Powertech

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Schweitzer Engineering Laboratories

Surge Withstand Capability Tests on 651R Controller and G&W 27 kV VIPER-S Recloser

Powertech

REPORT OF PERFORMANCE

CLIENT/MANUFACTURER	Schweitzer Engineering Laboratories 2440 N.E. Hopkins Court Pullman, WA USA 99163
TEST OBJECT	<u>Recloser Control</u> Type: 651R Serial Number: 5212387053 Part Number: 0651R21AXAAAAF121320XX <u>Recloser</u> Type: VIP388ER-12S Rated Voltage: 27 kV_{rms} BIL: 125 kV Rated Current: 800 A Interrupting Current: 12.5 kA Serial Number: 650-04-0331
TESTED BY	Powertech Labs Inc. 12388 - 88th Ave, Surrey, BC Canada V3W 7R7 www.powertechlabs.com
DATE RECEIVED	2021-09-27
TEST DATE(S)	2021-10-04 to 2021-10-12
TEST SPECIFICATION	IEEE C37.60-2018, Clause 7.111.1 and 7.111.2
TEST RESULT	PASS

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1 INTRODUCTION

At the request of Schweitzer Engineer Laboratories (SEL), a 651R recloser controller, manufactured by SEL, and Viper-S 27 kV recloser, manufactured by G&W Electric, were subjected to surge withstand capability tests in accordance with IEEE C37.60-2018. This report summarizes the results of the tests performed.

2 TEST OBJECT INFORMATION

The test object was identified based on the nameplate information as follows:

Recloser/FI

Manufacturer:	G&W Electric Co.
Type:	Viper-S 3-phase recloser
Rated Voltage:	27 kVrms
Rated Current:	800 Arms continuous, 12.5 kArms interrupting
BIL:	125 kV
Serial №:	650-04-0331
Condition:	New

Recloser/FI Controller

Manufacturer:	SEL
Type:	651R
Firmware:	SEL-651R-2-R411-V0-Z011003-D20210317
Serial №:	5212387053
Part №:	0651R21AXAAAAF121320XX
Condition:	New

3 GENERAL INFORMATION

3.1 Purpose

The purpose of the test was to verify if the test object complies with the requirements of the standard.

3.2 Witnesses

Name	Company
Tyler Simmons	SEL
Cody Marshall	SEL
Hesham Ismail	SEL

3.3 Tests Performed

Test Standards/Specifications

IEEE C37.60-2018	Clause 7.111.1 – Oscillatory and fast transient surge tests
	Clause 7.111.2 – Simulated surge arrester operation test

4 SIMULATED SURGE ARRESTER OPERATION TEST

General Information:

Standard	IEEE C37.60-2012, Clause 7.111.2
Test Date	2021-10-04 to 2021-10-05
Test Leader	Alex Webb

Environmental Conditions:

Ambient temperature:	19.6 °C
Barometric Pressure:	750 mmHg
Relative Humidity:	57.9 %

Test Conditions:

The tests was in accordance with the test set-up requirements outlined in section 7.111.2.2 of the test standard. The control was energized and operational during the tests with settings as follows:

a) Value of trip point (pick up setting) not to exceed the rated load current of the device;
b) Reclosers set for the maximum number of operations to lock-out;
c) Other settings for normal operation consistent with a) and b) above.

The surges were applied using the following test levels and configurations:

Test Voltage:	90.4 to 104.8 kV_{peak}
Surge Current:	5.432 to 6.276 kA_{peak}

Table 1: Simulated surge arrester operation test configurations

Configuration	Switch	HV Applied	Conditions
A	Open	Source Terminals	15 positive and 15 negative surges
B	Closed	Source Terminals	15 positive and 15 negative surges
C	Closed	Load Terminals	15 positive and 15 negative surges
D	Open	Properly Rated Transformer	15 positive and 15 negative surges
E	Closed	Properly Rated Transformer	15 positive and 15 negative surges

Requirements:

During the application of surges, the control shall neither close the recloser/FI from an open position nor open (trip) the recloser/FI from a closed position. No change of state shall occur or be reported.

Following the tests, the recloser/FI and control apparatus shall be capable of performing all normal functions without impairment. The following verifications shall be made following the test if supported by the control apparatus:

- Communicate with an external computer;
- Open and close the recloser;
- Upload event(s) or oscillography captured;
- Receive a firmware download;
- Receive a program download;
- Perform the rated maximum number of sequence operations at any convenient pick-up level.

Evaluation:

No change of state of the recloser occurred during the application of the surges, and the controller successfully performed all the above verifications at the conclusion of the test.

Result:

PASS

5 OSCILLATORY AND FAST TRANSIENT SURGE TESTS

General Information:

Standard	IEEE C37.60-2012, Clause 7.111.1
Test Date	2021-10-11 to 2021-10-12
Test Leader	Alex Webb

Test Conditions:

The tests were performed in accordance with IEEE C37.90.1-2012. The controller and recloser were tested while connected to 120 Volts, 60 Hz supply for all tests. Test surges were applied to the AC power cord and control cable using an external coupling/decoupling network in common and transverse mode, in accordance with Table 3 and 4 of IEEE C37.90.1.

Oscillatory Test Voltage:	4 kV_{peak}
Fast Transient Test Voltage:	2.5 kV_{peak}

Oscillatory Waveform Validity Tests

	Pre-Test	Post-Test	Requirements
Generator output voltage:	2.5 kV	2.5 kV	
Feed through voltage test:	2.8 V	2.0 V	(pass if ≤ 1%)

Test Generator performance verification:

	Pre-Test	Post-Test	Requirements
Test duration:	2.08 s	2.138 s	(2.0 to 2.2 s)
Repetition rate:	8 bursts / 16.7 ms	8 bursts / 16.7 ms	(6 to 10 bursts per # ms)
Oscillation frequency:	0.940 MHz	0.936 MHz	(0.9 to 1.1 MHz)
Waveform envelope decay:	4.9 µs	4.4 µs	(4 to 6 µs to 50%)
Rise time of the first peak:	61 ns	78 ns	(60 to 90 ns – 10% to 90%)
Peak voltage level (no load):	2.43 kV	2.283 kV	(2.25 to 2.5 kV when set to 2.5 kV)
Output impedance:	163 Ω	192 Ω	(160 to 240 Ω)

Fast Transient Waveform Validity Tests

	Pre-Test	Post-Test	Requirements
Generator output voltage:	4 kV	4 kV	
Feed through voltage test:	0.2 V	1.4 V	(pass if ≤ 1%)

Test Generator performance verification:

	Pre-Test	Post-Test	Requirements
Test duration:	60.99 s	61.01 s	(≥60 s)
Burst period:	300.8 ms	300.0 ms	(240 to 360 ms)
Burst duration:	14.8 ms	14.8 ms	(12 to 18 ms)
Repetition rate:	2.5 kHz	2.5 kHz	(2 to 3 kHz)
Impulse duration:	51 ns	43.4 ns	(35 to 65 ns to 50% value)
Rise time:	4.69 ns	4.40 ns	(3.5 to 6.5 ns – 10% to 90%)
Peak voltage level (no load):	4.189 kV	3.972 kV	(3.6 to 4.4 kV when set to 4 kV)
Output impedance:	55.4 Ω	56.7 Ω	(40 to 60 Ω)

The test configurations can be found in Appendix C. The controller signals were monitored during the tests using fibre-optic communications. The system communications diagram can be found in Appendix D.

Requirements:
The equipment is considered to have passed the tests if all the following conditions are met:

a) The specified performance of the equipment, including operating time, does not change beyond stated tolerances.
b) No hardware damage occurs.
c) No change in calibration beyond normal tolerances results.
d) No loss or corruption of stored memory or data, including active or stored settings, occurs
e) System resets do not occur, and manual resetting is not required.
f) Established communications not affecting protection functions recover within the manufacturer's time period, if disrupted.
g) Communications errors, if they occur, do not jeopardize the protective functions.
h) No loss of digital pulse synchronization occurs or where the loss of digital pulse synchronization does occur, it shall not produce and out of tolerance condition.
i) No changes in the states of the electrical, mechanical, or communications status outputs occur. This includes alarms, status outputs, or targets.

Evaluation:
The controller signals were monitored during the tests, and no activity was observed. The device successfully met all the requirements of the test standard.

Result:
PASS

APPENDIX A – EXAMPLE SSAO WAVEFORMS

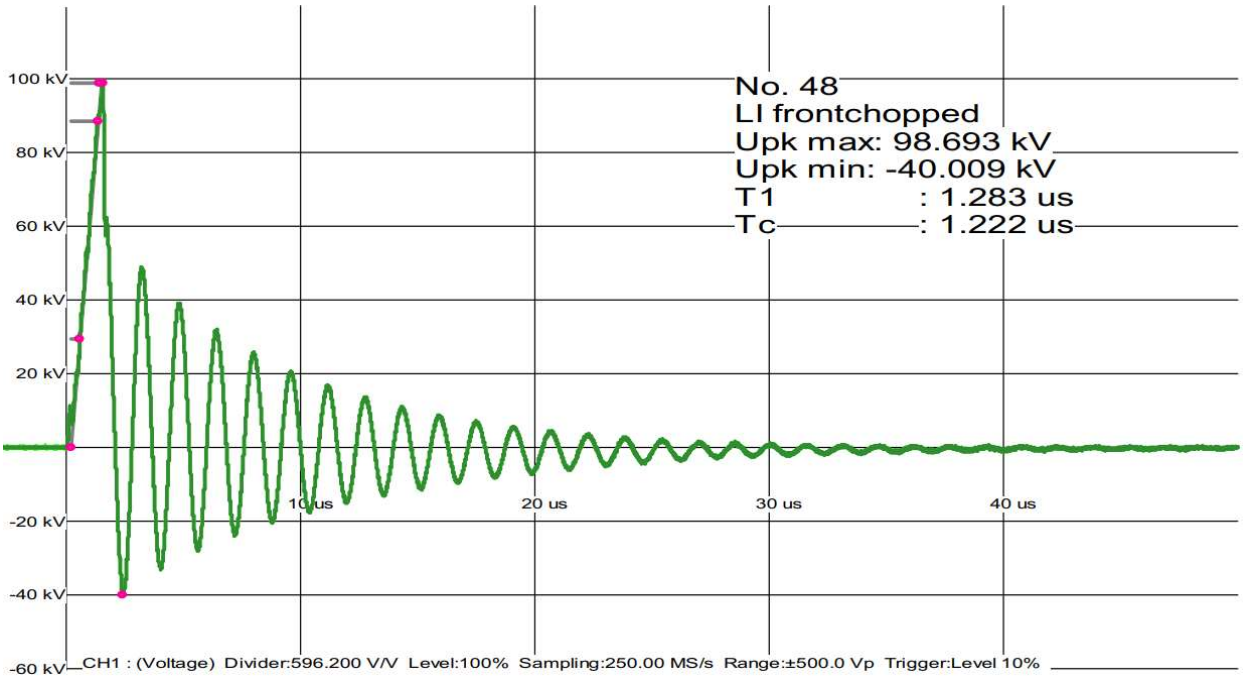

Figure 1. Example positive surge voltage waveform

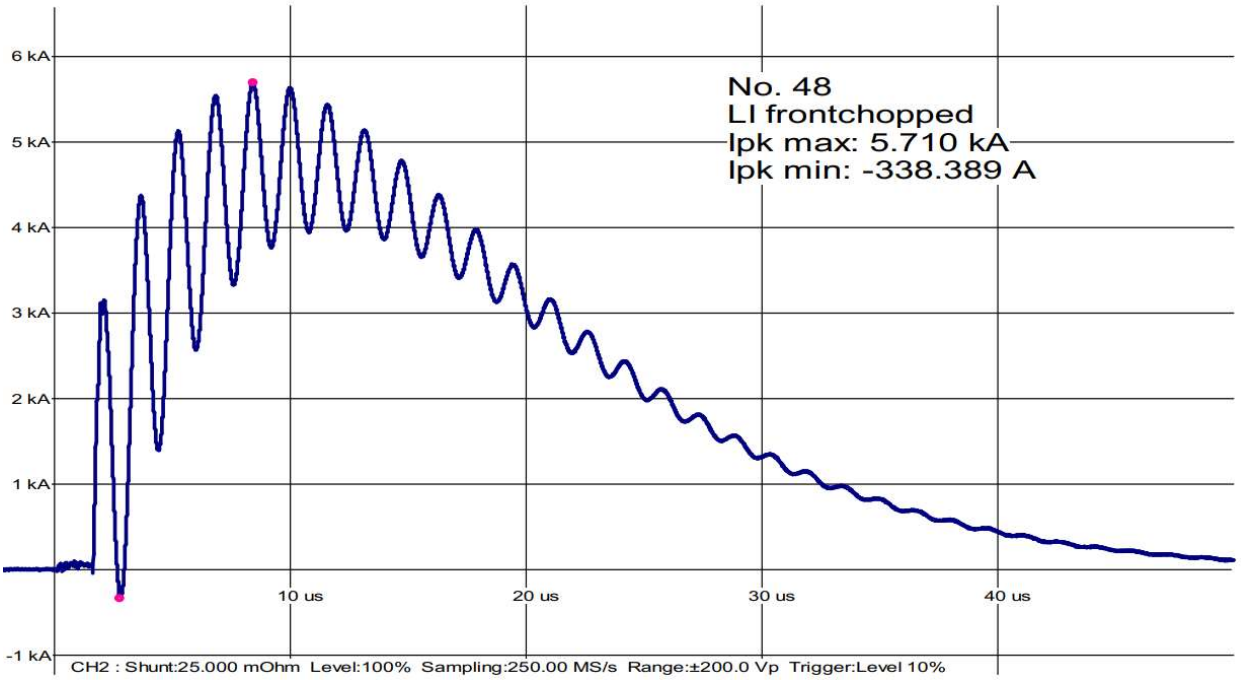

Figure 2. Example positive surge current waveform

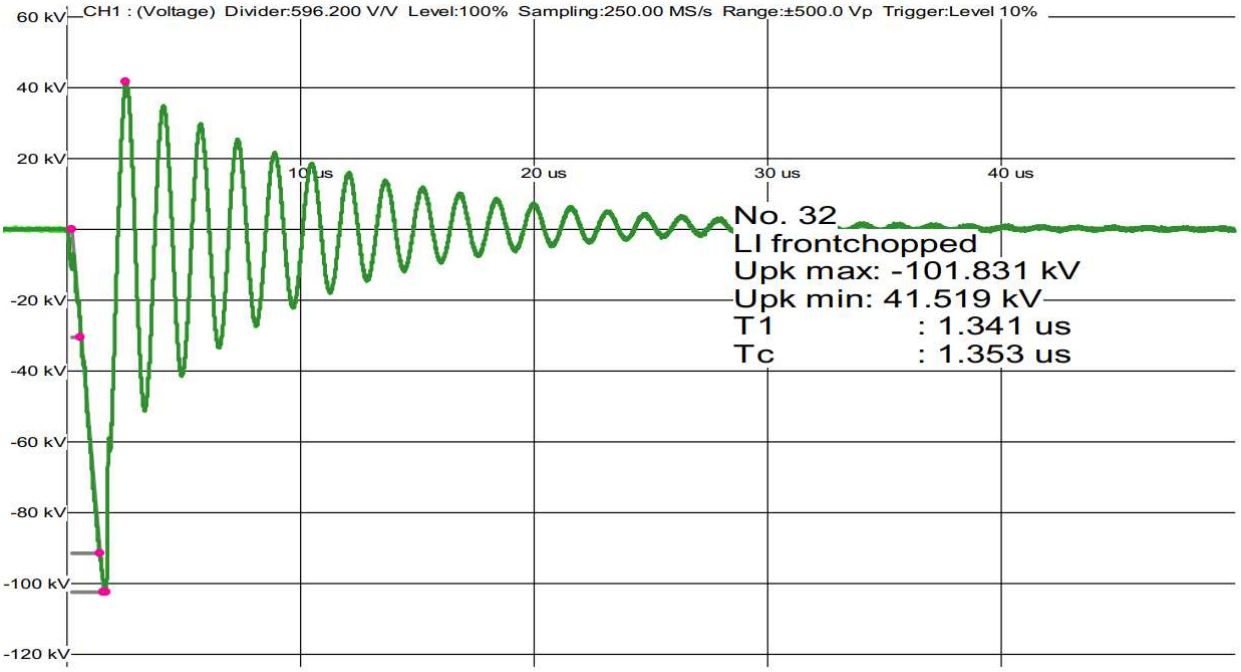

Figure 3. Example negative surge voltage waveform

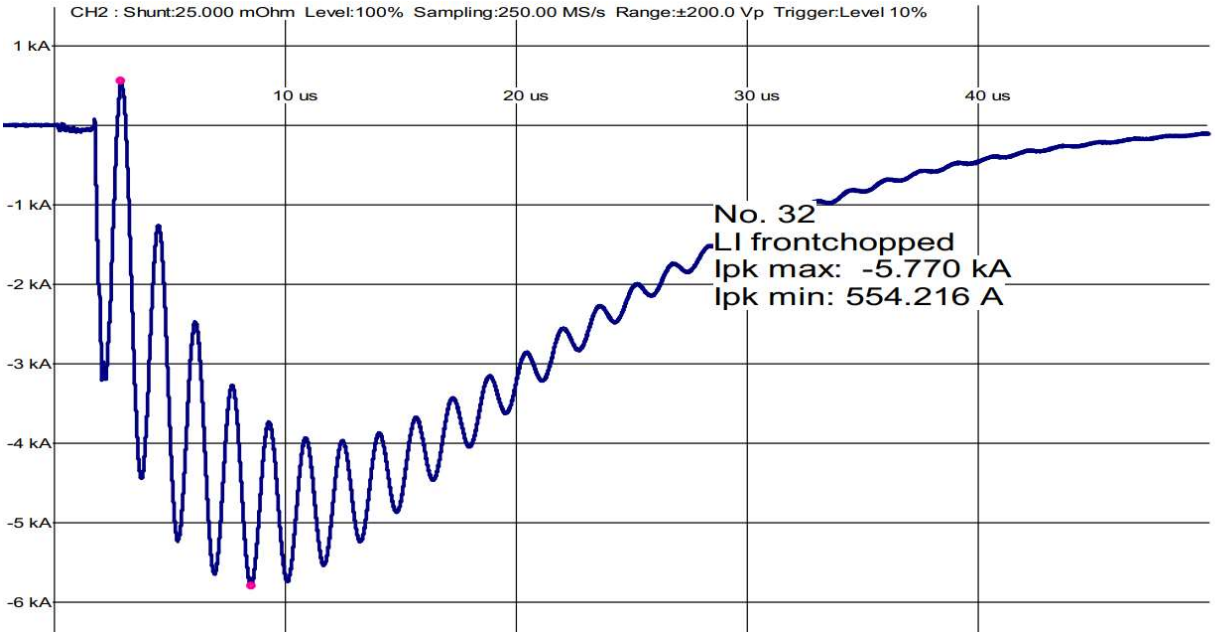

Figure 4. Example negative surge current waveform

APPENDIX B – OSCILLATORY AND FAST TRANSIENT SURGE WAVEFORMS

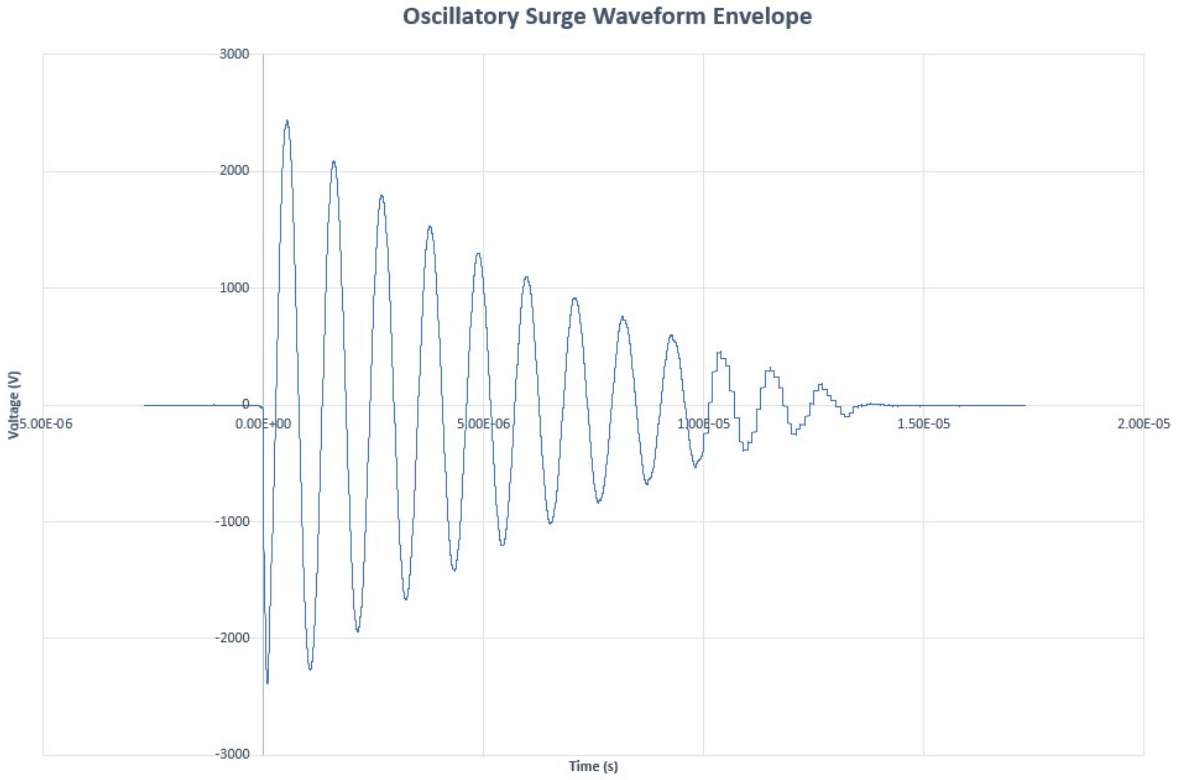

Figure 5. Oscillatory Surge Waveform (1)

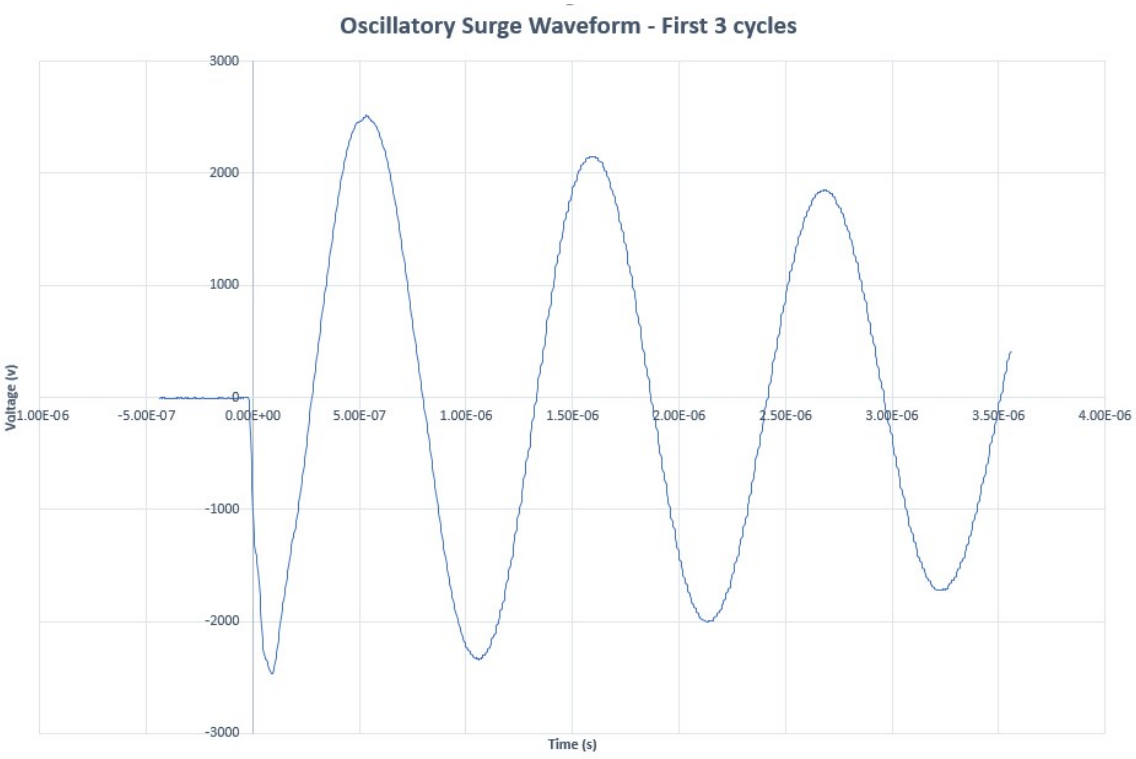

Figure 6. Oscillatory Surge Waveform (2)

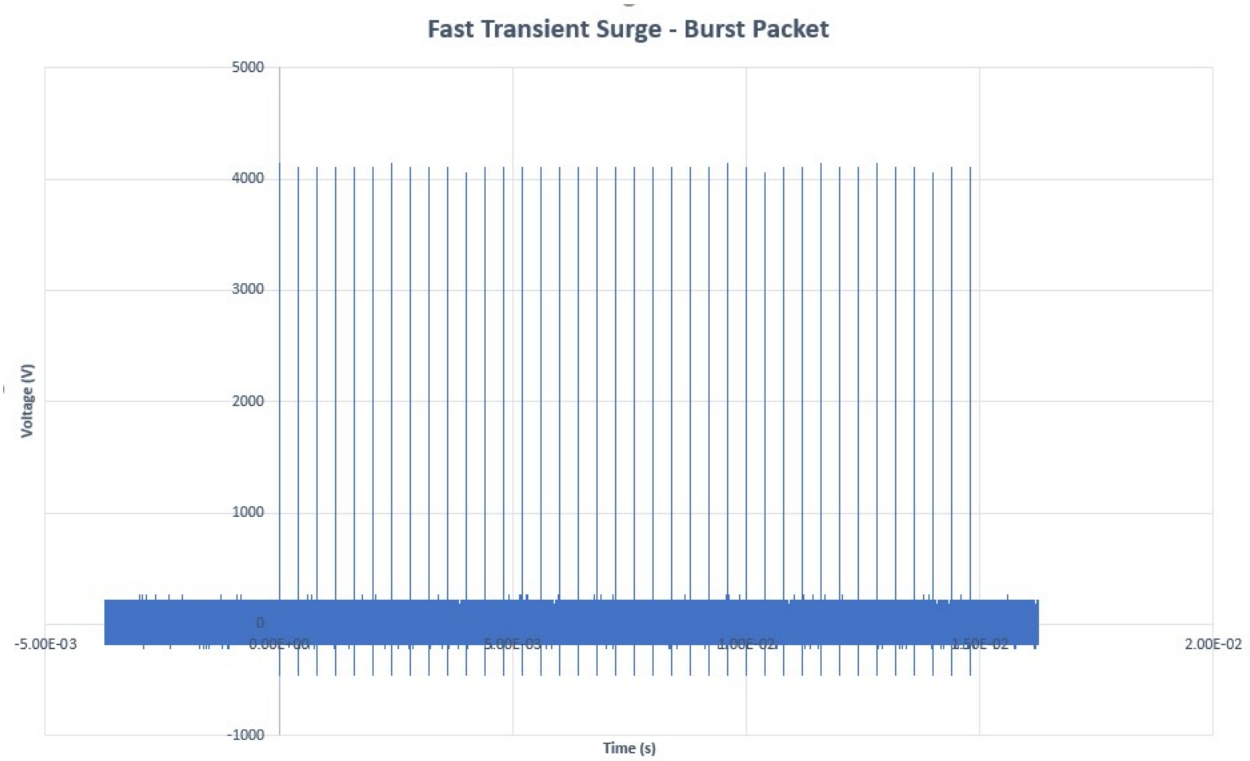

Figure 7. Fast Transient Surge Waveform (1)

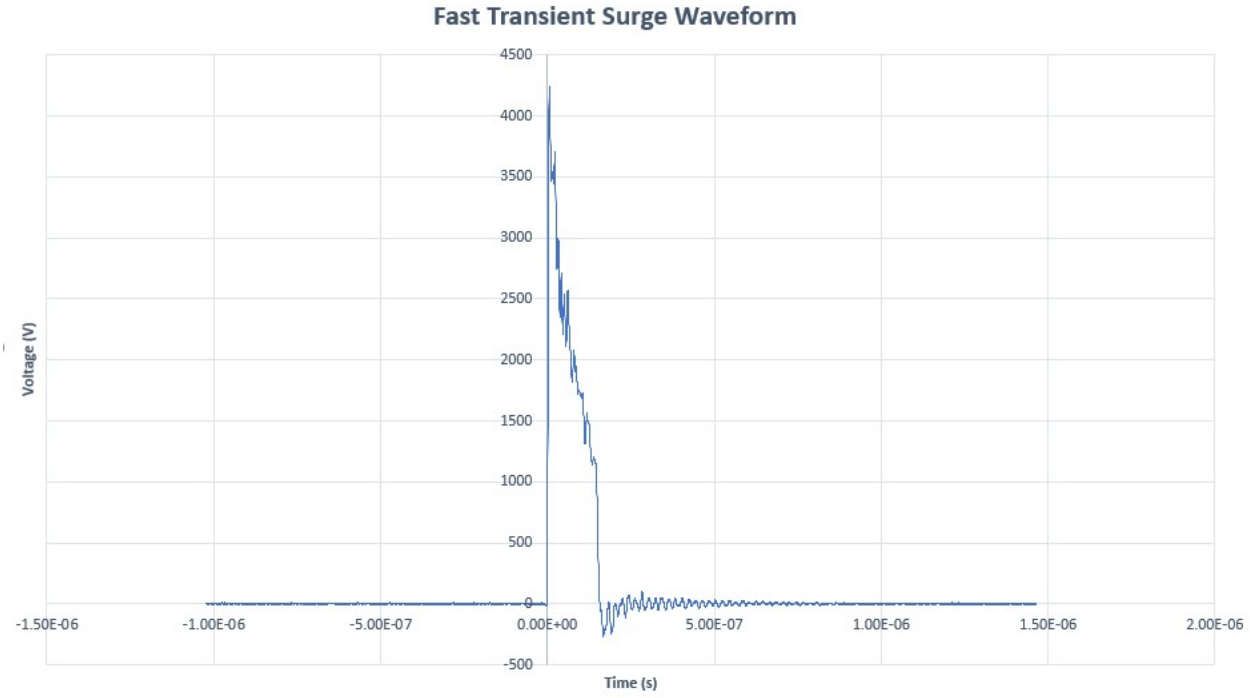

Figure 8. Fast Transient Surge Waveform (2)