object does not pass the tests, such behavior will be mentioned on the front sheet. Verification of the drawings (if submitted) and assessment of the condition after the tests is only done on client's request.
When the tests, test procedure and/or test parameters are not in accordance with a recognized standard, the front sheet will state the tests have been carried out in accordance with client's instructions.

4 Official and uncontrolled test documents

The official test documents of DNV GL are issued in bound form. Uncontrolled copies may be provided as loose sheets or as a digital file for convenience of reproduction by the client. The copyright has to be respected at all times.

5 Accreditation of KEMA Laboratories

The KEMA Laboratories of DNV GL are accredited in accordance with ISO/IEC 17025 by the respective national accreditation bodies. The KEMA Laboratories in the Netherlands are in the RvA register under nos. L020, L218, K006, K009 and I049. The KEMA Laboratory in the United States is accredited by the A2LA under no. 0553.01. The KEMA Laboratory in the Czech Republic is accredited by CAI under no. 1035.

IDENTIFICATION OF THE OBJECT TESTED

Ratings/characteristics of the object tested

Operating voltage	480 V, rms
Number of phases	3
Power frequency	60 Hz

Description of the object tested

Voltage stabilizing device, Phaseback – VSGR (Voltage Stabilizing Ground Reference)

GENERAL INFORMATION

The tests were witnessed by

Name	Company
William Stewart	Applied Energy LLC Saginaw, MI, USA

The tests were carried out by

Name	Company
Kresimir Starcevic	KEMA Powertest LLC, Chalfont PA USA

Accuracy of measurement

The guaranteed uncertainty in the figures mentioned, taking into account the total measuring system, is less than 3%, unless mentioned otherwise. Measurement uncertainty can be verified by reviewing the instrument calibration records. The instruments used are calibrated on a regular basis and are traceable to the National Institute of Standards and Technology.

Test Summary

The client submitted one voltage stabilizing device, Phaseback – VSGR, in good condition, to be subjected to phase to ground overvoltage withstand tests in accordance with the client's instructions.

The client requested phase to ground overvoltage withstand tests on the voltage stabilizing device, Phaseback – VSGR in accordance with the client's instructions. These test requirements are summarized in the test plan attached to this report.

The phase to ground overvoltage withstand tests for the voltage stabilizing device, Phaseback – VSGR were performed in accordance with the client's instructions.

Applied Energy Test Plan for Testing Phaseback Test Device (1.6.2016)

Available Source: 480V, 2.5kA, 3ϕ, 60 hertz

Peak Voltage Supply: 2.4kV – 6kV

Load: 5-50 amps

Setup test circuit as outlined in the circuit schematic lab2407.

Perform a baseline test with the above source subjected to overvoltage from peak voltage supply.

Connect test device using #10 wire.

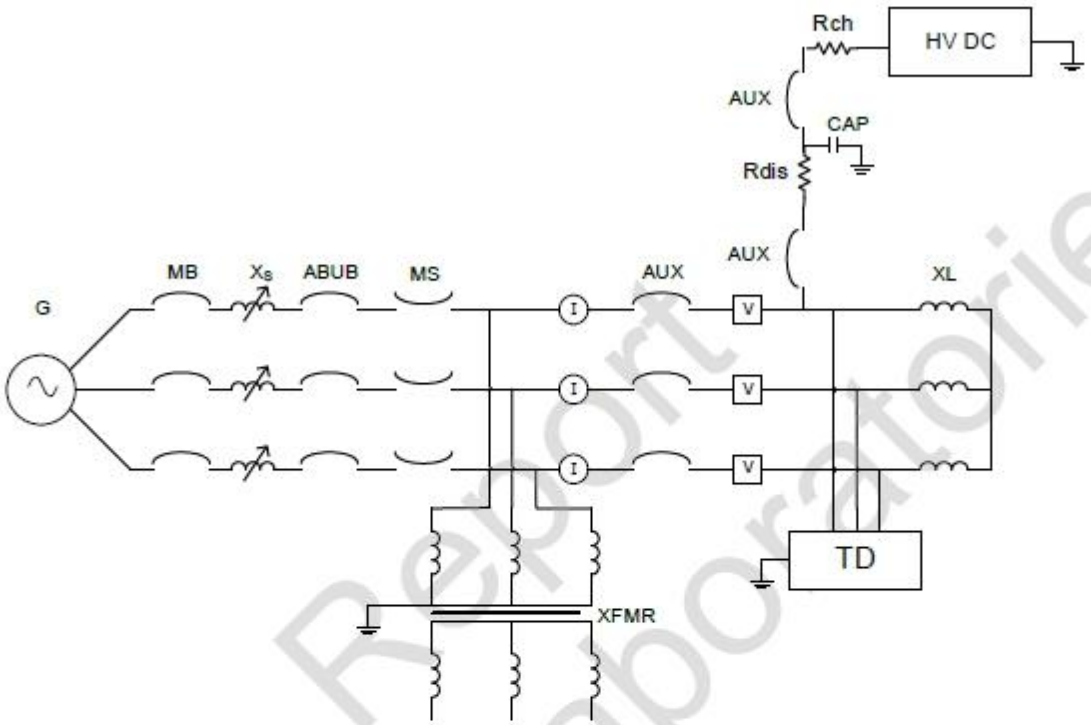
Test 1 – 480V, 2.5kA, 3ϕ, 60 hertz, with 5-50 amp load, ~2.4kV (peak voltage supply) with grounded load.

Test 2 – 480V, 2.5kA, 3ϕ, 60 hertz, with 5-50 amp load, ~6kV (peak voltage supply) with grounded load.

Test 3 – 480V, 2.5kA, 3ϕ, 60 hertz, with 5-50 amp load, ~2.4kV (peak voltage supply) ungrounded.

Test 4 – 480V, 2.5kA, 3ϕ, 60 hertz, with 5-50 amp load, ~6kV (peak voltage supply) ungrounded.

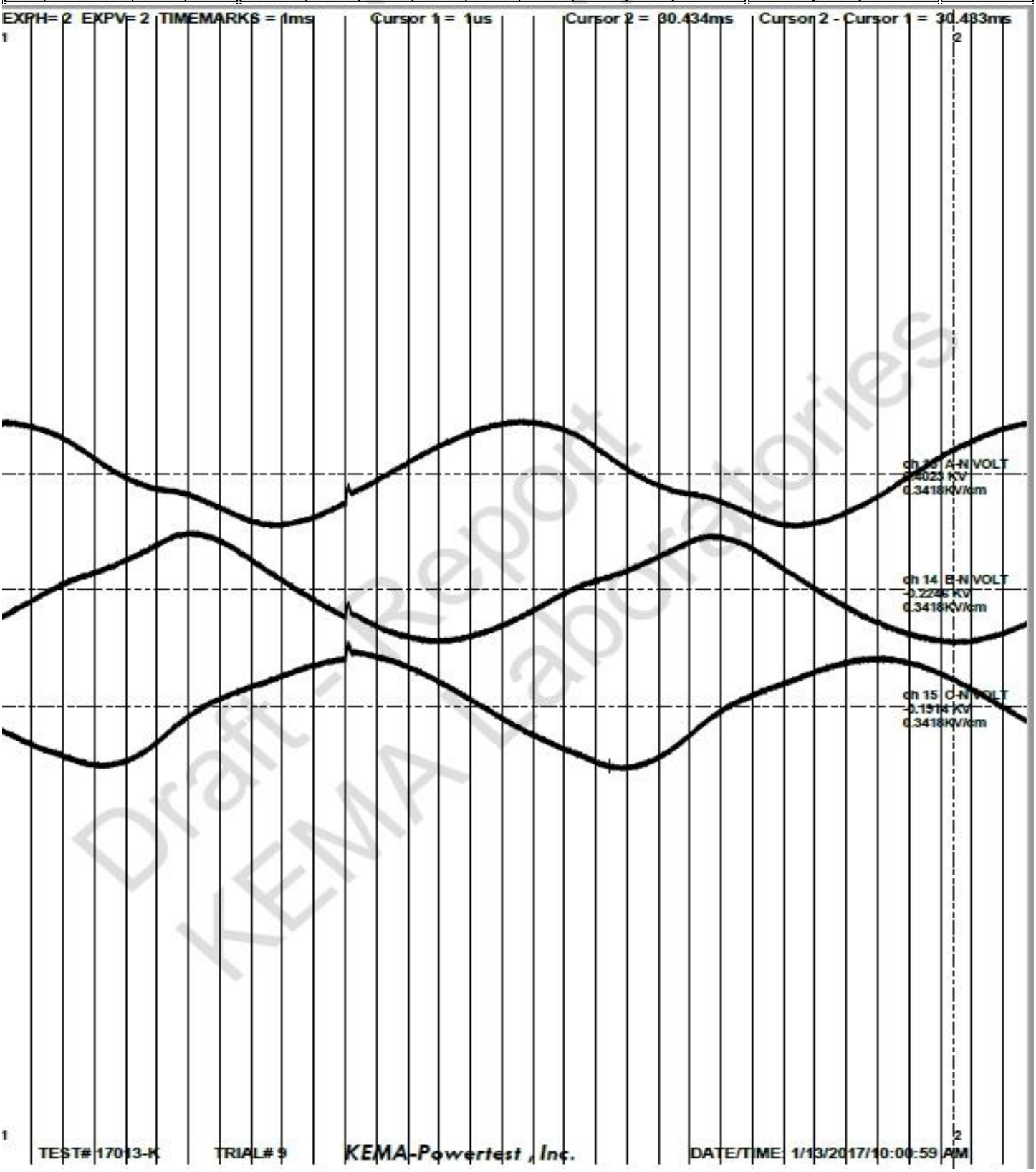
CIRCUIT SCHEMATIC LAB2407



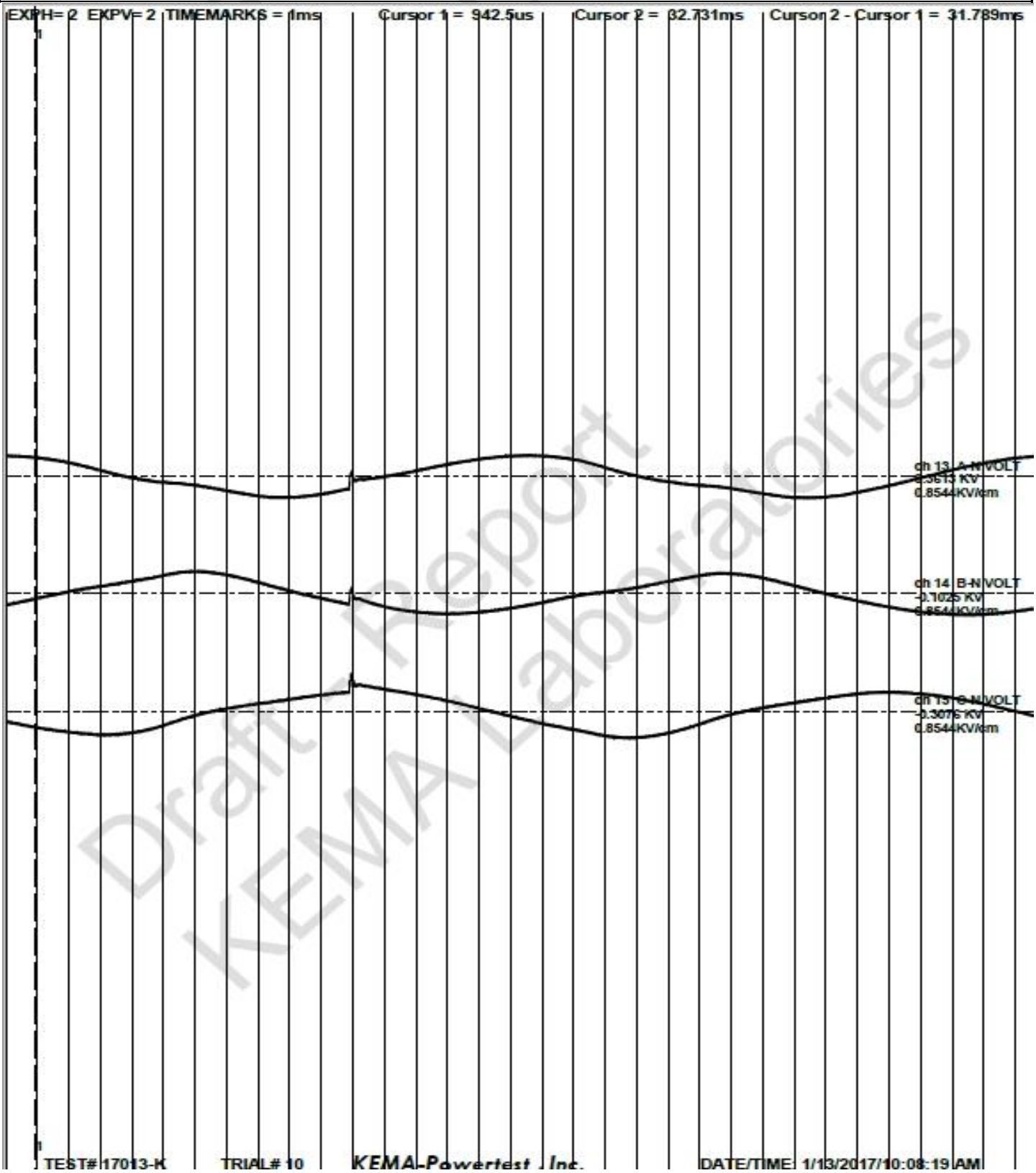
LEGEND

G	Generator
MB	Master Breaker
X_s	Station Reactance
ABUB	Auxiliary Back Up Breaker
MS	Making Switch
XFRM	Transformer
AUX	Auxiliary Circuit Breakers
Rdis	Discharge Resistor
Rch	Charge Resistor
TD	Test Device
CAP	High Voltage Capacitor
HV PS	High Voltage DC Power Supply
I	Current Measurement
V	Voltage Measurement
X_L	Load Reactance

Trial	Sample	Test Duty	O.C.V. (V)	Phase	Total (A)	Sym (A)	Peak (A)	Total @ End (A)	Sym @ End (A)	TD Gnd I pk (A)	Curr. Dura. (ms)	Transient Duration (µs)	Phase	C.C. Volts (V)	Transient Peak (V)	Remarks
9	2.4kV charge	With	480.00	A	35.61	28.44	62.79	-	25.67	-	390	339	A-N	279	-	2,3
	TD connected			B	33.17	26.34	57.03	-	25.30	-	390	339	B-N	278	-	
				C	50.27	28.66	82.76	-	25.51	-	390	339	C-N	280	461	
				AVG	39.68	27.81	-	-	25.50	-2.03	-	-	AVG L-L	483	-	

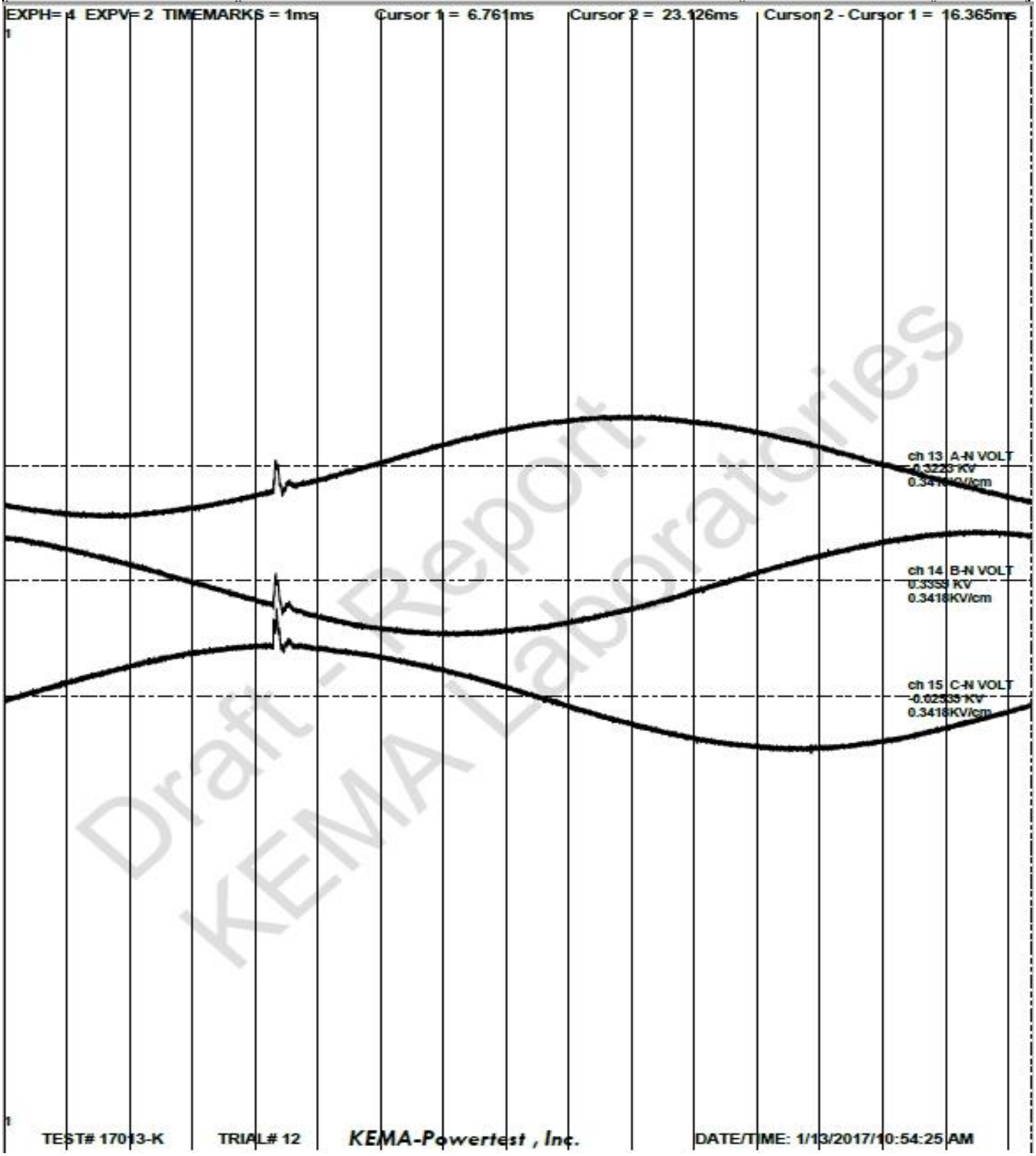


Trial	Sample	Test Duty	O.C.V. (V)	Phase	Total (A)	Sym (A)	Peak (A)	Total @ End (A)	Sym @ End (A)	TD Gnd I pk (A)	Curr. Dura. (ms)	Transient Duration (µs)	Phase	C.C. Volts (V)	Transient Peak (V)	Remarks
10	6.0kV charge	With	480.00	A	34.40	27.84	60.40	-	25.60	-	390	296	A-N	280	-	2,3
	TD connected			B	34.09	26.67	58.59	-	25.51	-	390	296	B-N	275	-	
				C	48.53	28.08	80.08	-	25.53	-5.33	390	296	C-N	281	727	
				AVG	39.01	27.53	-	-	25.55	-	-	-	AVG L-L	483	-	



Trial	Sample	Test Duty	O.C.V. (V)	Phase	Total (A)	Sym (A)	Peak (A)	Total @ End (A)	Sym @ End (A)	TD Gnd I pk (A)	Curr. Dura. (ms)	Transient Duration (µs)	Phase	C.C. Volts (V)	Transient Peak (V)	Remarks
11	2.4kV charge	With	480.00	A	33.59	27.62	58.84	-	25.76	-	390	263	A-N	286	-	1,2,3,4
	TD connected			B	33.25	26.16	57.18	-	25.51	-	390	263	B-N	275	-	
				C	55.99	31.18	91.94	-	25.67	-	390	263	C-N	277	475	
				AVG	40.94	28.32	-	-	25.65	8.2 clip.	-	-	AVG L-L	484	-	

Trial	Sample	Test Duty	O.C.V. (V)	Phase	Total (A)	Sym (A)	Peak (A)	Total @ End (A)	Sym @ End (A)	TD Gnd I pk (A)	Curr. Dura. (ms)	Transient Duration (µs)	Phase	C.C. Volts (V)	Transient Peak (V)	Remarks
12	6.0kV charge	With	480.00	A	33.69	27.69	58.94	-	25.74	-	390	358	A-N	274	-	2,4
	TD connected			B	34.10	26.68	58.64	-	25.62	-	390	358	B-N	279	-	
				C	54.45	30.47	89.36	-	25.62	-	390	358	C-N	287	697	
				AVG	40.75	28.28	-	-	25.66	15.76	-	-	AVG L-L	485	-	



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