EMC Testing of the

Data Panel Corp.
Controller Model 34044-1

In accordance with:
ISO 13766-2:2018
EN 13309:2010

America

Add value.
Inspire trust.

Prepared for: Data Panel Corp.
181 Cheshire Lane, Suite 300
Plymouth, MN 55441 USA

COMMERCIAL-IN-CONFIDENCE

Document Number: NC72152279.1 | Issue: 1

SIGNATURE			
			
NAME	**JOB TITLE**	**RESPONSIBLE FOR**	**ISSUE DATE**
Sean Sellergren	EMC Test Engineer	Authorized Signatory	26 September 2019

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD America, Inc. document control rules.

EXECUTIVE SUMMARY
A sample of this product was tested and found to be compliant with ISO 13766-2:2018 and EN 13309:2010.

A2LA Cert. No. 2955.11

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Contents

1 Report Summary

1.1 Report Modification Record

Alterations and additions to this report will be issued to the holders of each copy in the form of a complete document.

Table 1.1-1 – Modification Record

Issue	Description of Change	Date of Issue
1	First Issue	26 September 2019

1.2 Introduction

Applicant	Shi Xiang Lim
Manufacturer	Data Panel Corp.
Applicant's Email Address	llim@datapanel.com
Model Number(s)	34044-1
Serial Number(s)	N/A
Hardware Version(s)	N/A
Software Version(s)	N/A
Number of Samples Tested	1
Test Specification/Issue/Date	ISO 13766-1:2018 EN 13309:2010
Order Number	72152279.1
Date of Receipt of EUT	19 August 2019
Condition of EUT	Normal - No Damage
Start of Test	19 August 2019
Finish of Test	21 August 2019
Related Document(s)	N/A

1.3 Summary of Tests & Results

A summary of the tests carried out in accordance with the specifications shown below.

Table 1.3-1 – Summary of Tests

Report Section	Specification Clause		Test Description	Accreditation	Comments
	ISO 13766-2	EN 13309			
2.1	4.5 & 4.6 (ISO 13766-1)	4.5 & 4.6	Electromagnetic Radiated Emissions	A2LA	
2.2	4.9.3 (ISO 13766-1)	4.9.3	Conducted Transient Emissions	A2LA	
2.3	5.3.3	4.9	Immunity to Conducted Transients on Power Leads	A2LA	
2.3	5.3.3	N/A	Immunity to Electrical Transients on Non-Supply Lines	A2LA	
2.4	5.3.4	4.8	Electrostatic Discharges	A2LA	N/A. No ESD testing required per customer.
2.5	5.3.1	4.7	Immunity to Electromagnetic Radiation [ALSE Method]	A2LA	Tested from 1-400 MHz
2.6	5.3.1	4.7	Immunity to Electromagnetic Radiation [BCI Method]	A2LA	Tested from 400-2700 MHz
Tested in **Configuration and Mode 1 and 2**					

Table 1.3-2 – Summary of Results

Test Name	Name of Tester(s)	Result
Immunity to Conducted Transients on Power Leads	Thomas J Brumbaugh	Pass
Immunity to Electrical Transients on Lines	Thomas J Brumbaugh	Pass
Electromagnetic Radiated Emissions	Thomas J Brumbaugh	Pass
Conducted Transient Emissions	Thomas J Brumbaugh	Pass
Electrostatic Discharges	Thomas J Brumbaugh	N/A. No ESD testing required per customer.
Immunity to Electromagnetic Radiation [ALSE Method]	Thomas J Brumbaugh	Pass
Immunity to Electromagnetic Radiation [BCI Method]	Thomas J Brumbaugh	Pass

1.4 Declaration of Build Status

EQUIPMENT DESCRIPTION	
Model Name/Number	34044-1
Serial Number	N/A
Hardware Version	N/A
Software Version	N/A
Technical Description (Please provide a brief description of the intended use of the equipment)	The device is a combo I/O module which has a solid-state design with digital or PWM outputs, digital or analog inputs. It is designed to meet the requirements of the utility truck market.

UN-INTENTIONAL RADIATOR	
Highest frequency generated or used in the device or on which the device operates or tunes	**N/A**
Lowest frequency generated or used in the device or on which the device operates or tunes	**N/A**

Power Source			
AC	Single Phase	Three Phase	Nominal Voltage
	☐	☐	
External DC	Nominal Voltage		Maximum Current
	24 VDC		N/A
Battery	Nominal Voltage		Battery Operating End Point Voltage

EXTREME CONDITIONS					
Maximum temperature	N/A	°C	Minimum temperature	N/A	°C

Ancillaries
Control Box used to Monitor EUT during immunity testing.
Fiber optic isolator

1.5 Product Information

1.5.1 Technical Description

The Equipment Under Test (EUT) was a combo I/O module which has a solid-state design with digital or PWM outputs, digital or analog inputs. It is designed to meet the requirements of the utility truck market.

A full description and detailed product specification details are available from the manufacturer.

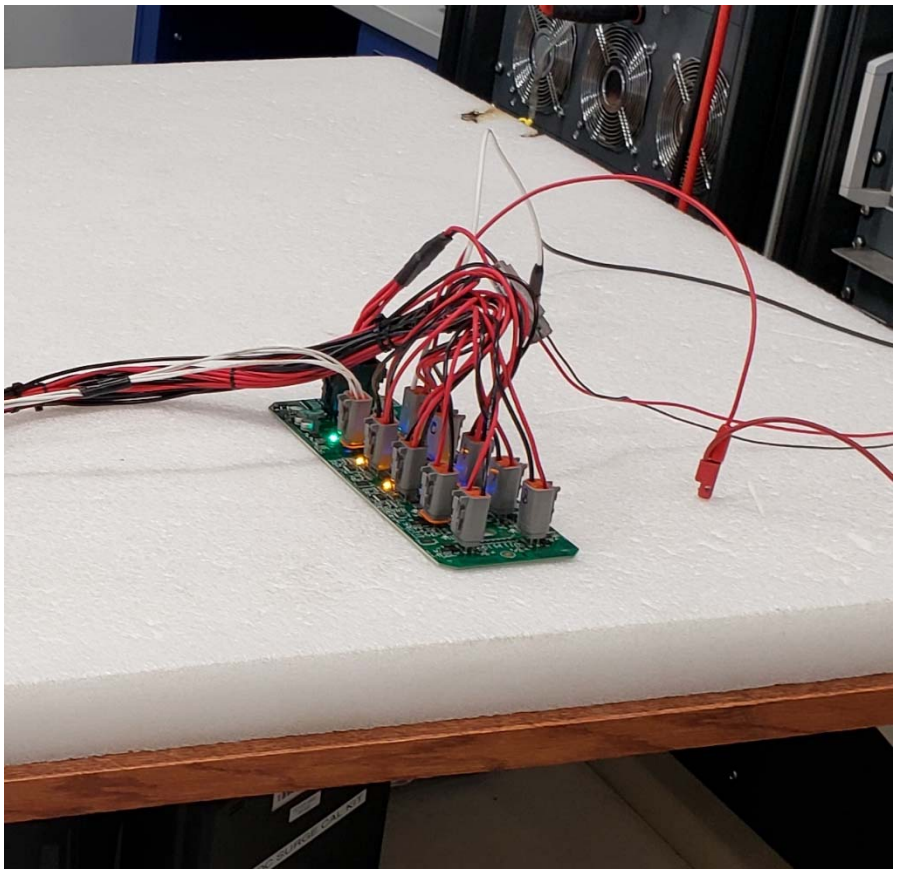


Figure 1.5.1-1 - Front View of the EUT

Table 1.5.1-1 – Cable Descriptions

Cable/Port	Description
Power Cable	24/27 VDC Applied to EUT during testing
I/O Cable	Cable bundle attached to board.
Data Cable	Cable bundle attached to board.

Table 1.5.1-2 – Support Equipment Descriptions

Make/Model	Description
Control Box	Used to Monitor EUT during immunity testing.
Fiber Optic Isolator	Used during BCI and Radiated Immunity Testing

1.5.2 Mode of Operation

Configuration and Mode 1: The EUT was powered at 27 VDC while being subjected to Immunity Testing. A Control Box was connected to the EUT to monitor its performance when tested. For Immunity to Electromagnetic Radiation testing, an optical isolator was used to prevent the support equipment from being affected.

Configuration and Mode 2: The EUT was powered at 13.5 VDC or 27 VDC while being subjected to Emissions Testing. For Electromagnetic Radiated Emissions testing, an optical isolator was used to prevent the support equipment from being affected.

1.6 Deviations from the Standard

Immunity to Electrostatic Discharges was not tested per customer request.

1.7 EUT Modification Record

The table below details modifications made to the EUT during the test program. The modifications incorporated during each test are recorded on the appropriate test pages.

Table 1.7-1 – Modification Record

Modification State	Description of Modification still fitted to EUT	Modification Fitted By	Date Modification Fitted
0	Initial State	N/A	N/A

1.8 Classification of Functional Status

Class A: All functions of a device/system perform as designed during and after exposure to disturbance.
Class B: All functions of a device/system perform as designed during exposure. However, one or more of them can go beyond specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain class A.
Class C: One or more functions of a device/system do not perform as designed during exposure but return automatically to normal operation after exposure is removed.
Class D: One or more functions of a device/system do not perform as designed during exposure and do not return to normal operation until exposure is removed and the device/system is reset by simple "operator/use" action.
Class E: One or more functions of a device/system do not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

1.9 Test Location

TÜV SÜD conducted the following tests at our New Brighton, MN Test Laboratory.

Office address:

TÜV SÜD America
141 14th Street NW
New Brighton, MN 55112 USA

2 Test Details

2.1 Radiated Emissions

2.1.1 Specification Reference

See §1.3 for the specification references relevant to this EUT.

2.1.2 Equipment Under Test and Modification State

As shown in §1.5 with Modification State “0” as shown in §1.7.

EUT powered at 13.5VDC and 27VDC during testing.

2.1.3 Date of Test

19 August 2019

2.1.4 Test Method

The EUT was setup in a semi-anechoic chamber and laid on a non-conductive support 5cm above a copper ground plane table with a height of 90cm (± 10cm). The EUT was placed 20cm from the front edge of the ground plane while the stretched-out cable bundle was 10cm from the front edge. Each measurement antenna had a height of 10cm above the ground plane table and a measurement distance of 1m from the front edge of the routed cabling. For the frequency range of 30–1000 MHz, the antenna was centered on the test setup and focused on the cable bundle.

The EUT emission profile was made using a measurement receiver that utilized a peak and average detector for the required frequency ranges. The peak and average data collected was compared to the applicable peak and average test limits via software to determine pass or fail conditions. In the event a Quasi-peak measurement was required, the test software would identify those frequencies and a subsequent Quasi-peak measurement would be made. The test measurements were made in both horizontal and vertical antenna orientation for all frequencies above 30 MHz.

2.1.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.1.6 Additional Observations

The frequency range investigated was 30 MHz to 1 GHz.

Measurements were made using BAT-EMC (v3.18) automated software. Reported levels are the actual level with all the correction factors mathematically accounted for. Correction Factor column is for informational purposes only. See Section 2.2.6 below for sample computation.

2.1.7 Sample Computation (Electromagnetic Radiation Disturbance) – Example Only

Measuring equipment raw measurement (dBµV) @ 30 MHz			20.0
Correction Factor (dB)	Cable 2	0.24	18.94
	NBLE11579 (antenna)	18.70	
Reported Quasi-peak Final Measurement (dBµV/m) @ 30MHz			38.94

Note: The values shown above are for example purposes only and not a reflection of the measured data taken during this test program.

2.1.8 Test Results

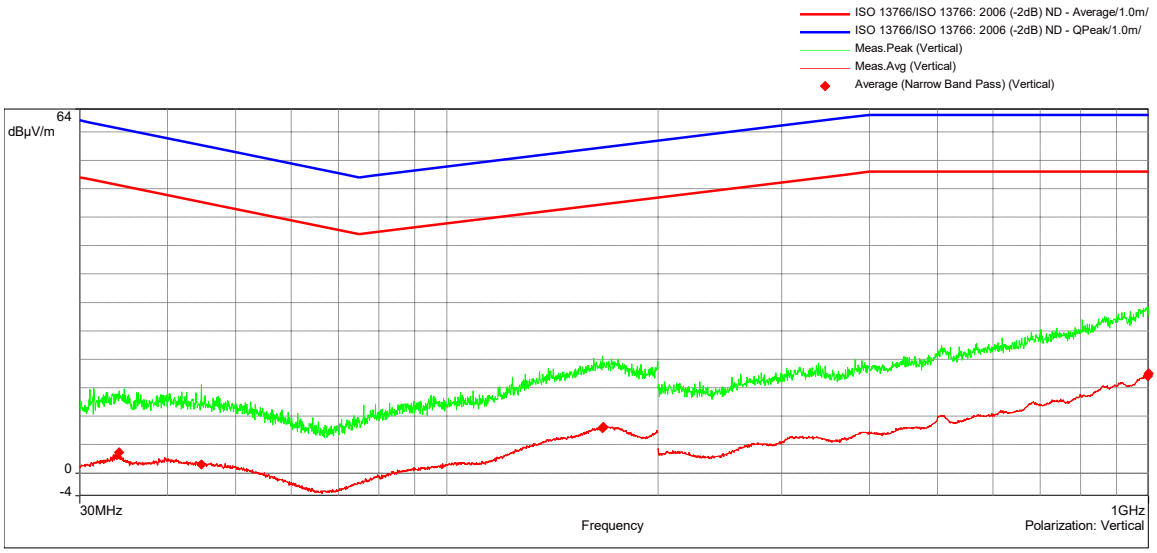
The EUT was tested in **Configuration and Mode 2** as described in Section 1.5.2 of this test report.

Performance assessment of the EUT made during this test: **Pass**

Detailed results are shown below.

30 MHz–1 GHz – Vertical Ambient Measurement

Frequency Range	Antenna Distance	Antenna Height	Antenna Polarization	RBW	Step Size	Sweep Time
30MHz- 200MHz	1m	1m	Vertical	120kHz	50kHz	5 ms/Pts
200MHz- 1GHz	1m	1m	Vertical	120kHz	50kHz	5 ms/Pts



Limit:	Class	EUT Orientation:	Test Results:
ISO 13766: 2018 (-2dB)	ND	Front	Pass

Figure 2.1.8-1 – Graphical Results for 30 MHz–1 GHz – Vertical Ambient Measurement

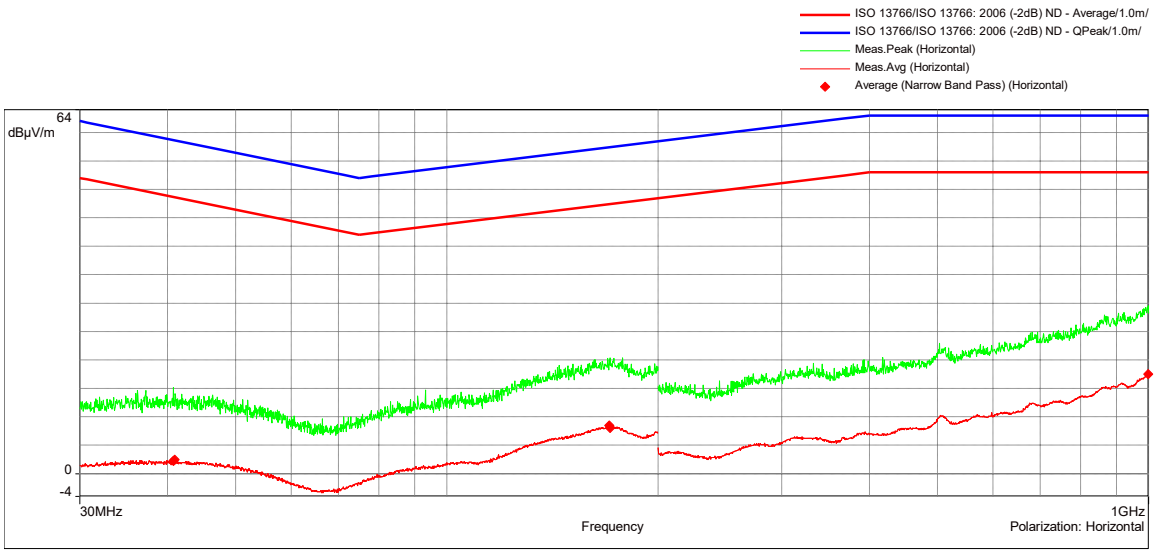
Table 2.1.8-1 – Data Table for 30 MHz–1 GHz – Vertical Ambient Measurement

Frequency	Peak (dBuV/m)	Peak Margin (dB)*	Average (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	QPeak (dBuV/m)	QPeak Limit (dBuV/m)	QPeak Margin (dB)	Peak-Avg Delta	Results
34.1MHz	14.45	-46.15	3.60	50.60	-47.00	N/A	60.60	N/A	10.85	Pass
44.7MHz	15.51	-42.14	1.48	47.65	-46.17	N/A	57.65	N/A	14.03	Pass
166.75MHz	20.51	-36.74	7.88	47.25	-39.37	N/A	57.25	N/A	12.63	Pass
167.2MHz	18.49	-38.78	8.12	47.27	-39.15	N/A	57.27	N/A	10.37	Pass
997.25MHz	29.25	-33.75	17.06	53.00	-35.94	N/A	63.00	N/A	12.19	Pass
999.8MHz	28.19	-34.81	17.52	53.00	-35.48	N/A	63.00	N/A	10.66	Pass

* Peak reading vs. Quasi-Peak Limit

30 MHz–1 GHz – Horizontal Ambient Measurement

Frequency Range	Antenna Distance	Antenna Height	Antenna Polarization	RBW	Step Size	Sweep Time
30MHz- 200MHz	1m	1m	Horizontal	120kHz	50kHz	5 ms/Pts
200MHz- 1GHz	1m	1m	Horizontal	120kHz	50kHz	5 ms/Pts



Limit:	Class	EUT Orientation:	Test Results:
ISO 13766: 2018 (-2dB)	ND	Front	Pass

Figure 2.1.8-2 – Graphical Results for 30 MHz–1 GHz – Horizontal Ambient Measurement

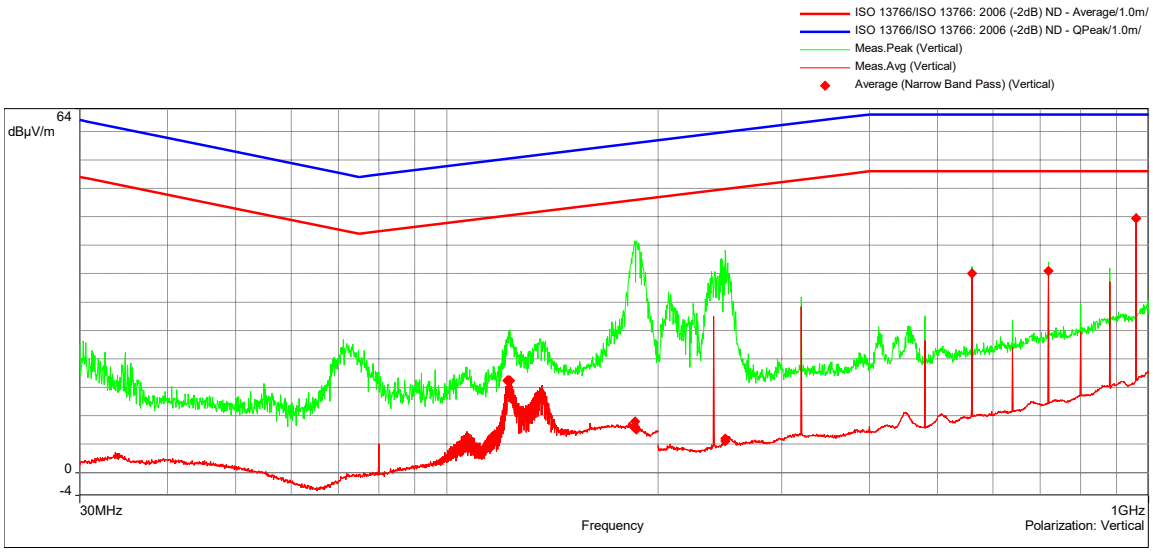
Table 2.1.8-2 – Data Table for 30 MHz–1 GHz – Horizontal Ambient Measurement

Frequency	Peak (dBuV/m)	Peak Margin (dB)*	Average (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	QPeak (dBuV/m)	QPeak Limit (dBuV/m)	QPeak Margin (dB)	Peak-Avg Delta	Results
40.75MHz	15.13	-43.53	2.27	48.66	-46.39	N/A	58.66	N/A	12.86	Pass
40.95MHz	11.87	-46.73	2.48	48.60	-46.13	N/A	58.60	N/A	9.39	Pass
170.35MHz	20.00	-37.39	8.45	47.39	-38.94	N/A	57.39	N/A	11.55	Pass
170.85MHz	20.38	-37.03	8.01	47.41	-39.40	N/A	57.41	N/A	12.37	Pass
998.5MHz	29.52	-33.48	17.48	53.00	-35.52	N/A	63.00	N/A	12.04	Pass

* Peak reading vs. Quasi-Peak Limit

30 MHz–1 GHz – Vertical Operational Measurement [13.5VDC]

Frequency Range	Antenna Distance	Antenna Height	Antenna Polarization	RBW	Step Size	Sweep Time
30MHz- 200MHz	1m	1m	Vertical	120kHz	50kHz	5 ms/Pts
200MHz- 1GHz	1m	1m	Vertical	120kHz	50kHz	5 ms/Pts



Limit:	Class	EUT Orientation:	Test Results:
ISO 13766: 2018 (-2dB)	ND	Front	Pass

Figure 2.1.8-3 – Graphical Results for 30 MHz–1 GHz – Vertical Operational Measurement

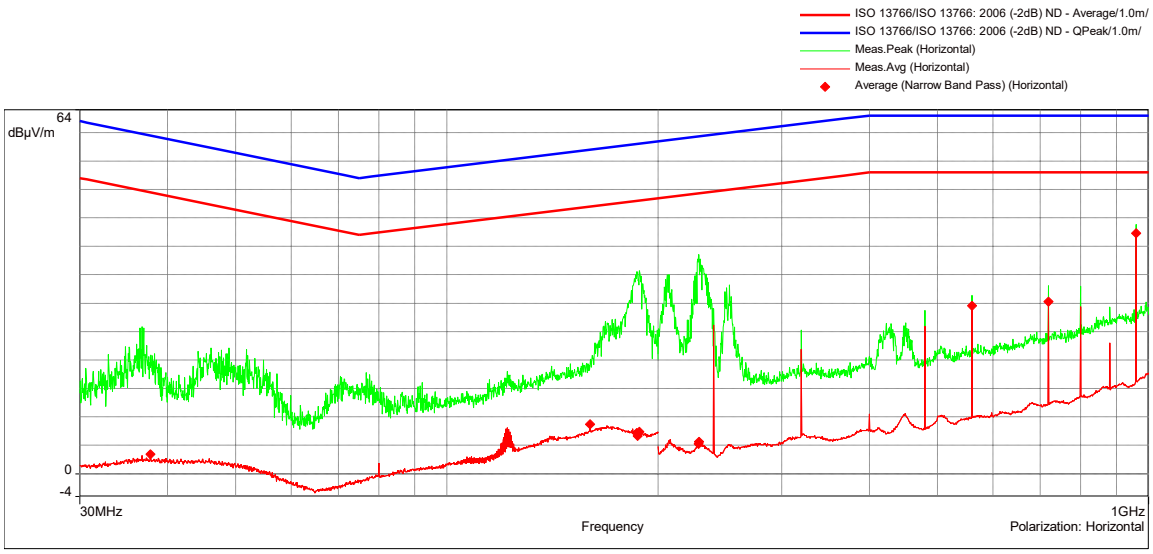
Table 2.1.8-3 – Data Table for 30 MHz– 1 GHz – Vertical Operational Measurement

Frequency	Peak (dBuV/m)	Peak Margin (dB)*	Average (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	QPeak (dBuV/m)	QPeak Limit (dBuV/m)	QPeak Margin (dB)	Peak-Avg Delta	Results
122MHz	23.87	-31.32	16.20	45.20	-29.00	N/A	55.20	N/A	7.67	Pass
122.5MHz	24.10	-31.13	16.25	45.22	-28.97	N/A	55.22	N/A	7.85	Pass
123MHz	23.78	-31.47	16.20	45.25	-29.05	N/A	55.25	N/A	7.58	Pass
185.2MHz	40.75	-17.19	7.91	47.94	-40.03	N/A	57.94	N/A	32.84	Pass
185.45MHz	40.59	-17.35	8.97	47.95	-38.98	N/A	57.95	N/A	31.63	Pass
186.25MHz	40.76	-17.21	7.60	47.98	-40.38	N/A	57.98	N/A	33.16	Pass
249.25MHz	39.04	-20.85	5.55	49.89	-44.35	N/A	59.89	N/A	33.49	Pass
249.45MHz	38.67	-21.23	5.95	49.90	-43.94	N/A	59.90	N/A	32.71	Pass
560MHz	36.24	-26.76	35.02	53.00	-17.98	N/A	63.00	N/A	1.22	Pass
720MHz	37.03	-25.97	35.44	53.00	-17.56	N/A	63.00	N/A	1.60	Pass
960MHz	45.60	-17.40	44.69	53.00	-8.31	N/A	63.00	N/A	0.91	Pass

* Peak reading vs. Quasi-Peak Limit

30 MHz–1 GHz – Horizontal Operational Measurement (13.5VDC)

Frequency Range	Antenna Distance	Antenna Height	Antenna Polarization	RBW	Step Size	Sweep Time
30MHz- 200MHz	1m	1m	Horizontal	120kHz	50kHz	5 ms/Pts
200MHz- 1GHz	1m	1m	Horizontal	120kHz	50kHz	5 ms/Pts



Limit:	Class	EUT Orientation:	Test Results:
ISO 13766: 2018 (-2dB)	ND	Front	Pass

Figure 2.1.8-4 – Graphical Results for 30 MHz–1 GHz – Horizontal Operational Measurement

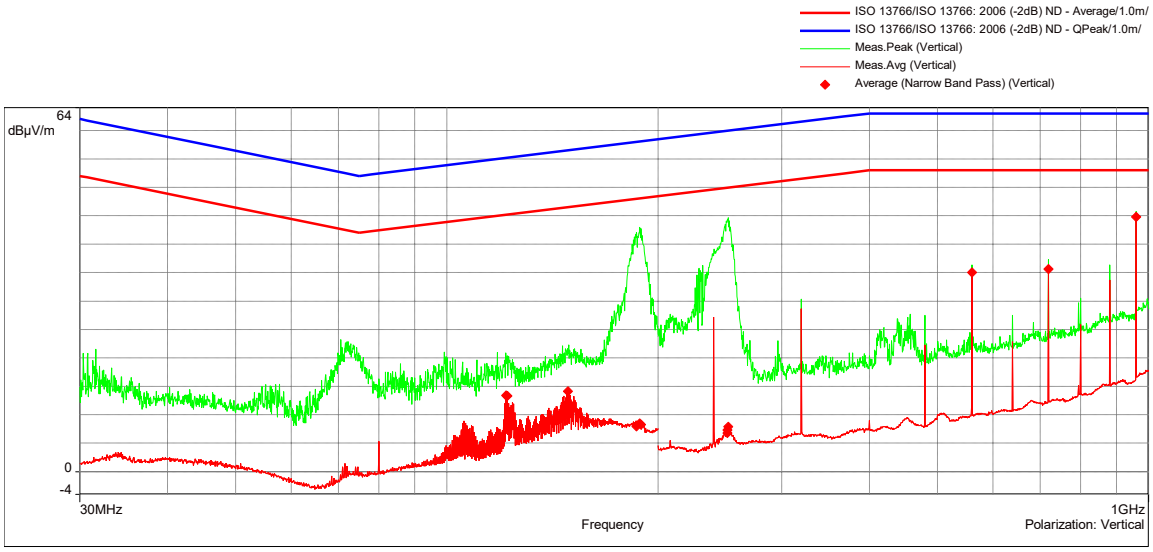
Table 2.1.8-4 – Data Table for 30 MHz–1 GHz – Horizontal Operational Measurement

Frequency	Peak (dBuV/m)	Peak Margin (dB)*	Average (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	QPeak (dBuV/m)	QPeak Limit (dBuV/m)	QPeak Margin (dB)	Peak-Avg Delta	Results
37.8MHz	18.67	-40.81	3.38	49.48	-46.10	N/A	59.48	N/A	15.29	Pass
160MHz	18.20	-38.78	8.72	46.98	-38.25	N/A	56.98	N/A	9.48	Pass
186.6MHz	35.55	-22.44	7.16	47.99	-40.83	N/A	57.99	N/A	28.39	Pass
187.15MHz	35.49	-22.52	6.67	48.01	-41.33	N/A	58.01	N/A	28.82	Pass
188MHz	35.67	-22.37	7.41	48.04	-40.63	N/A	58.04	N/A	28.26	Pass
228.35MHz	38.52	-20.79	5.23	49.32	-44.09	N/A	59.32	N/A	33.29	Pass
228.8MHz	38.51	-20.82	5.60	49.33	-43.73	N/A	59.33	N/A	32.91	Pass
560MHz	31.36	-31.64	29.51	53.00	-23.49	N/A	63.00	N/A	1.85	Pass
720MHz	33.05	-29.95	30.26	53.00	-22.74	N/A	63.00	N/A	2.79	Pass
960MHz	43.86	-19.14	42.31	53.00	-10.69	N/A	63.00	N/A	1.54	Pass

* Peak reading vs. Quasi-Peak Limit

30 MHz–1 GHz – Vertical Operational Measurement (27VDC)

Frequency Range	Antenna Distance	Antenna Height	Antenna Polarization	RBW	Step Size	Sweep Time
30MHz- 200MHz	1m	1m	Vertical	120kHz	50kHz	5 ms/Pts
200MHz- 1GHz	1m	1m	Vertical	120kHz	50kHz	5 ms/Pts



Limit:	Class	EUT Orientation:	Test Results:
ISO 13766: 2018 (-2dB)	ND	Front	Pass

Figure 2.1.8-5 – Graphical Results for 30 MHz–1 GHz – Vertical Operational Measurement

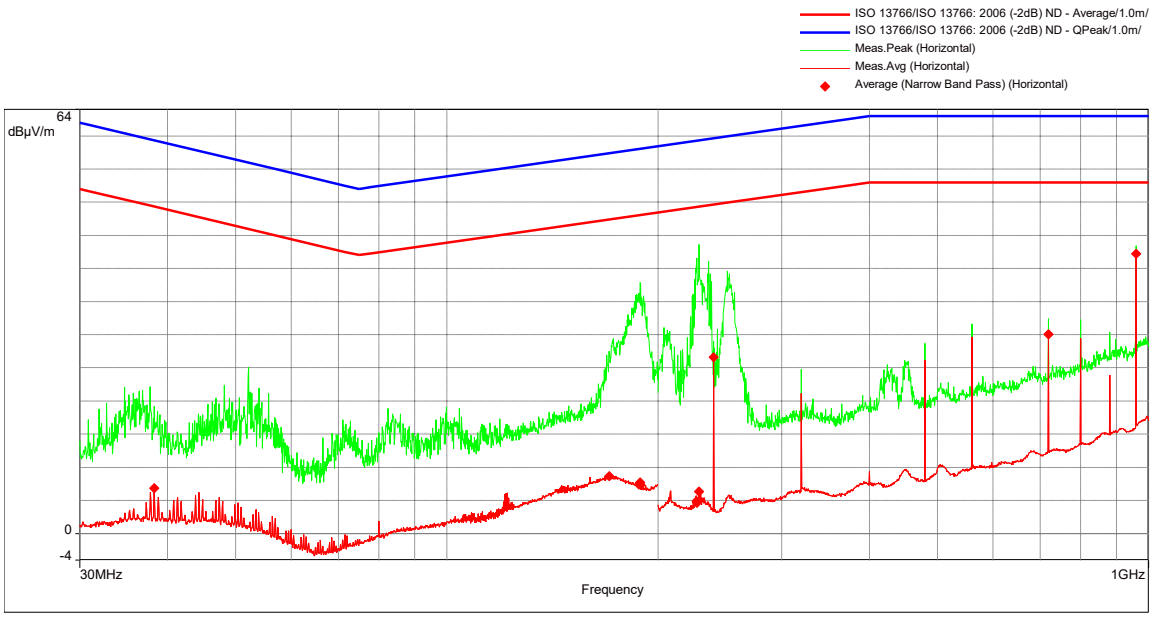
Table 2.1.8-5 – Data Table for 30 MHz–1 GHz – Vertical Operational Measurement

Frequency	Peak (dBuV/m)	Peak Margin (dB)*	Average (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	QPeak (dBuV/m)	QPeak Limit (dBuV/m)	QPeak Margin (dB)	Peak-Avg Delta	Results
121.45MHz	19.71	-35.45	13.39	45.17	-31.78	N/A	55.17	N/A	6.33	Pass
121.95MHz	20.33	-34.86	13.35	45.19	-31.85	N/A	55.19	N/A	6.98	Pass
148.7MHz	21.67	-34.83	14.14	46.50	-32.35	N/A	56.50	N/A	7.53	Pass
186.25MHz	42.06	-15.92	7.99	47.98	-39.99	N/A	57.98	N/A	34.07	Pass
188.25MHz	42.95	-15.09	8.49	48.05	-39.56	N/A	58.05	N/A	34.46	Pass
189MHz	42.73	-15.34	8.23	48.07	-39.84	N/A	58.07	N/A	34.50	Pass
250.95MHz	44.29	-15.65	7.32	49.94	-42.61	N/A	59.94	N/A	36.96	Pass
251.15MHz	44.30	-15.64	6.82	49.94	-43.12	N/A	59.94	N/A	37.48	Pass
251.6MHz	44.61	-15.34	7.86	49.95	-42.09	N/A	59.95	N/A	36.75	Pass
560MHz	36.36	-26.64	35.03	53.00	-17.97	N/A	63.00	N/A	1.33	Pass
720MHz	37.28	-25.72	35.64	53.00	-17.36	N/A	63.00	N/A	1.65	Pass
960MHz	45.73	-17.27	44.80	53.00	-8.20	N/A	63.00	N/A	0.93	Pass

* Peak reading vs. Quasi-Peak Limit

30 MHz–1 GHz – Horizontal Operational Measurement (27VDC)

Frequency Range	Antenna Distance	Antenna Height	Antenna Polarization	RBW	Step Size	Sweep Time
30MHz- 200MHz	1m	1m	Horizontal	120kHz	50kHz	5 ms/Pts
200MHz- 1GHz	1m	1m	Horizontal	120kHz	50kHz	5 ms/Pts



Limit:	Class	EUT Orientation:	Test Results:
ISO 13766: 2018 (-2dB)	ND	Front	Pass

Figure 2.1.8-6 – Graphical Results for 30 MHz–1 GHz – Horizontal Operational Measurement

Table 2.1.8-6 – Data Table for 30 MHz–1 GHz – Horizontal Operational Measurement

Frequency	Peak (dBuV/m)	Peak Margin (dB)*	Average (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)	QPeak (dBuV/m)	QPeak Limit (dBuV/m)	QPeak Margin (dB)	Peak-Avg Delta	Results
38.3MHz	19.18	-40.16	6.84	49.33	-42.50	N/A	59.33	N/A	12.34	Pass
170.4MHz	25.82	-31.57	8.66	47.39	-38.73	N/A	57.39	N/A	17.16	Pass
187.9MHz	36.22	-21.81	7.42	48.04	-40.61	N/A	58.04	N/A	28.80	Pass
188.55MHz	37.88	-20.18	7.73	48.06	-40.32	N/A	58.06	N/A	30.14	Pass
188.8MHz	37.45	-20.62	7.32	48.07	-40.75	N/A	58.07	N/A	30.13	Pass
226.75MHz	41.00	-18.27	4.89	49.27	-44.38	N/A	59.27	N/A	36.12	Pass
227.25MHz	41.52	-17.77	4.65	49.28	-44.63	N/A	59.28	N/A	36.86	Pass
228.85MHz	43.63	-15.70	6.33	49.33	-43.00	N/A	59.33	N/A	37.30	Pass
240MHz	28.98	-30.66	26.58	49.64	-23.07	N/A	59.64	N/A	2.40	Pass
720MHz	32.39	-30.61	30.07	53.00	-22.93	N/A	63.00	N/A	2.32	Pass
960MHz	43.42	-19.58	42.23	53.00	-10.77	N/A	63.00	N/A	1.20	Pass

* Peak reading vs. Quasi-Peak Limit

2.1.9 Test Location and Test Equipment Used

This test was carried out in New Brighton, MN.
Test Area: STS

Table 2.1.9-1 – Equipment List – Radiated Emissions

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE02091	Electro-metrics	Antenna, Log Periodic 0.2-1 GHz	LPA-25	1042	G	05/13/2019	05/13/2021
NBLE02308	Singer	Antenna, Bicon 20-300MHz	94455-1	46	G	10/24/2018	10/24/2020
NBLE11143	Hewlett-Packard	Preamplifier, 0.1 to 1300 MHz	844F	3113A06191	B	01/04/2019	01/04/2020
NBLE11430	Rohde & Schwarz	Receiver, 20 Hz-40 GHz	ESI40	835193/007	G	04/30/2019	04/30/2020

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.1.10 Radiated Emissions Setup Photos

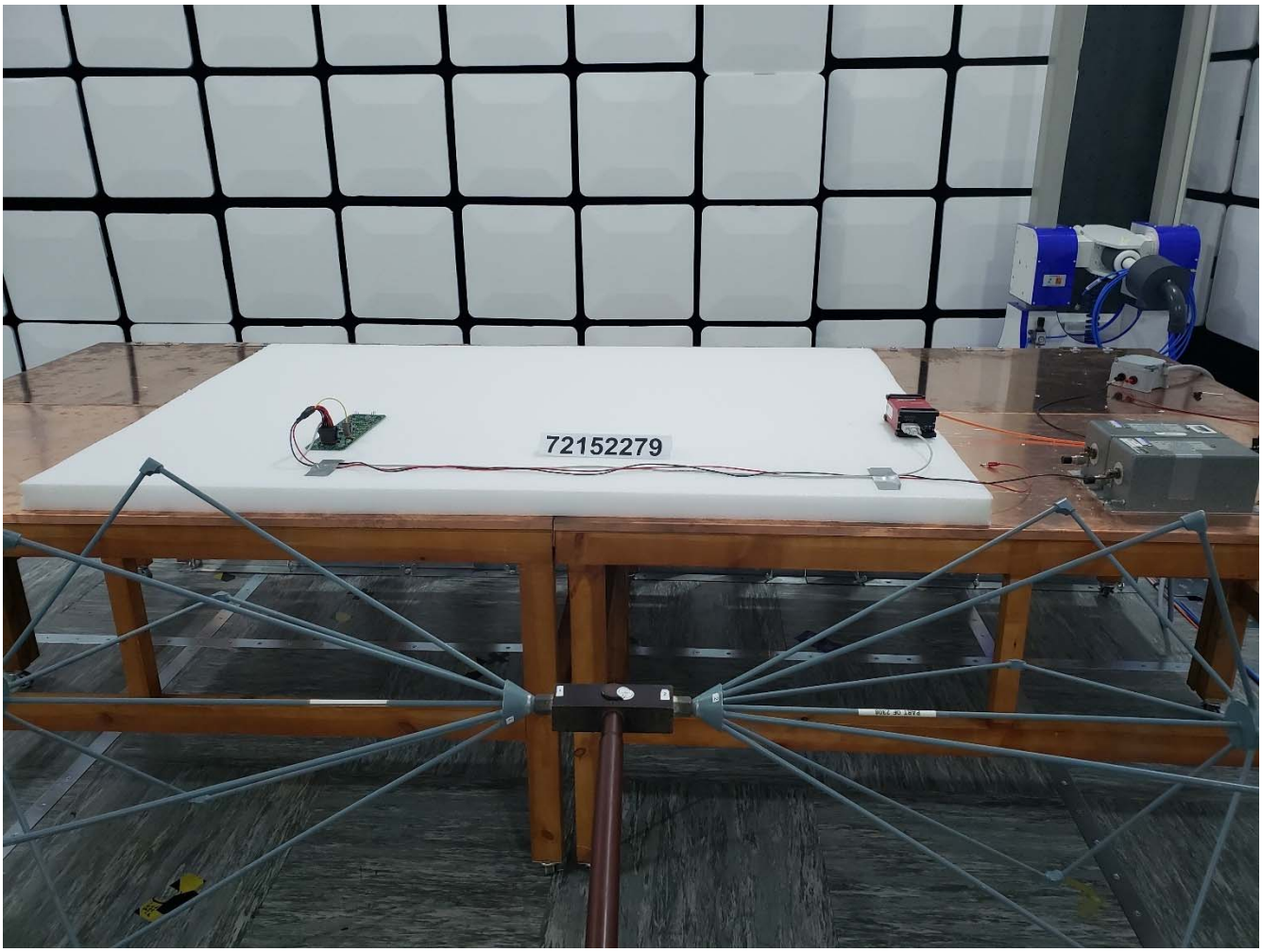


Photo 2.1.10-1 – 30-200 MHz Test Setup

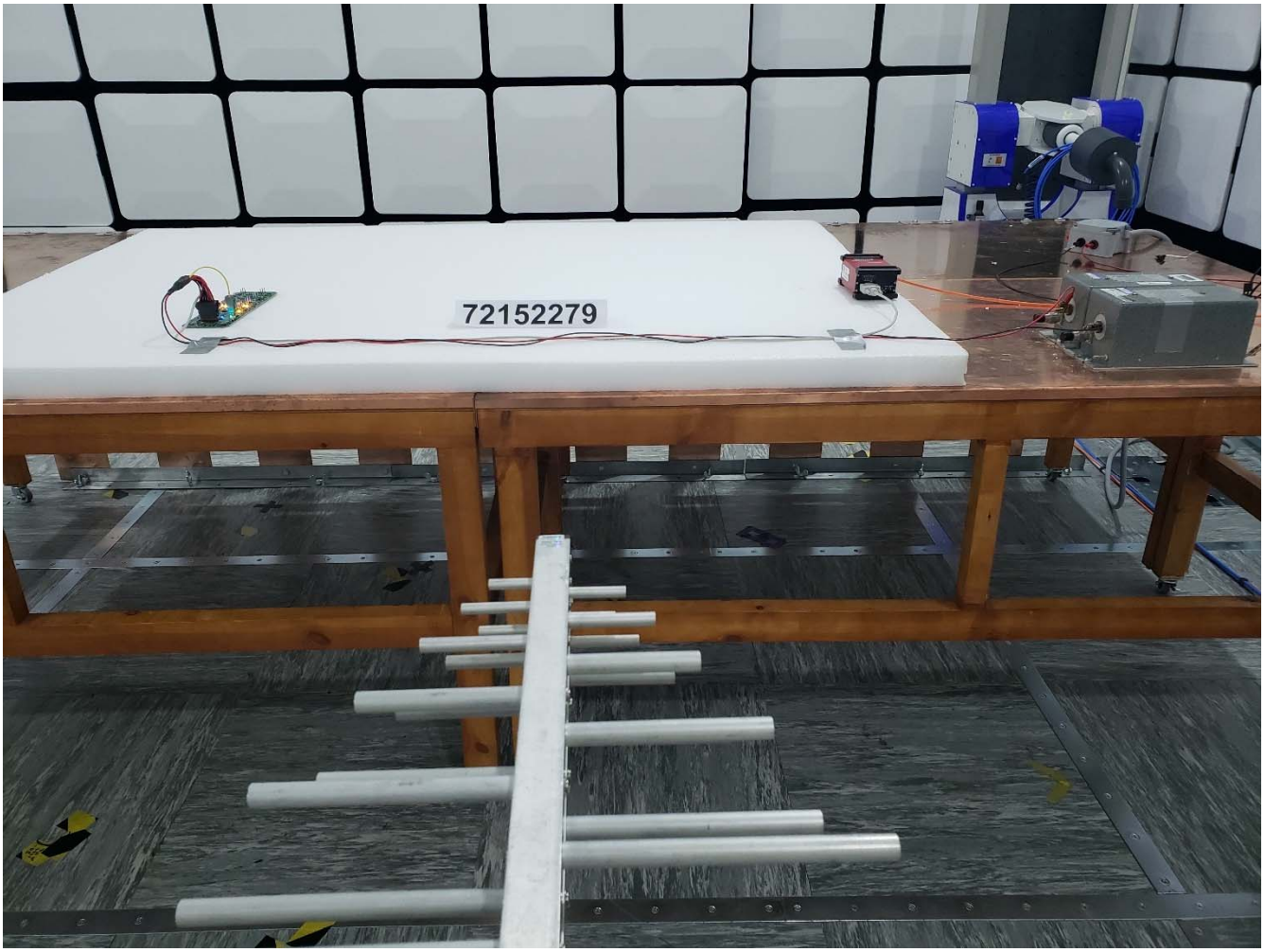


Photo 2.1.10-2 – 200-1000 MHz Test Setup

2.2 Conducted Transient Emissions

2.2.1 Specification Reference

See §1.3 for the specification references.

2.2.2 Equipment Under Test and Modification State

As shown in §1.5 with Modification State “0” if any as shown in §1.7.

EUT powered at 27VDC during testing.

2.2.3 Date of Test

21 August 2019

2.2.4 Test Methods

The measurements were made in two configurations: one with the switch between the battery and the artificial network (AN), and one with the switch between the EUT and AN. The length of the DC lines between the EUT and AN or switch was 200 mm, with measurements made at the EUT in both cases. Traces were captured for both switching on and switching off conditions for each setup and for each mode required. The test was performed 10 times for each configuration, and the worst-case voltage emission was captured in each configuration and documented.

2.2.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.2.6 Test Results

The EUT was tested in the **Configuration and Mode 2** as described in Section 1.5.2 of this test report.

Performance assessment of the EUT made during this test: **Pass**

Detailed results are shown below.

Table 2.2.6-1 –Test specification:

Polarity of Pulse Amplitude	Max Allowed Pulse Amplitude Vehicles w/24 V Systems Level III	Measured Transient Max / Min Voltage	Repetitions	Test Conditions
Positive / Negative	+150 V / -450 V	+2.75 V / -0V	10	Slow pulses - Switched On
Positive / Negative	+150 V / -450 V	+0 V / -0 V	10	Slow pulses - Switched Off
Positive / Negative	+150 V / -450 V	+2.9375 V / -0V	10	Fast pulses - Switched On
Positive / Negative	+150 V / -450 V	+0 V / -0 V	10	Fast pulses - Switched Off

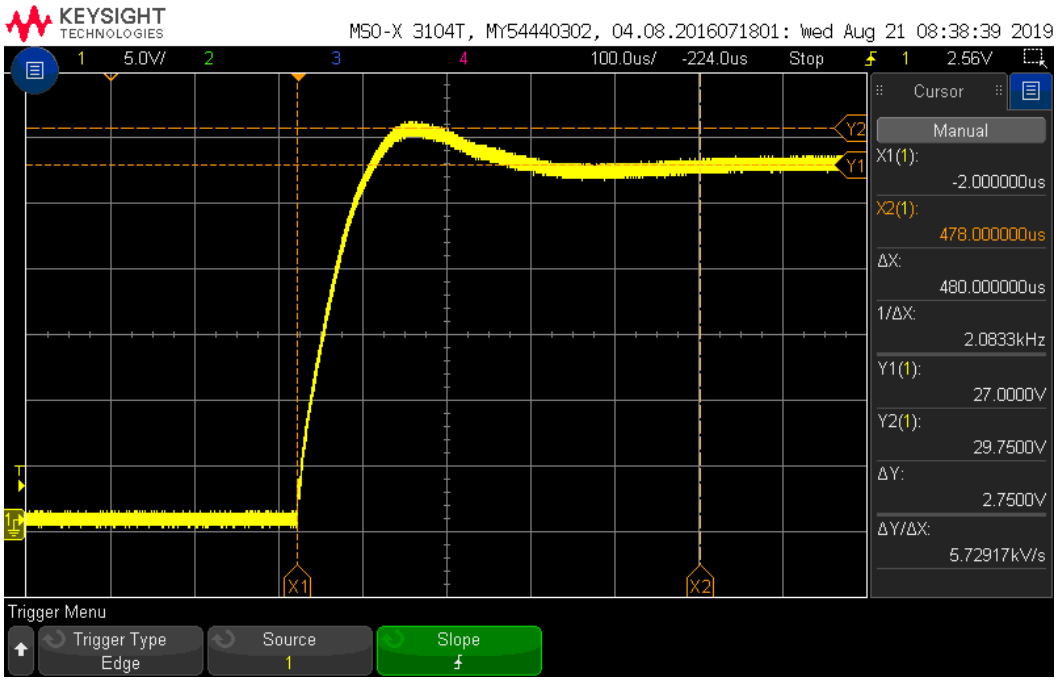


Figure 2.2.6-1 – Input Power Switched Slow On

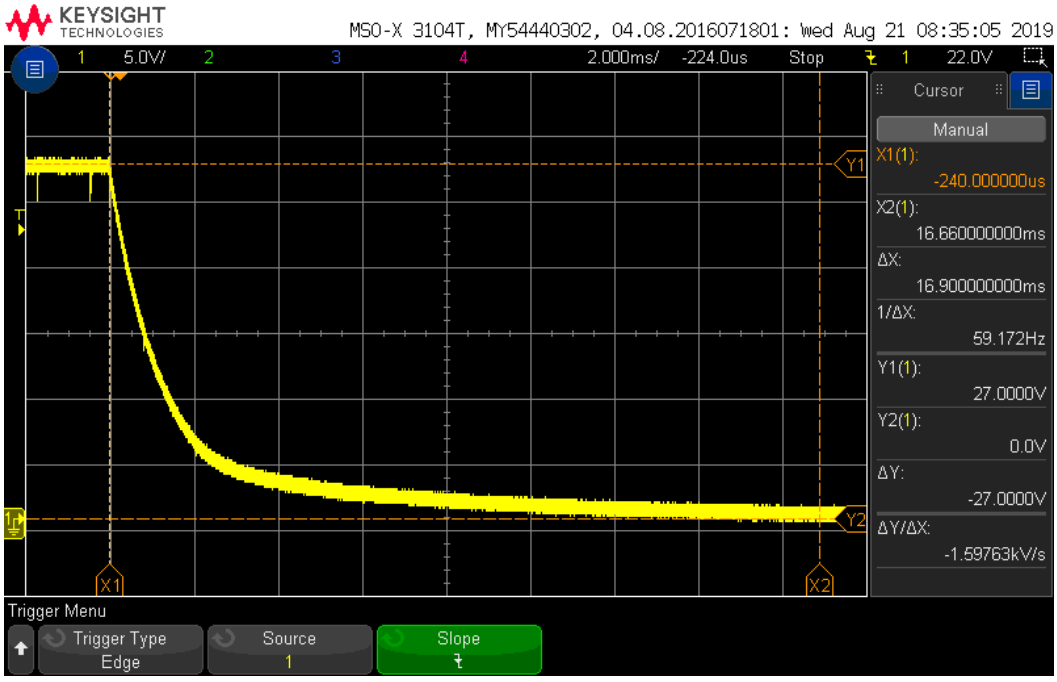


Figure 2.2.6-2 – Input Power Switched Slow Off

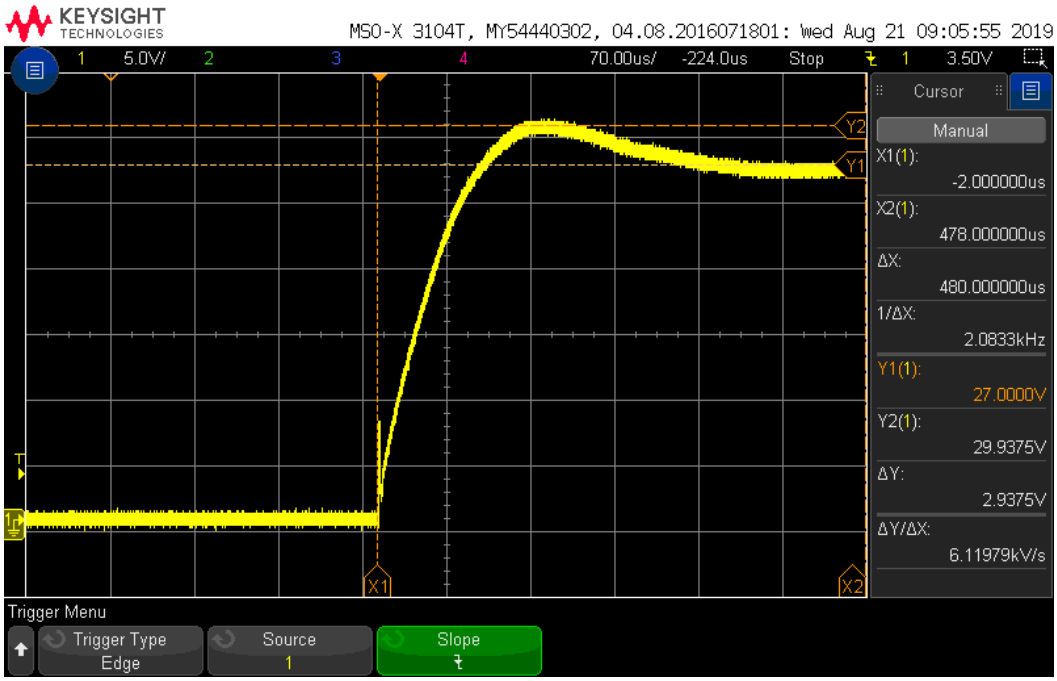


Figure 2.2.6-3 – Input Power Switched Fast On

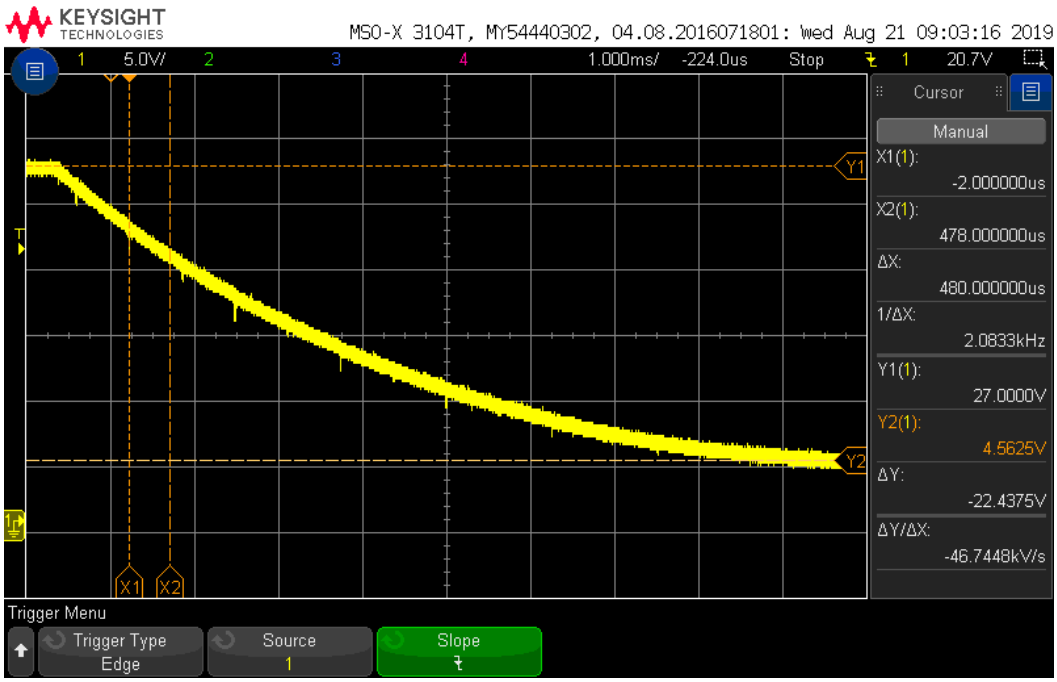


Figure 2.2.6-4 – Input Power Switched Fast Off

2.2.7 Test Location and Test Equipment Used

This test was carried out in New Brighton, MN.
Test Area: TRN1

Table 2.2.7-1 – Equipment List – Conducted Transient Emissions

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE02822	Hewlett-Packard	Oscilloscope, 500 MHz 2-CH	54615B	US35421312	G	01/22/2019	01/22/2020
NBLE11363	Tektronix	Scope Probe, 100:1	P5100A	C005799	G	10/25/2018	10/25/2019
NBLE11408	EM Test	Battery Vltg Variation Arb Gen	AutoWave	P1551169051	B	05/13/2019	05/13/2020
NBLE11409	EM Test	Voltage Drop Simulator, TP 2b/4	VDS 200Q100	P1607181941	B	05/13/2019	05/13/2020
NBLE11410	EM Test	Transient Rack AutoWave/VDS200Q (Tall)	None	None	Y	N/A	N/A
NBLE11417	EM Test	Single line Artificial Network	AN 200N100	P1606171531	B	05/22/2019	05/22/2020
NBLE11418	EM Test	Electronic Switch for Voltage Transient	BS 200N100	P1546167410	B	11/05/2018	11/05/2019
NBLE11425	EM Test	Load Impedance for BS200N Semiconductor Switch	RS-BOX	P1605171472	B	11/06/2018	11/06/2019

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.2.8 Conducted Transient Emissions Setup Photos

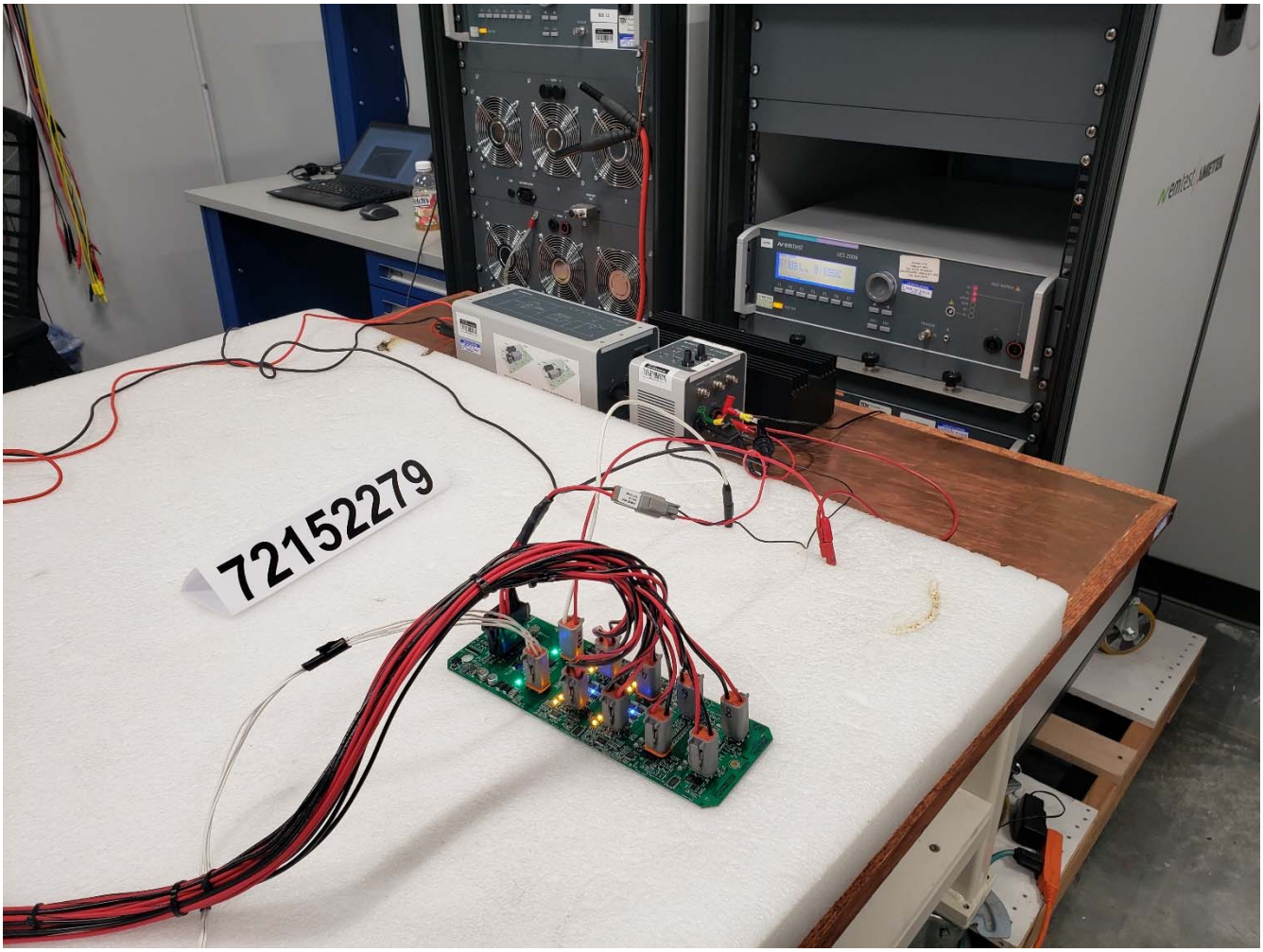


Photo 2.2.8-1 – Conducted Transient Emissions Test Setup

2.3 Immunity to Conducted Transients on Power Leads and Non-Supply Lines

2.3.1 Specification Reference

See §1.3 for the specification references.

2.3.2 Equipment Under Test and Modification State

As shown in §1.5 with modifications if any as shown in §1.7.

EUT powered at 27 VDC during testing.

2.3.3 Date of Test

20, 21 August 2019

2.3.4 Test Method

Test Pulses 1-5, Starting Profile and Load Dump: The EUT was setup on a conductive test bench 50 mm (±10 mm) above the ground plane on top of an insulating support. Prior to testing each applicable transient was verified open circuit. Once verified, the EUT was connected to the transient generator, and the test was performed. EUT functioning was monitored throughout the test and a post-test functional test was performed.

Slow (ICC) and Fast (CCC) Transient Pulses: A CCC fixture as defined in ISO 7637-3 was used to couple CCC fast transients onto all non-supply lines. An ICC fixture (bulk current injection probe) as defined in ISO 7637-3 was used to couple slow ICC transients on all non-supply lines.

During this testing any anomalies in the equipment under test's performance were recorded.

2.3.5 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.3.6 Test Results

Table 2.3.6-1 – Requirements [ISO 7637-2:2004 per EN 13309]

Pulse (24 V System)	Level	Severity (Volts)	Status
1	III	-450	C
2a	III	+37	B
2b	III	+20	C
3a	III	-150	A
3b	III	+150	A
4	III	-12	C
5	III	+123	C

Table 2.3.6-2 – Requirements [ISO 7637-2:2011 per ISO 13766-2]

Pulse (24 V System)	Level	Severity (Volts)	Status
1	III	-450	C
2a	III	+55	B
2b	III	+20	C
3a	III	-220	A
3b	III	+220	A

Table 2.3.6-3 – Requirements [ISO 16750-2:2012 per ISO 13766-2]

Pulse (24 V System)	Level	Severity (Volts)	Status
Starting Profile	II (24V)	8 (U_{S6}), 15 (U_S)	A
Load Dump (clamped)	N/A	+151	C
Load Dump (unclamped)	N/A	+151	C

Table 2.3.6-4 – Requirements [ISO 7637-3:2016 per ISO 13766-2]

Pulse (24 V System)	Level	Severity (Volts)	Status
Fast 3a (CCC)	IV	-110	A
Fast 3b (CCC)	IV	+75	A
Slow Positive 2a (ICC)	IV	+6	A
Slow Negative 2a (ICC)	IV	-6	A

The overall test verdict for the EUT when tested in **Configuration and Mode 1** as described in Section 1.5.2 of this was: **Pass.**

Detailed results are shown below.

Table 2.3.6-4 – Summary of Observations During Testing

Pulse 24 V System	Level	Severity	Required Status	# of Pulses / Duration	Status Met
1	III	-450 V	C	5000 pulses	A
2a	III	+55 V	B	5000 pulses	A
2b	III	+20 V	C	10 pulses	A
3a	III	-220 V	A	1 hour	A
3b	III	+220 V	A	1 hour	A
4	III	-15 V	C	3 pulses	A
Starting Profile	II	-14.5 V	B	10 pulses	A
5a [Load Dump (unclamped)]	N/A	+202 V	C	10 pulses	A
Fast 3a (CCC)	IV	-110	A	10 minutes	A
Fast 3b (CCC)	IV	+75	A	10 minutes	A
Slow Positive 2a (ICC)	IV	+6	A	5 minutes	A
Slow Negative 2a (ICC)	IV	-6	A	5 minutes	A

2.3.6.1 Test Pulse 1

Table 2.3.6.1-1 – Test Pulse 1 Parameters

Test Voltage (Volts)	test Level (Volts)	Pulse Width (mSec)	Pulse Period (Sec)	Source Impedance (Ohms)	repetitions
27	-450	1	0.5	50	5000

Remarks: EUT powers down with each transient, returns to normal operation when test is completed.

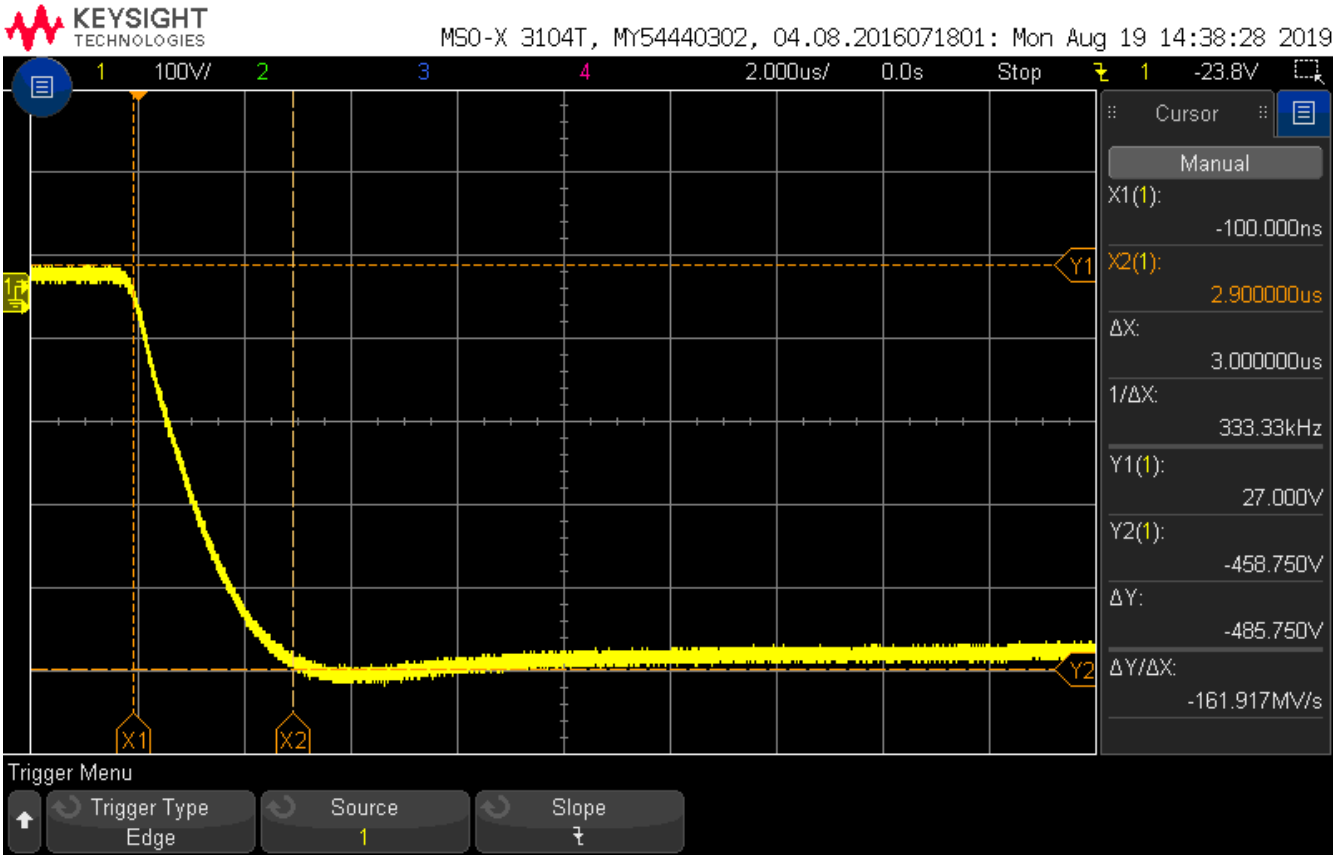


Figure 2.3.6.1-1 – Pulse 1 – Tr, T3, & Us – Open Circuit

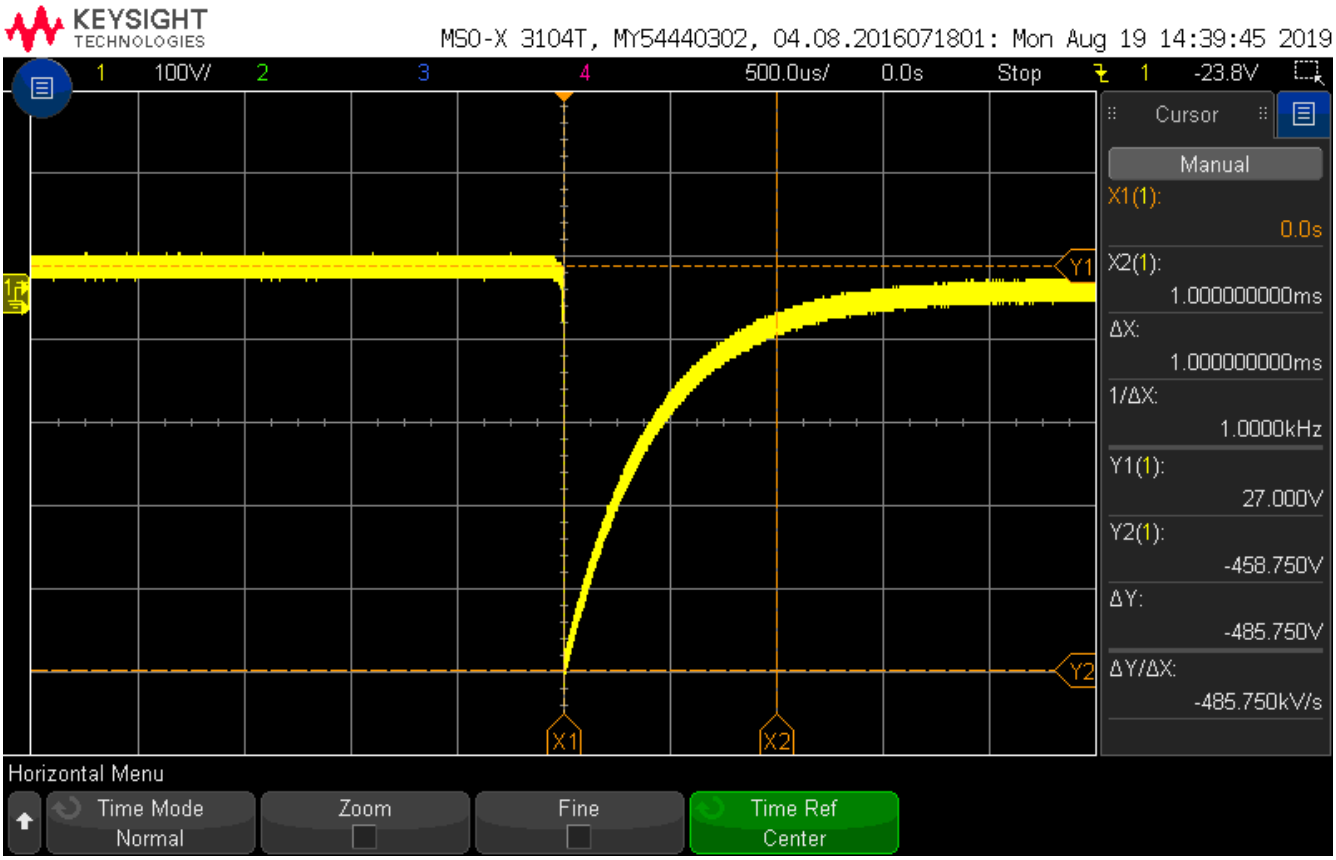


Figure 2.3.6.1-2 – Pulse 1 – Td – Open Circuit

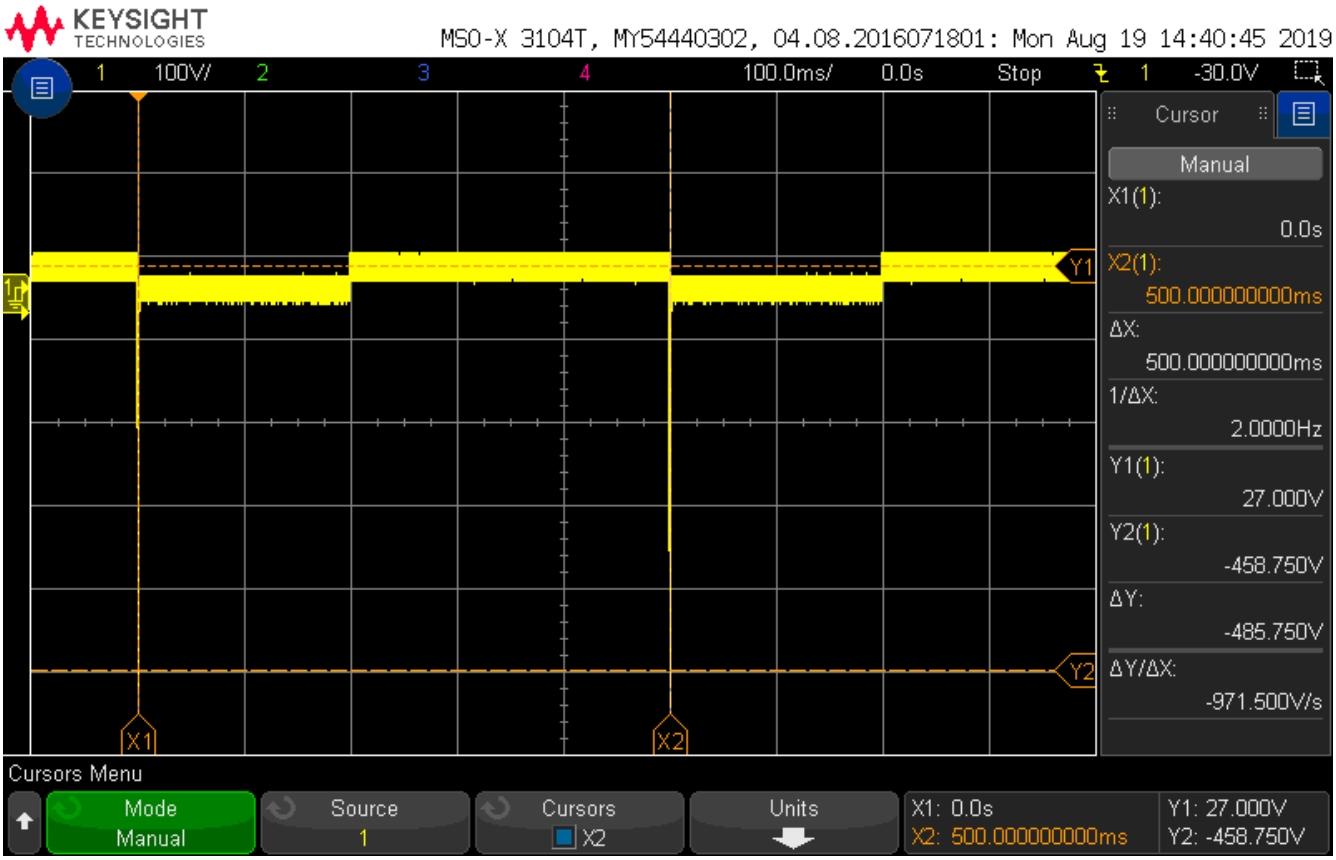


Figure 2.3.6.1-3 – Pulse 1 – T1 & T2 – Open Circuit

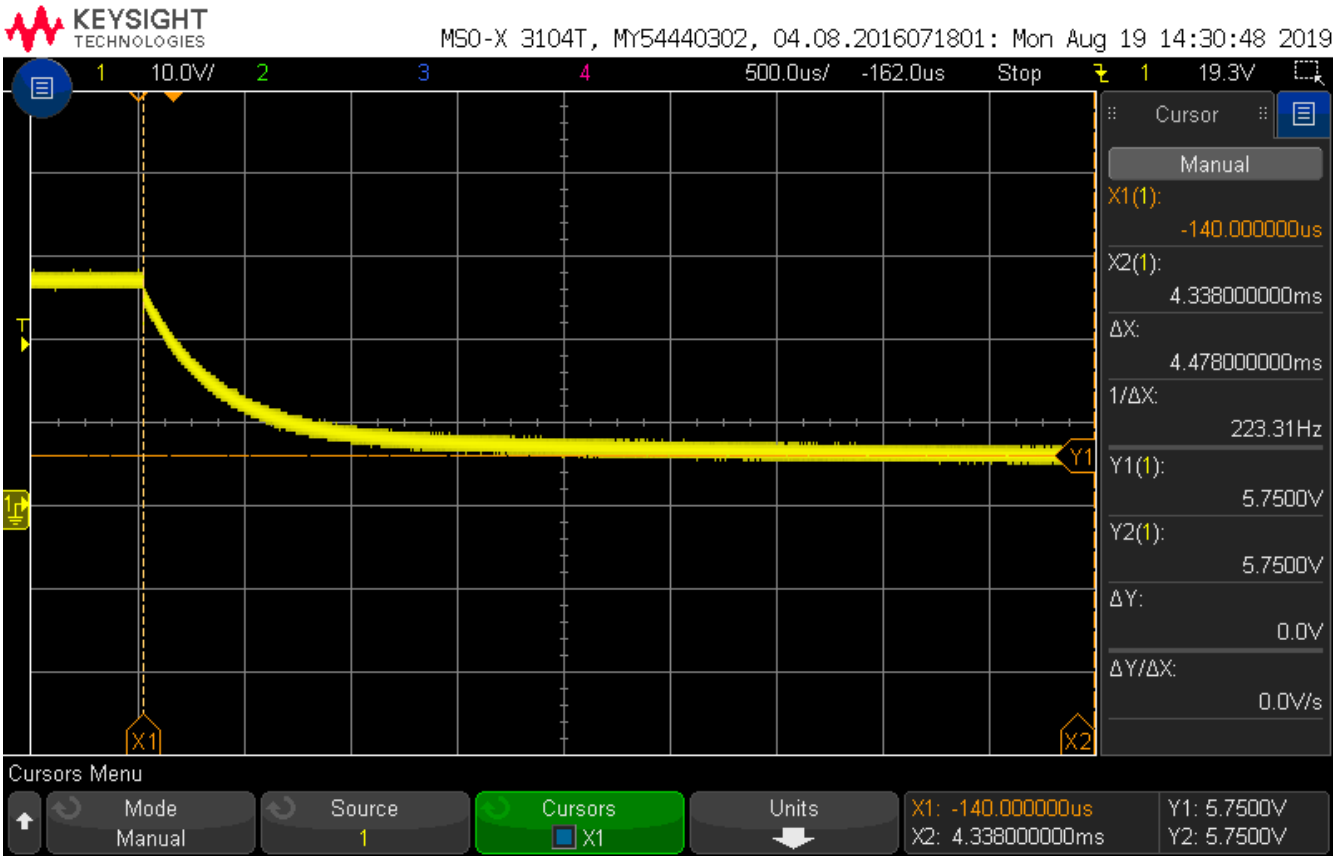


Figure 2.3.6.1-4 – Pulse 1 – Td – EUT

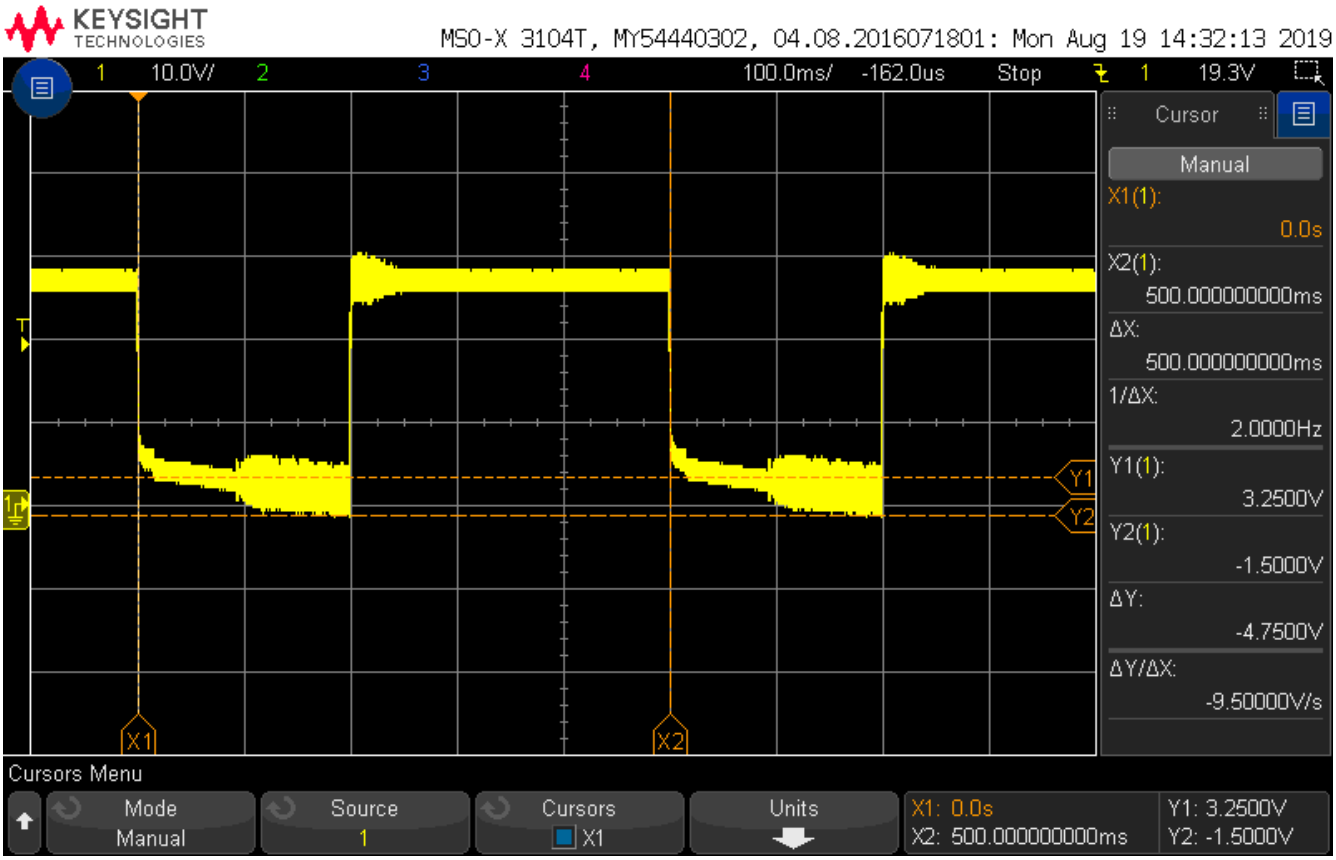


Figure 2.3.6.1-5– Pulse 1 – T1 & T2 – EUT

2.3.6.2 Test Pulse 2a

Table 2.3.6.2-1 – Test Pulse 2a Parameters

Test Voltage (Volts)	test Level (Volts)	Pulse Width (mSec)	Pulse Period (Sec)	Source Impedance (Ohms)	repetitions
27	+55	0.05	0.5	2	5000

Remarks:

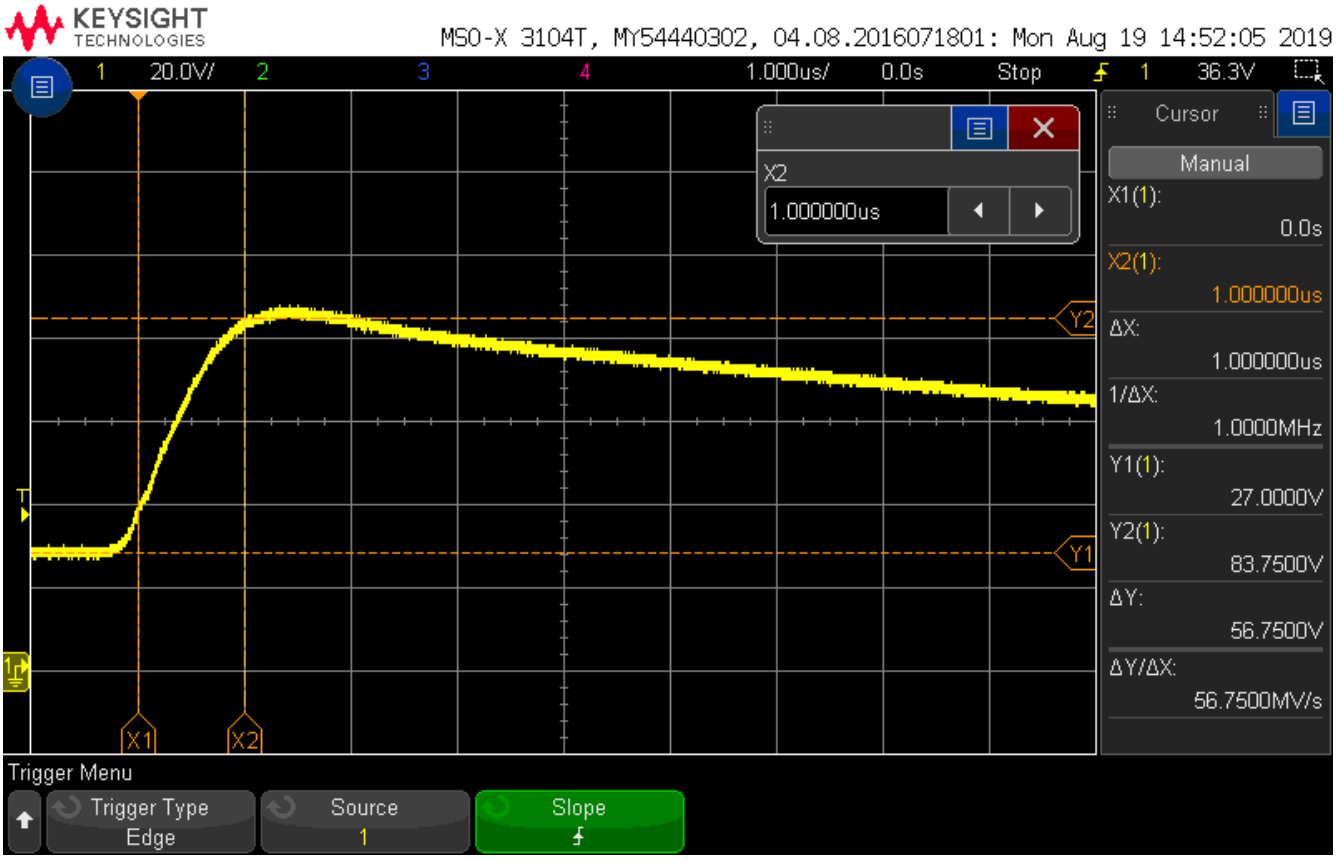


Figure 2.3.6.2-1 – Pulse 2a – Tr – Open Circuit

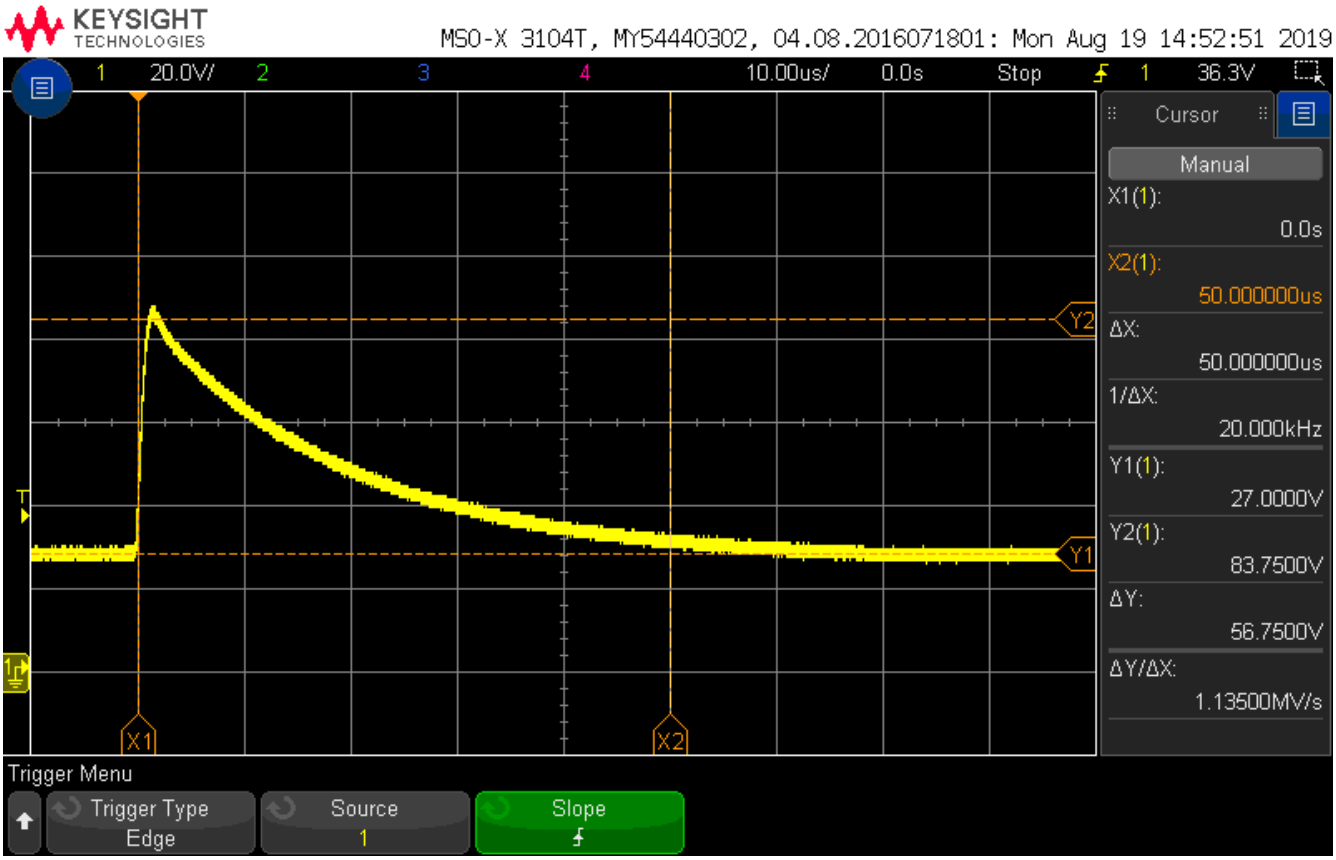


Figure 2.3.6.2-2 – Pulse 2a – Td – Open Circuit

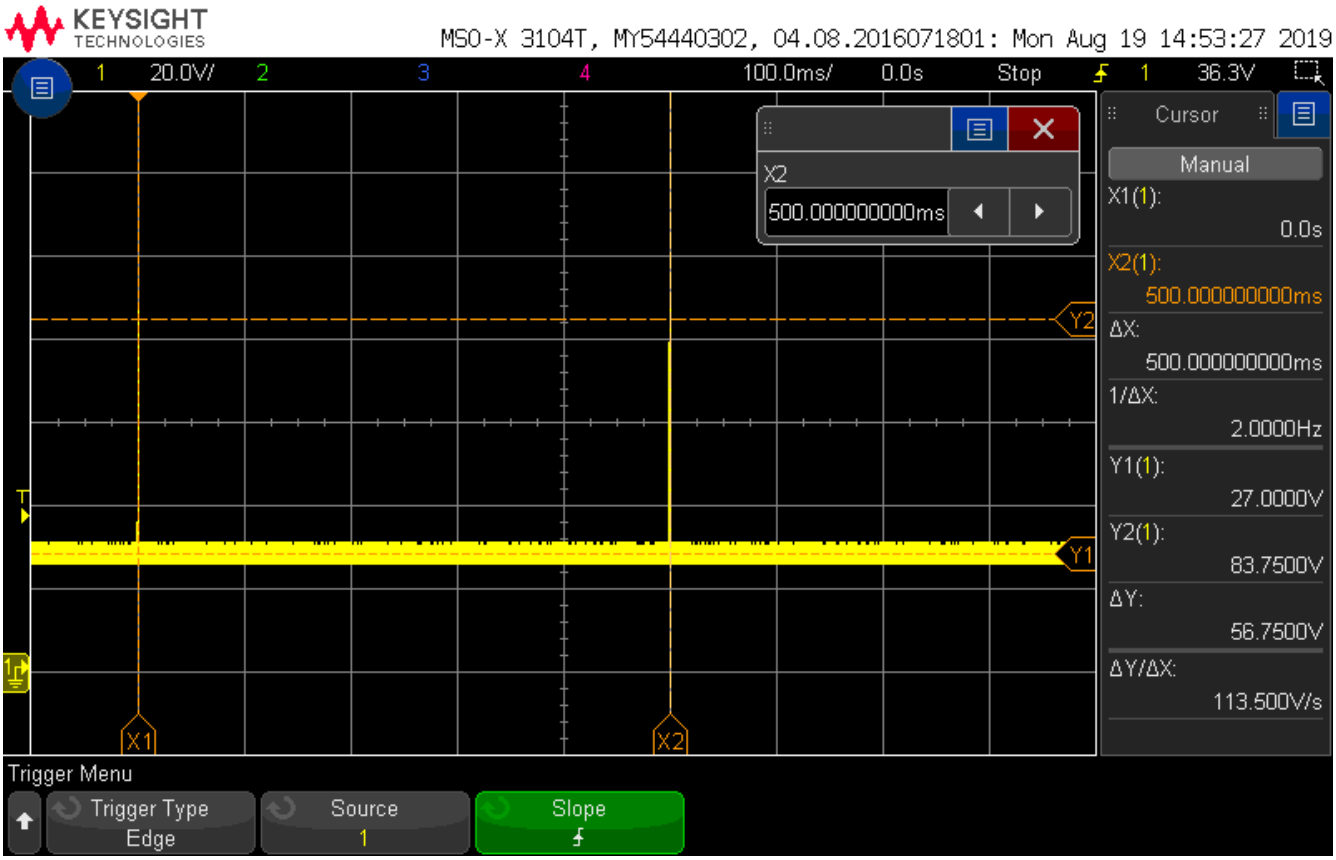


Figure 2.3.6.2-3 – Pulse 2a – T1 – Open Circuit

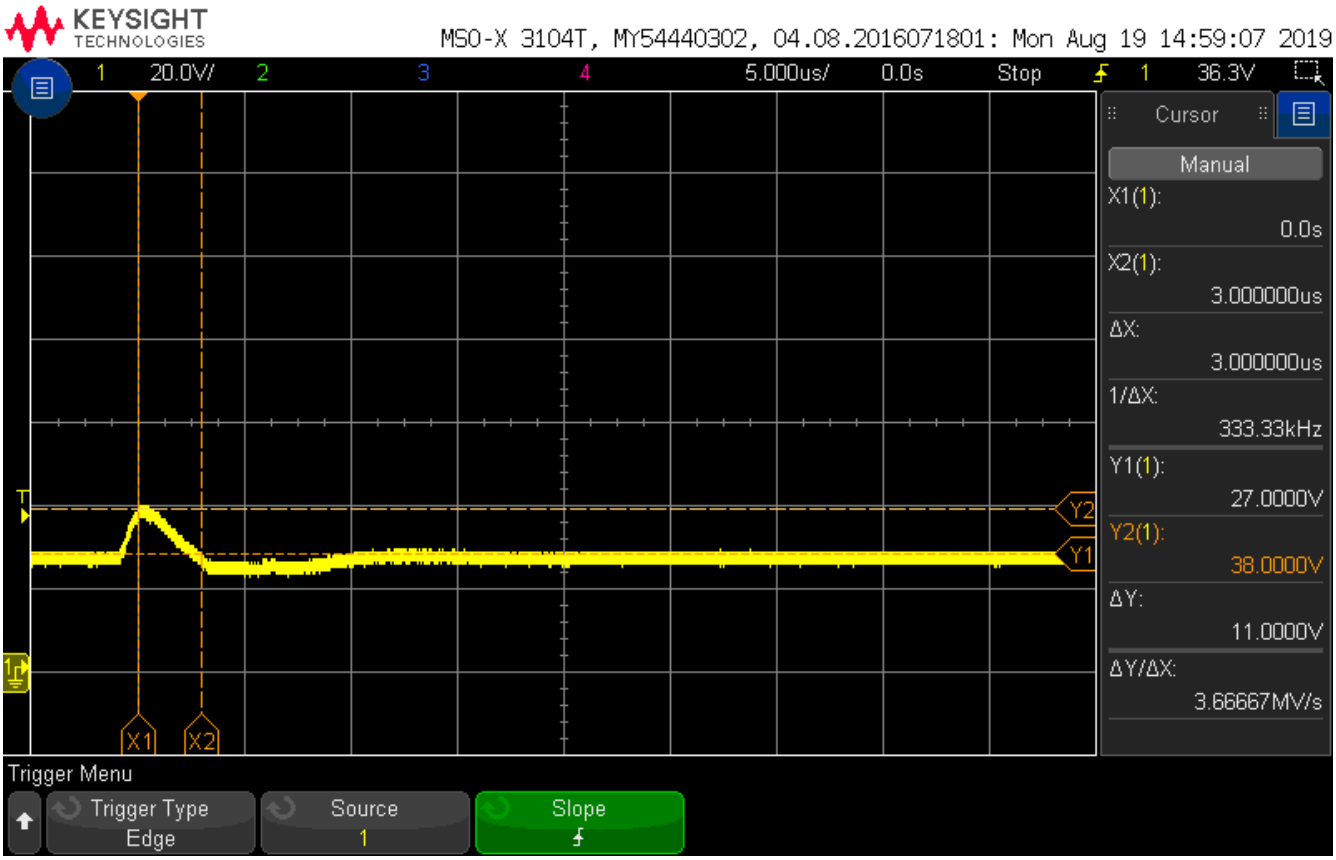


Figure 2.3.6.2-4 – Pulse 2a – Tr & Td – EUT

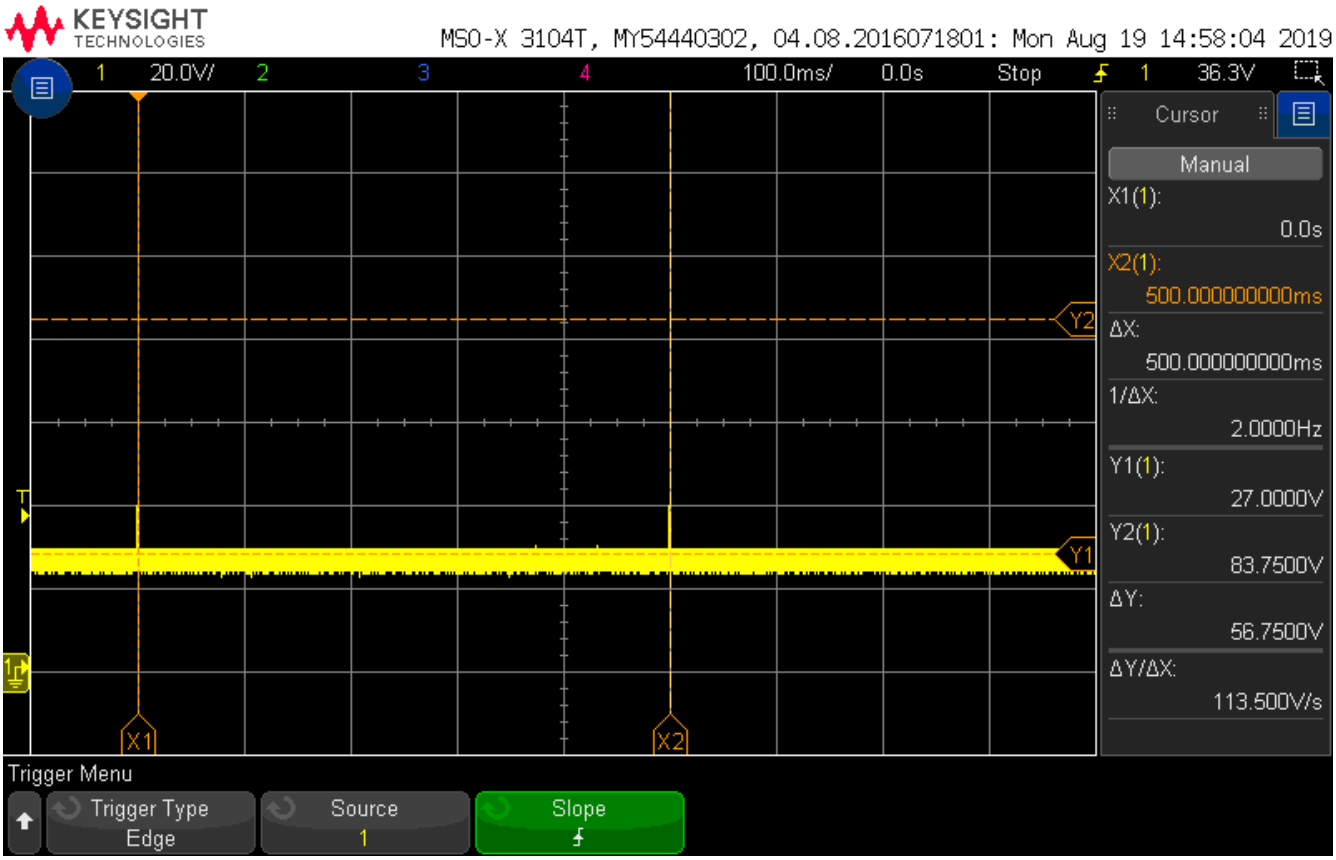


Figure 2.3.6.2-5 – Pulse 2a – T1 – EUT

2.3.6.3 Test Pulse 2b

Table 2.3.6.3-1 – Test Pulse 2b Parameters

Test Voltage (Volts)	test Level (Volts)	Pulse Width (Sec)	Rep Rate (Sec)	Source Impedance (Ohms)	Repetitions
27	20	2	10	0.05	10

Remarks: EUT powers down with each transient, returns to normal operation when test is completed.

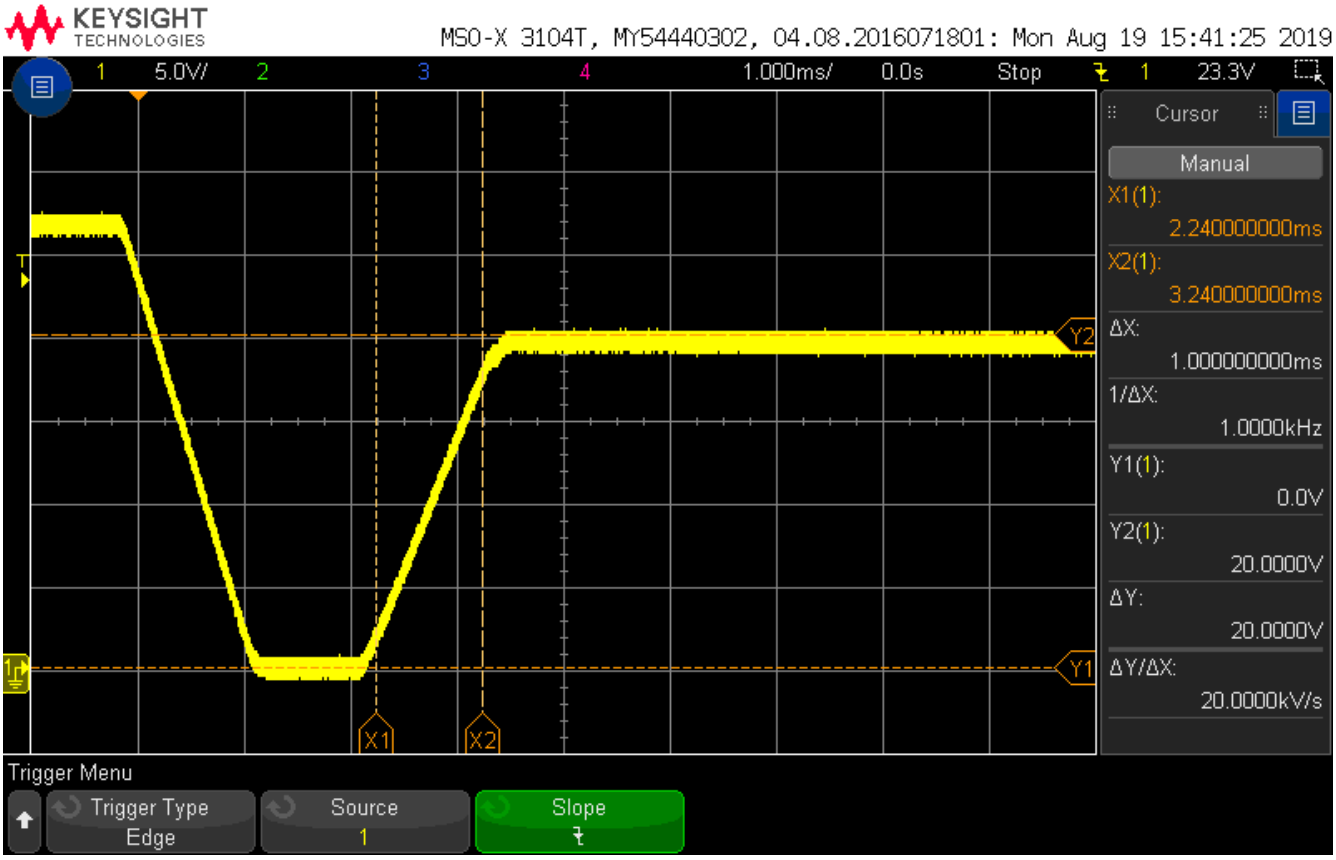


Figure 2.3.6.3-1 – Pulse 2b – Tr – Open Circuit

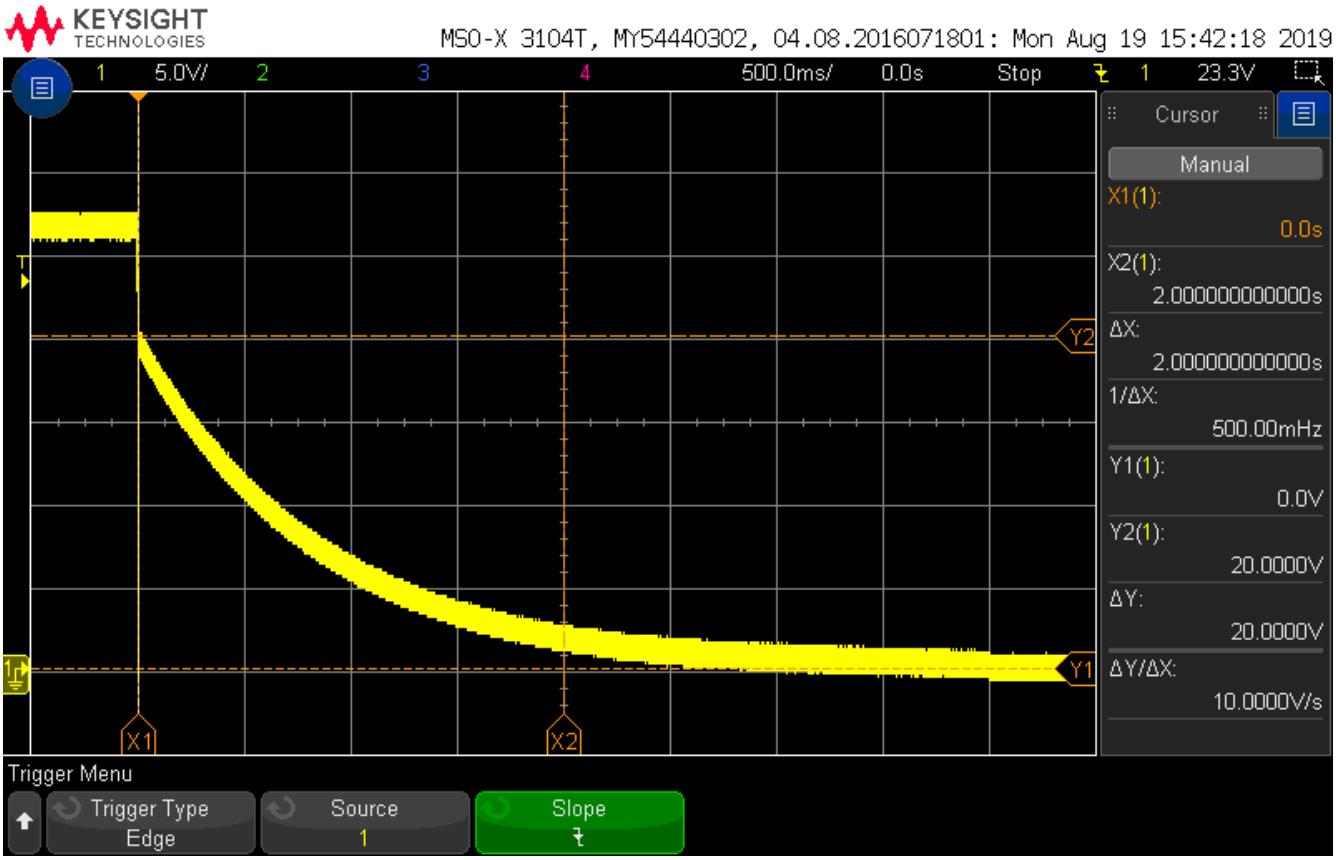


Figure 2.3.6.3-2 – Pulse 2b – Td – Open Circuit

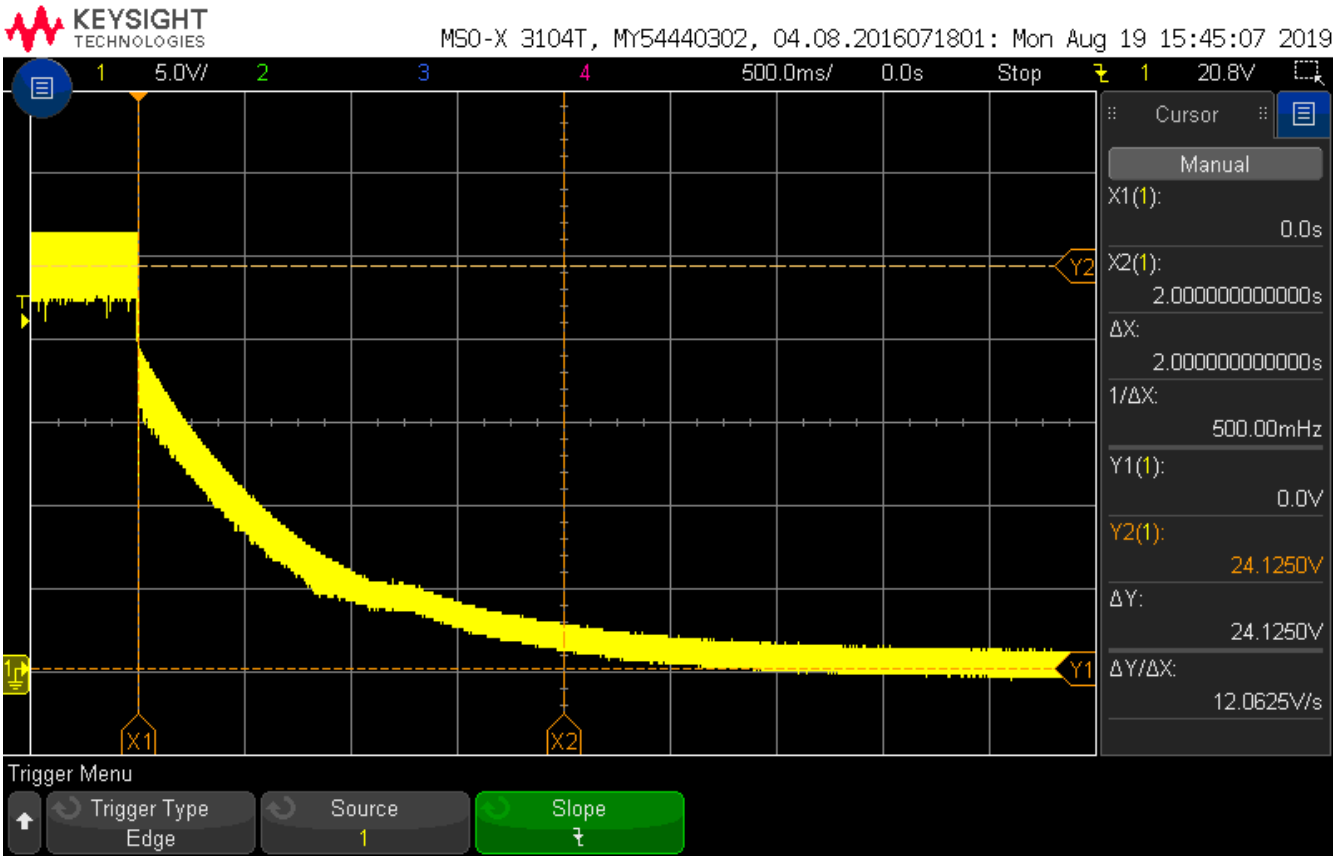


Figure 2.3.6.3-3 – Pulse 2b – Td – EUT

2.3.6.4 Test Pulse 3a

Table 2.3.6.4-1 – Test Pulse 3a Parameters

Test Voltage (Volts)	test Level (Volts)	Rep Rate (µSec)	Burst Width (mSec)	Burst Period (mSec)	Source Impedance (Ohms)	Test Time (Min)
27	-220	100	10	100	50	60

Remarks:

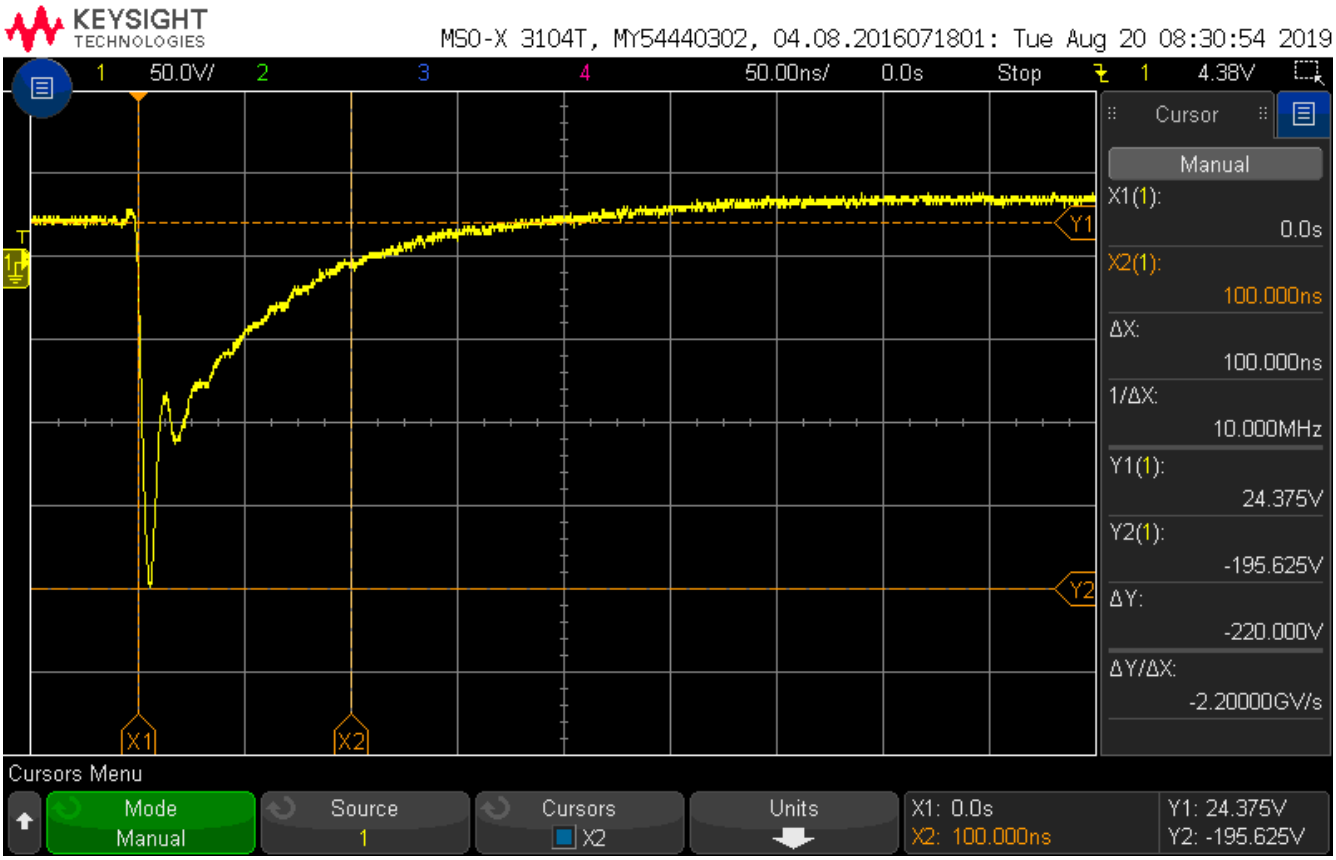


Figure 2.3.6.4-1 – Pulse 3a – Tr & Td – Open Circuit

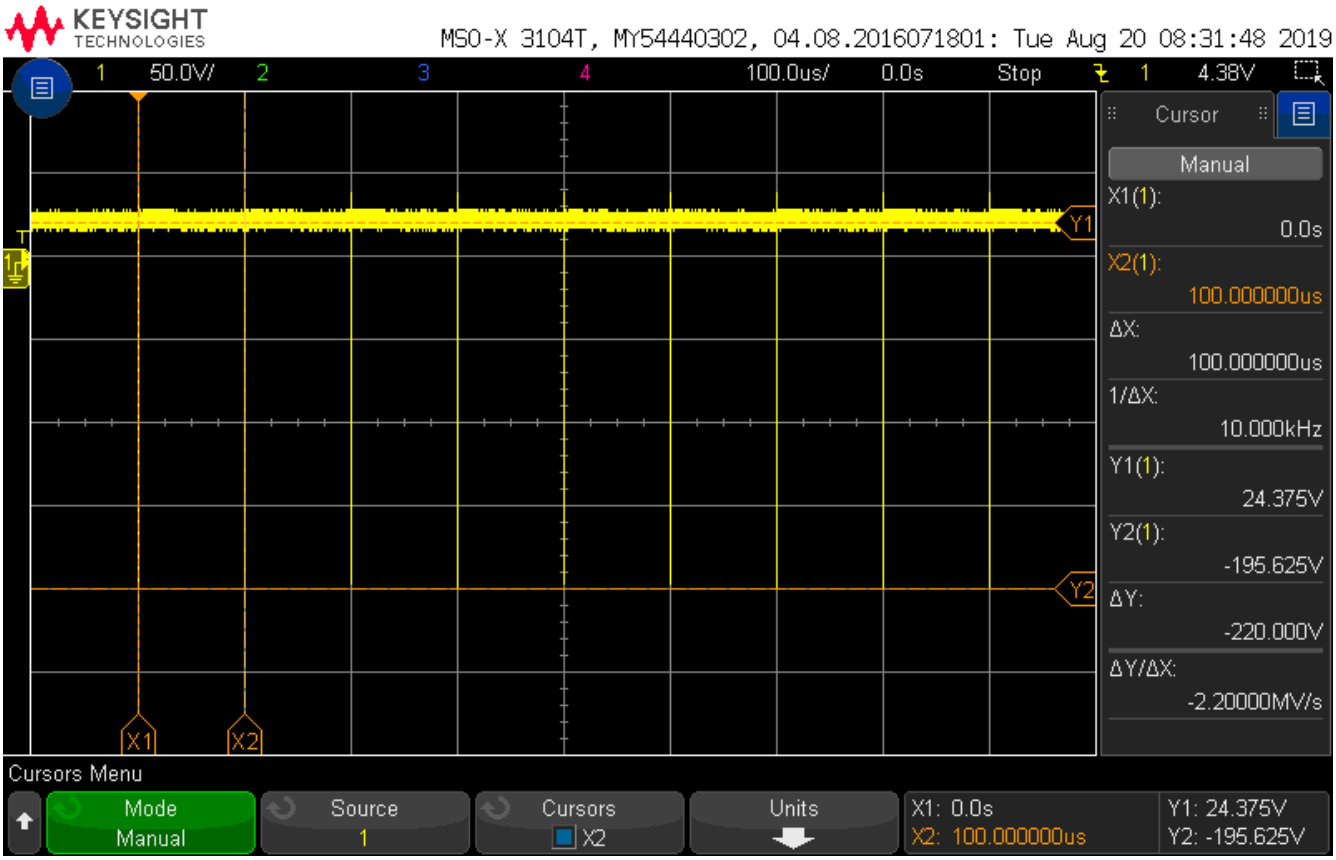


Figure 2.3.6.4-2 – Pulse 3a – T1 – Open Circuit

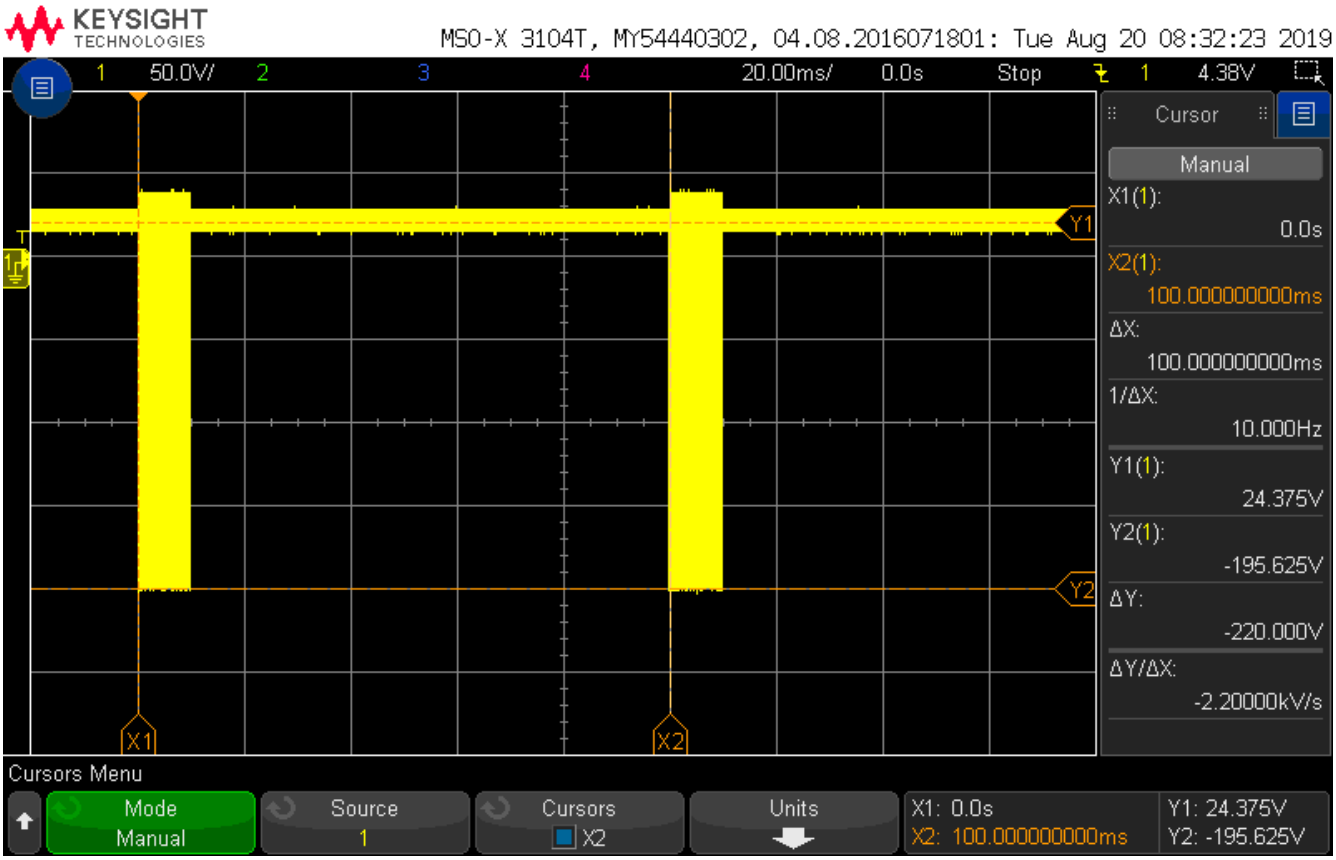


Figure 2.3.6.4-3 – Pulse 3a – T4 & T5 – Open Circuit

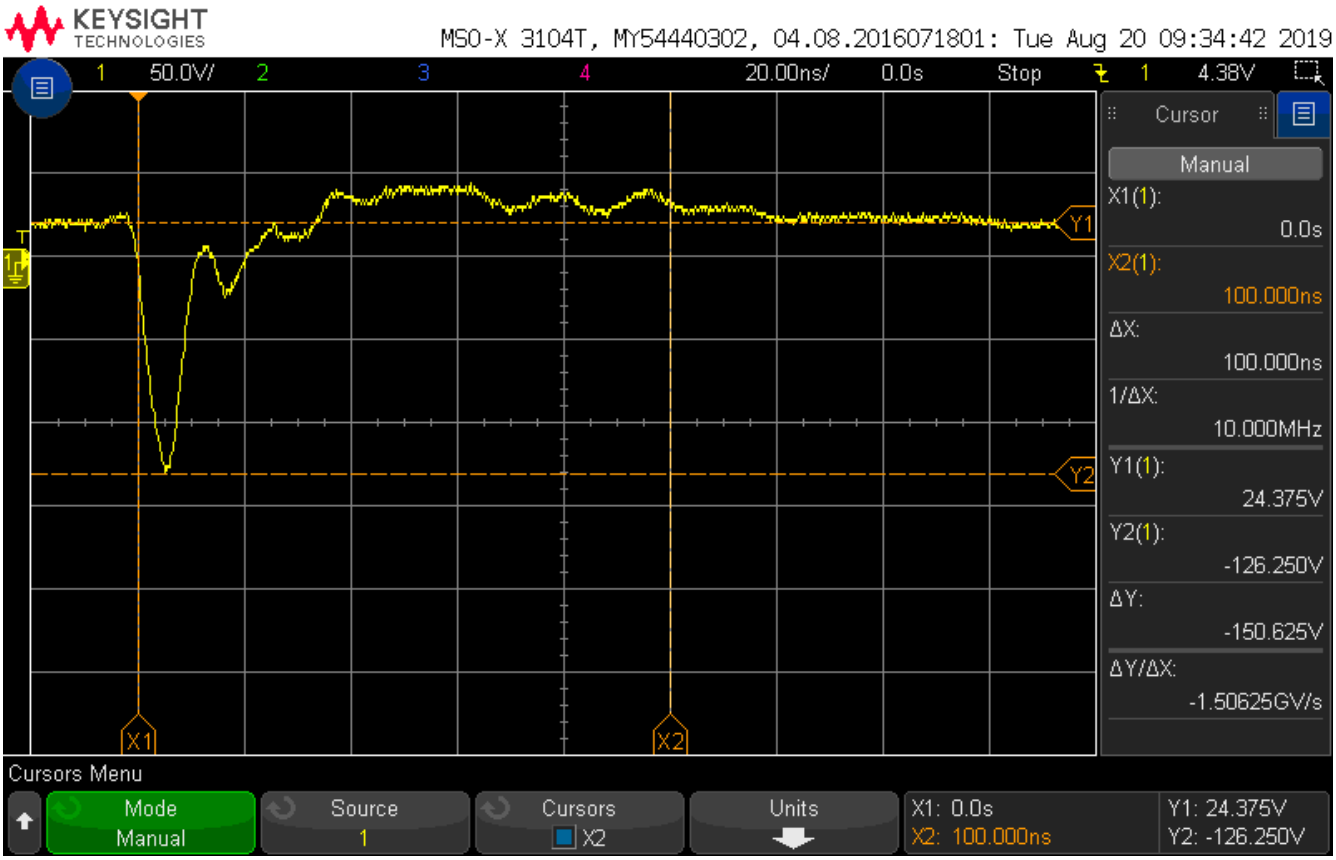


Figure 2.3.6.4-4 – Pulse 3a – Tr & Td – EUT

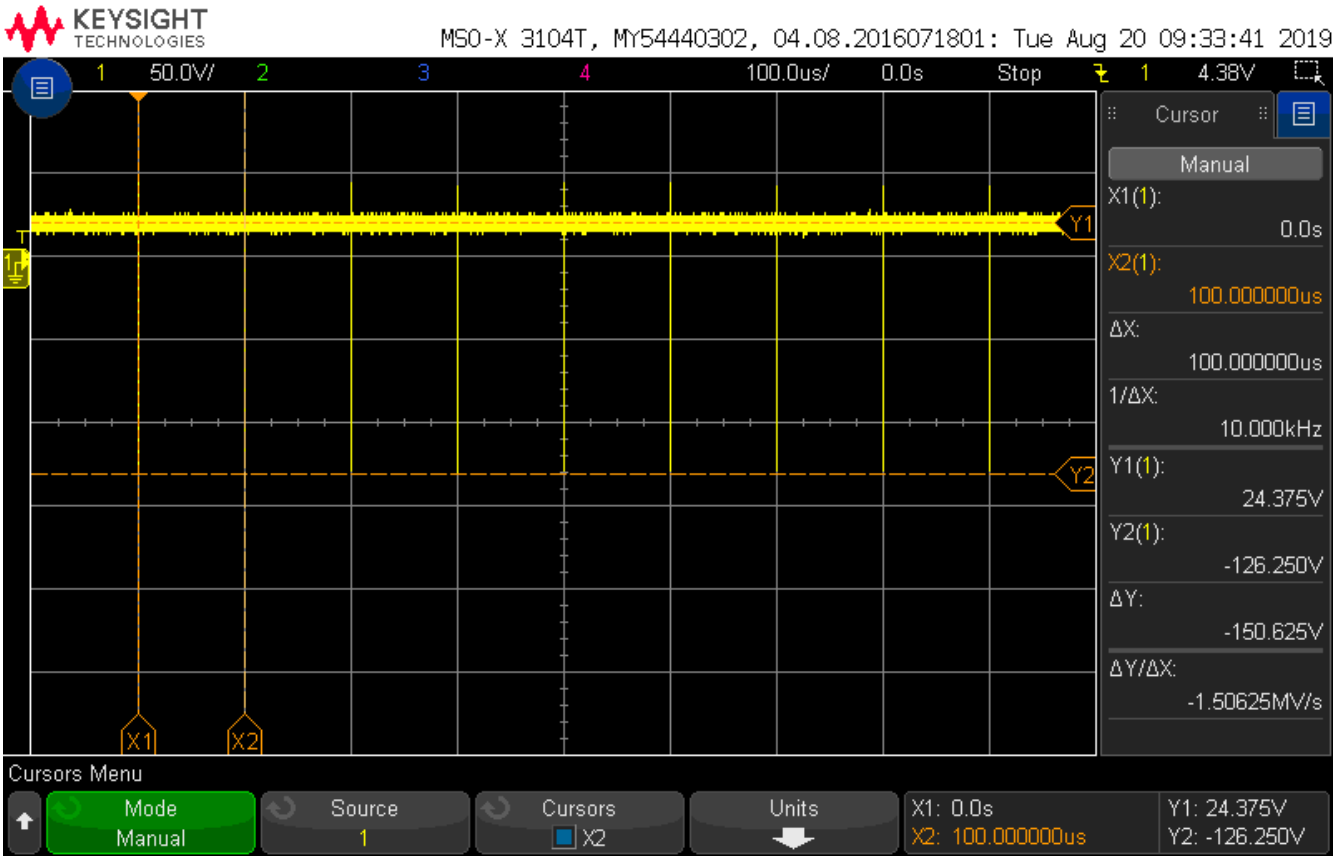


Figure 2.3.6.4-5 – Pulse 3a – T1 – EUT

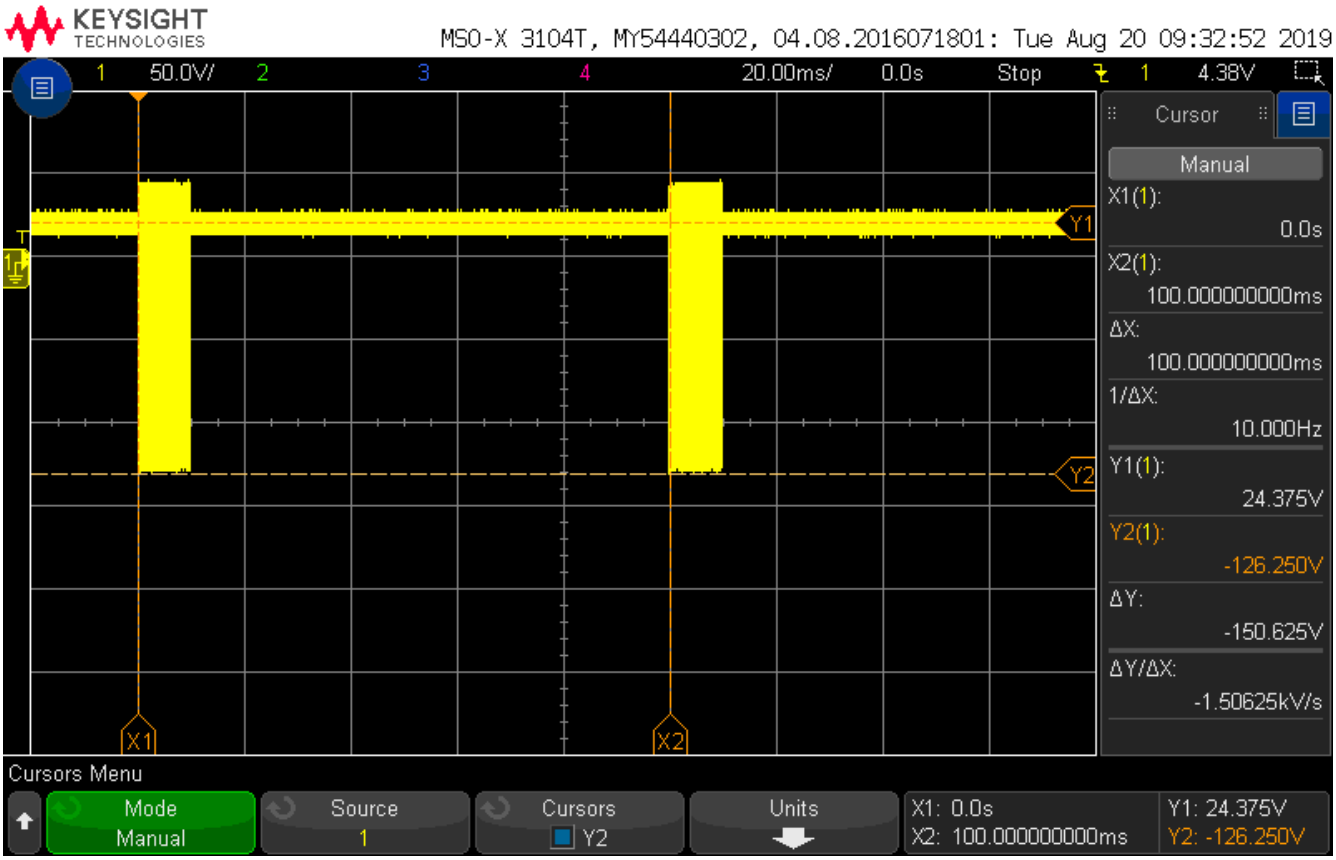


Figure 2.3.6.4-6 – Pulse 3a – T4 & T5 – EUT

2.3.6.5 Test Pulse 3b

Table 2.3.6.5-1 – Test Pulse 3b Parameters

Test Voltage (Volts)	test Level (Volts)	Rep Rate (µSec)	Burst Width (mSec)	Burst Period (mSec)	Source Impedance (Ohms)	Test Time (Min)
27	+220	100	10	100	50	60

Remarks:

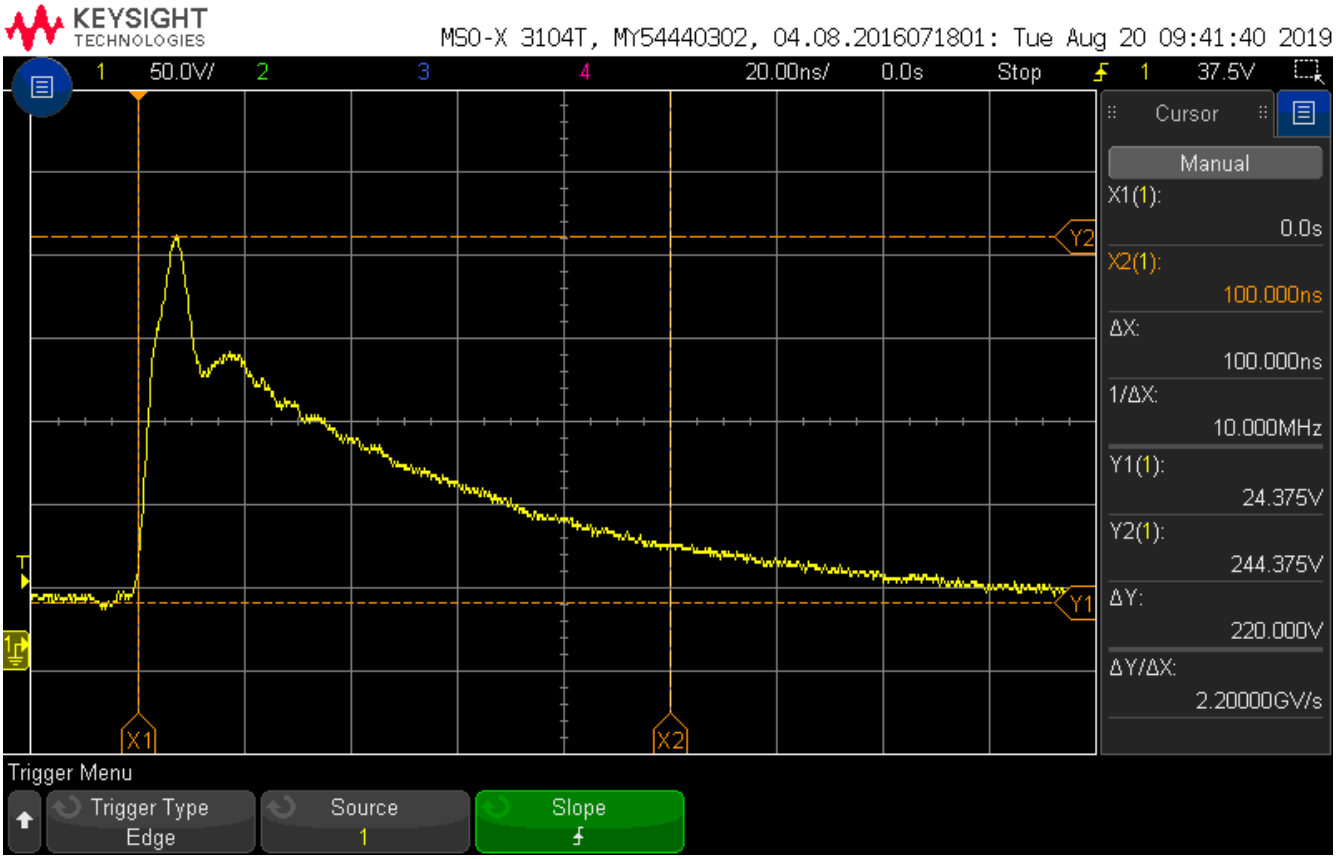


Figure 2.3.6.5-1 – Pulse 3b – Tr & Td – Open Circuit

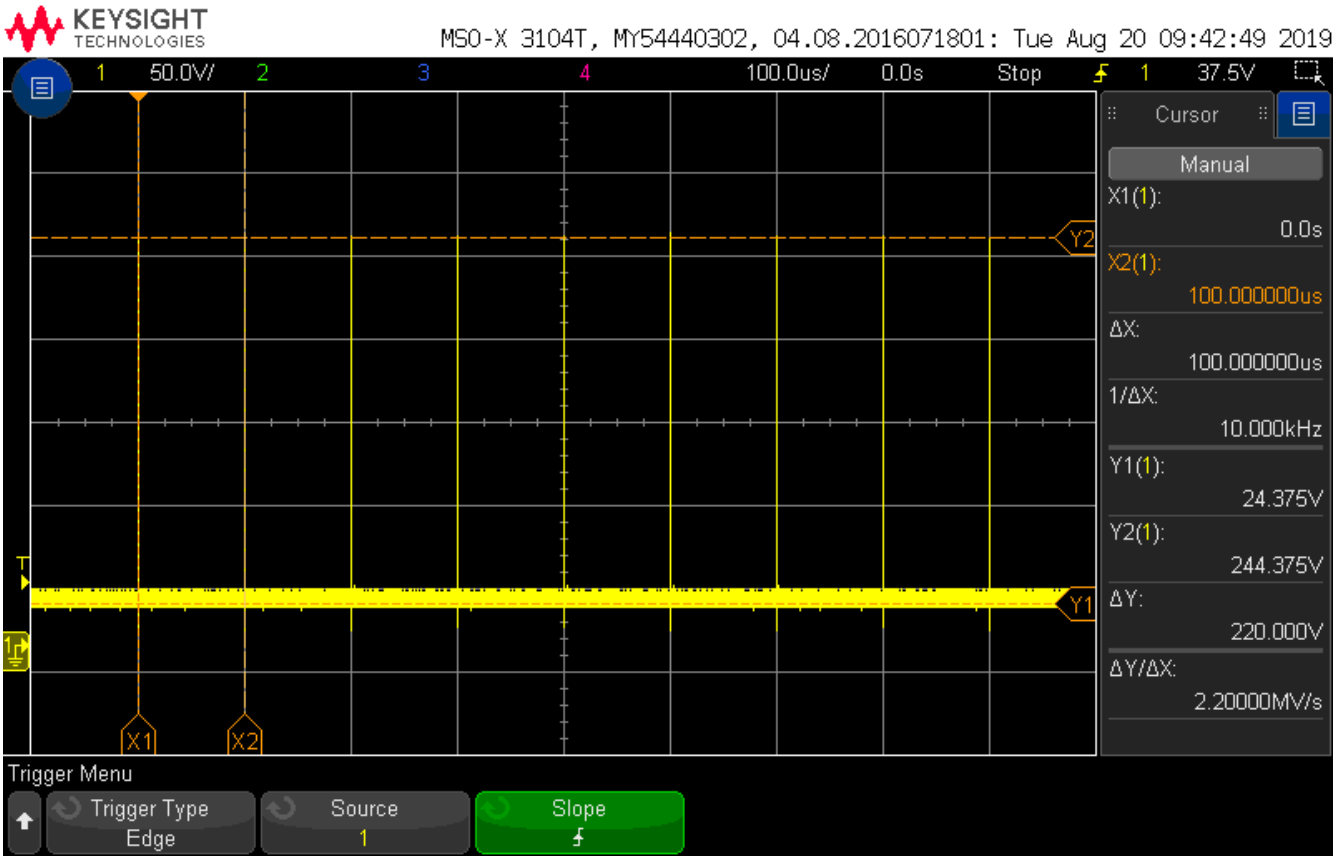


Figure 2.3.6.5-2 – Pulse 3b – T1 – Open Circuit

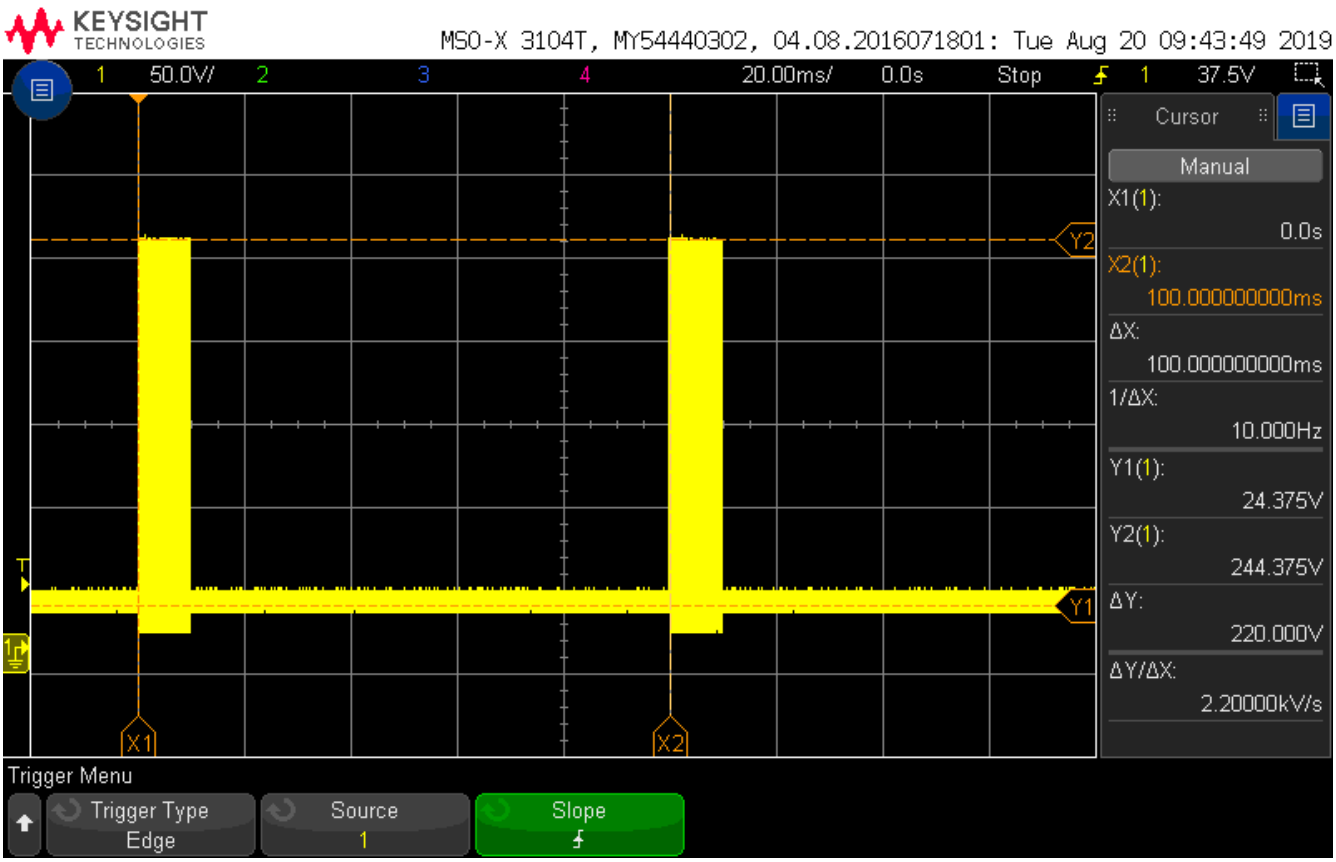


Figure 2.3.6.5-3 – Pulse 3b – T4 & T5 – Open Circuit

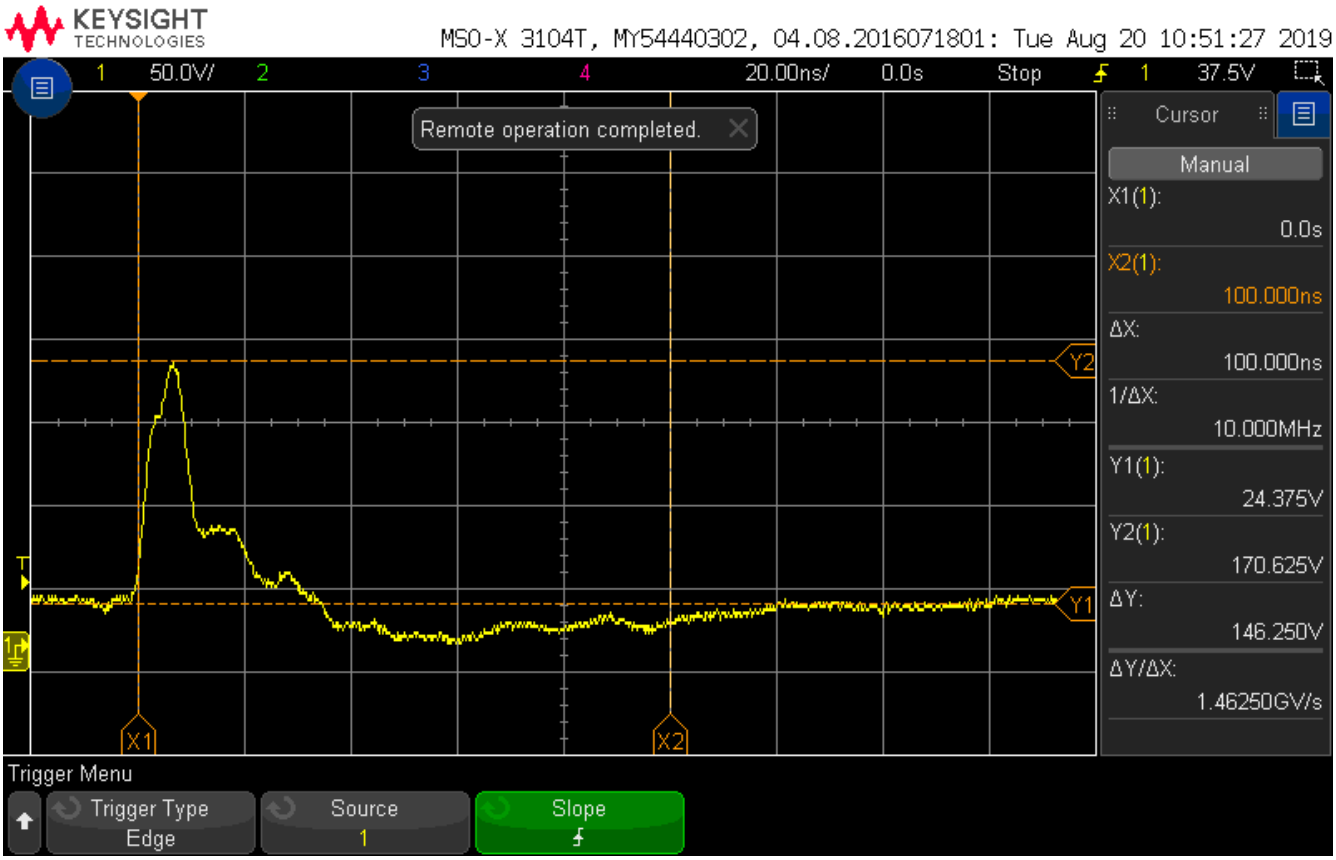


Figure 2.3.6.5-4 – Pulse 3b – Tr & Td – EUT

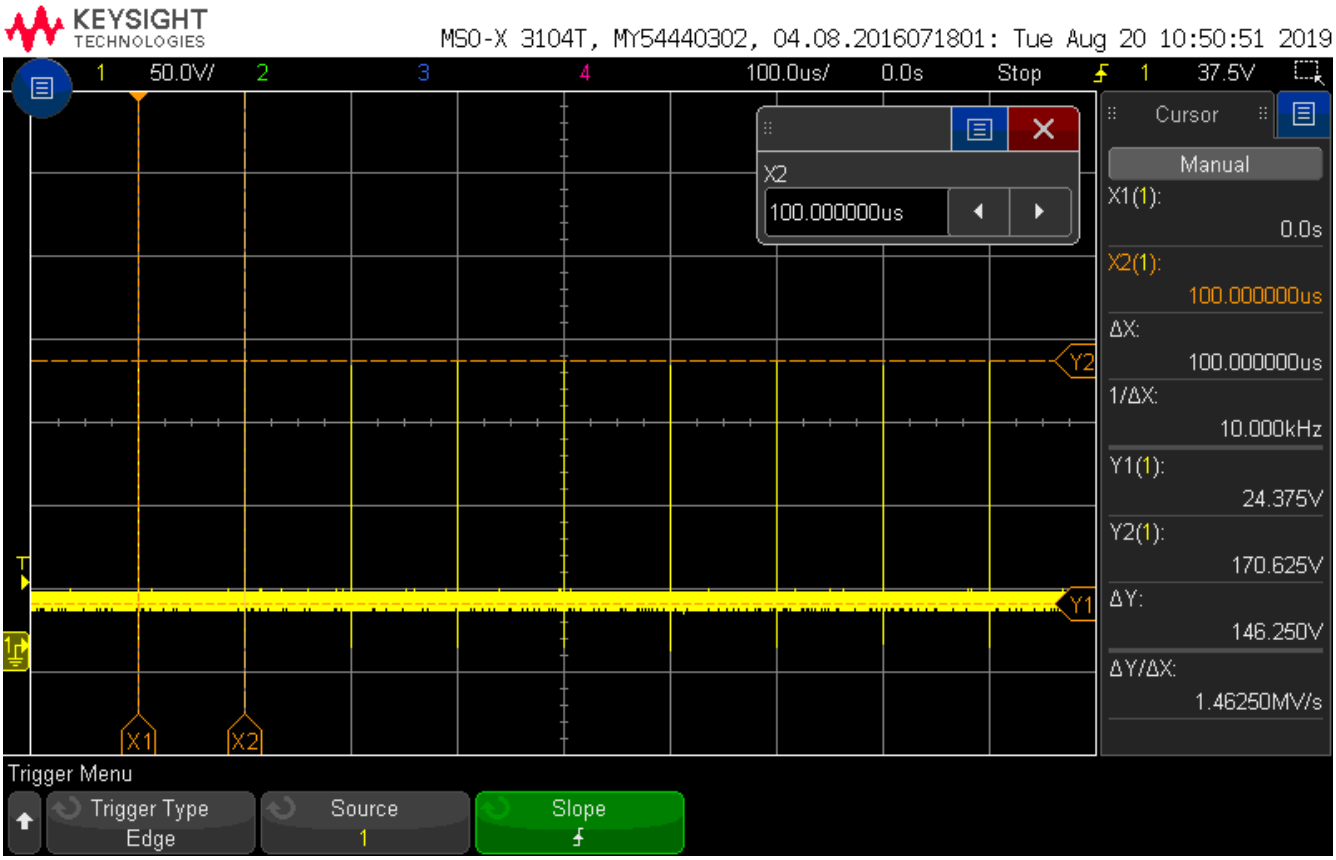


Figure 2.3.6.5-5 – Pulse 3b – T1 – EUT

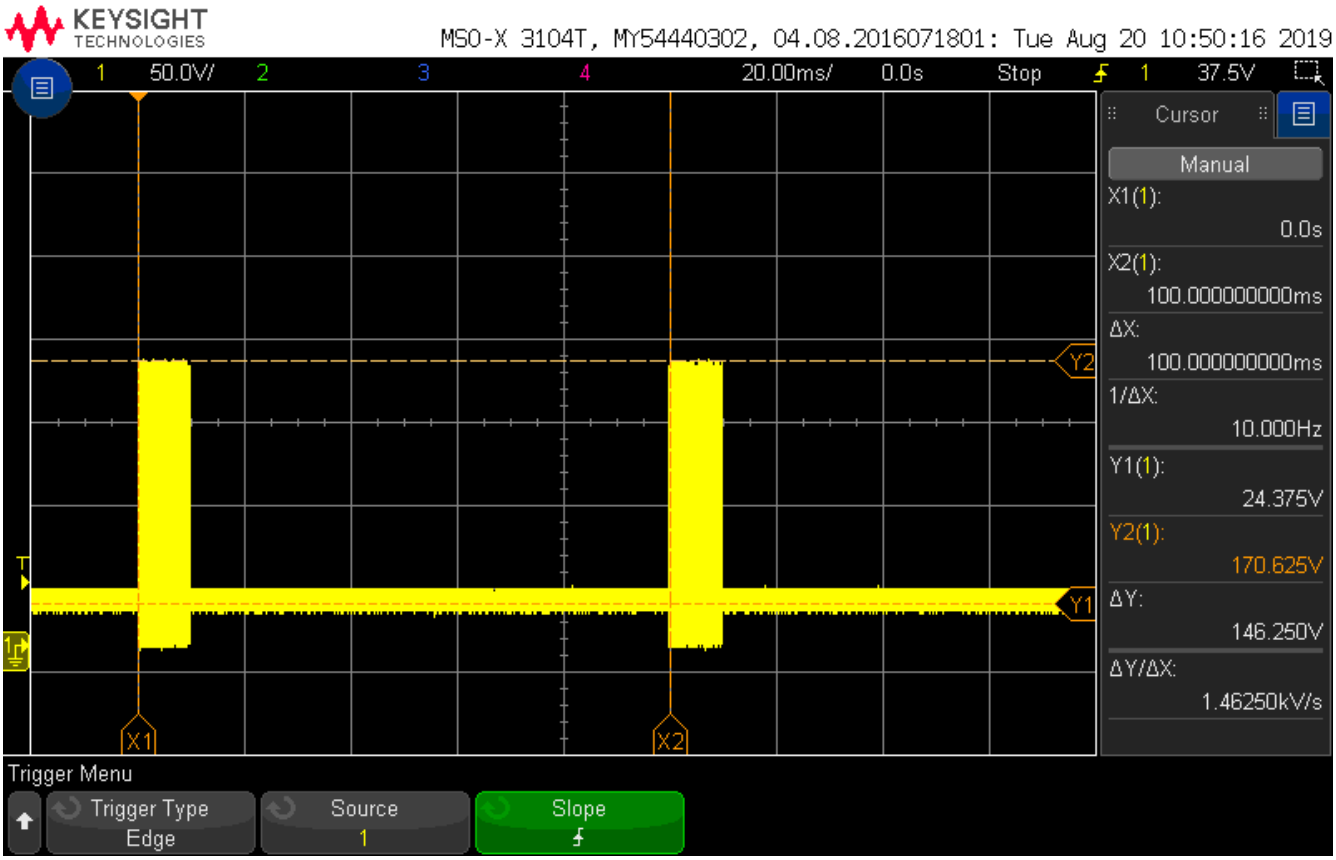


Figure 2.3.6.5-6 – Pulse 3b – T4 & T5 – EUT

2.3.6.6 Test Pulse 4

Table 2.3.6.6-1 – Test Pulse 4 Parameters

Test Voltage (Volts)	test Level (U_S)	Transient Time (mSec)	Test Level (U_A)	Transient Time (Sec)	Source Impedance (Ohms)	Repetitions
12	6	15	2.5	2	0	10
24	12	50	6	2	0	10

Remarks: Light blinks during transient and returns to normal operation after transient. The EUT was tested using 12V and 24Vdc power input.

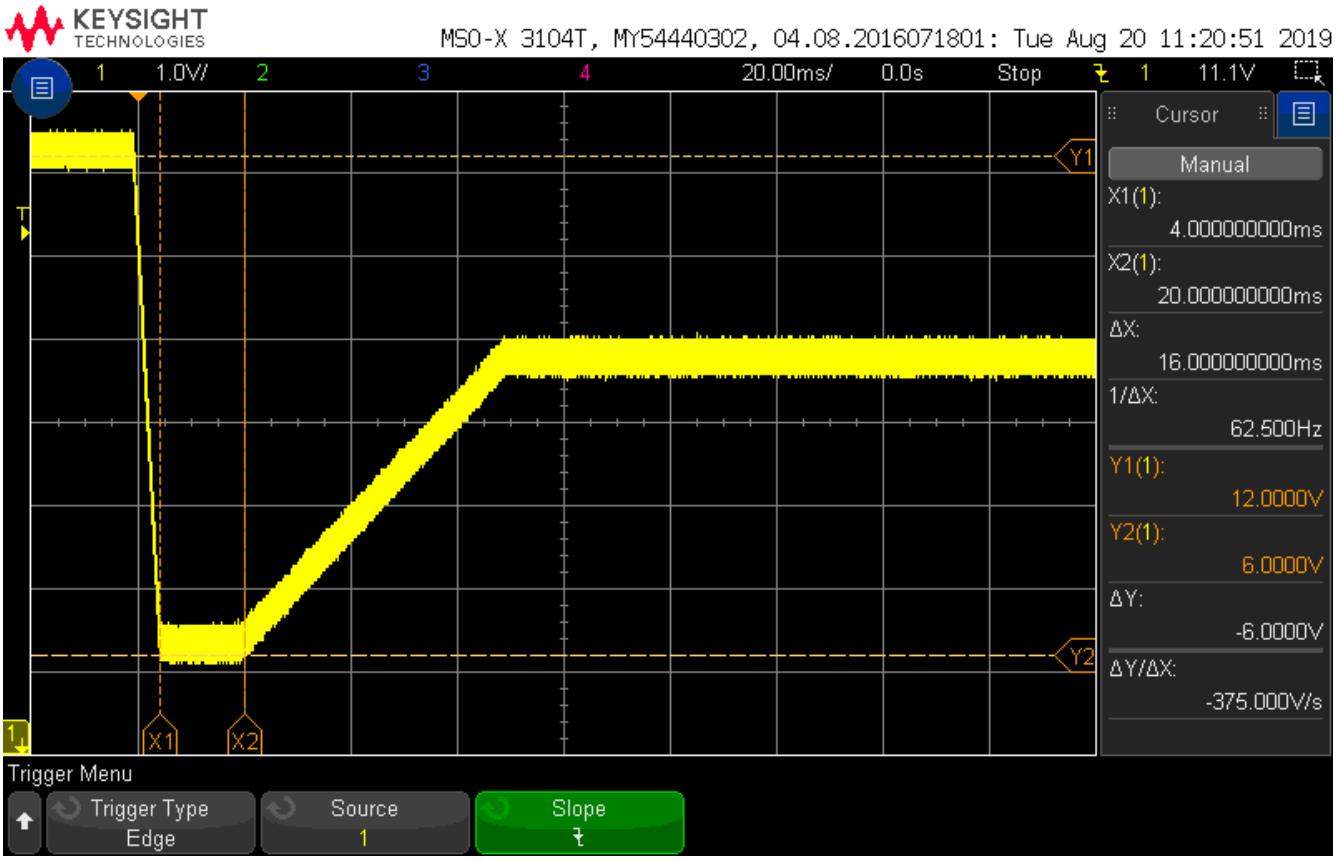


Figure 2.3.6.6-1 – Us & T6 – Open Circuit [12 VDC]

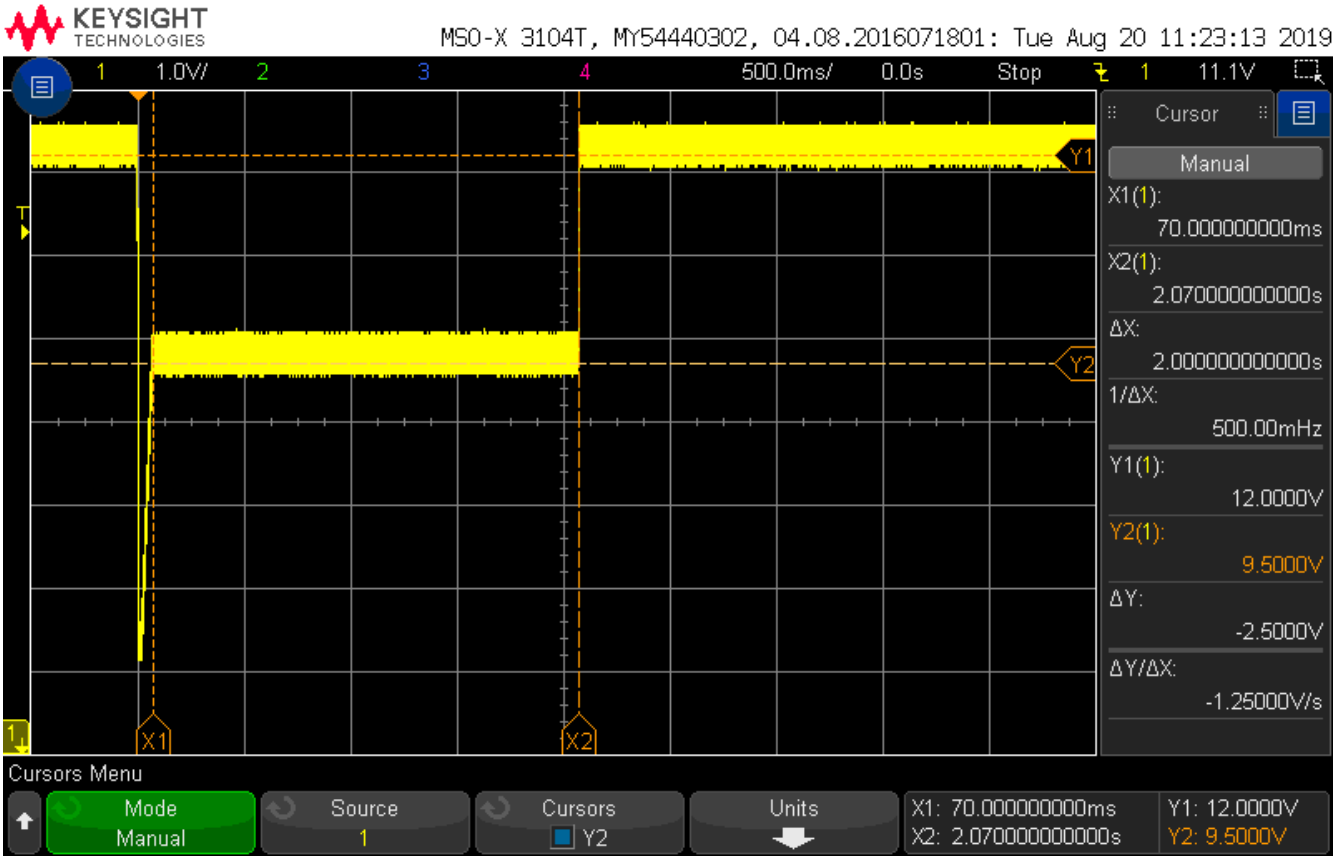


Figure 2.3.6.6-2 – Pulse 4 – Us6 & T8 – Open Circuit [12 VDC]

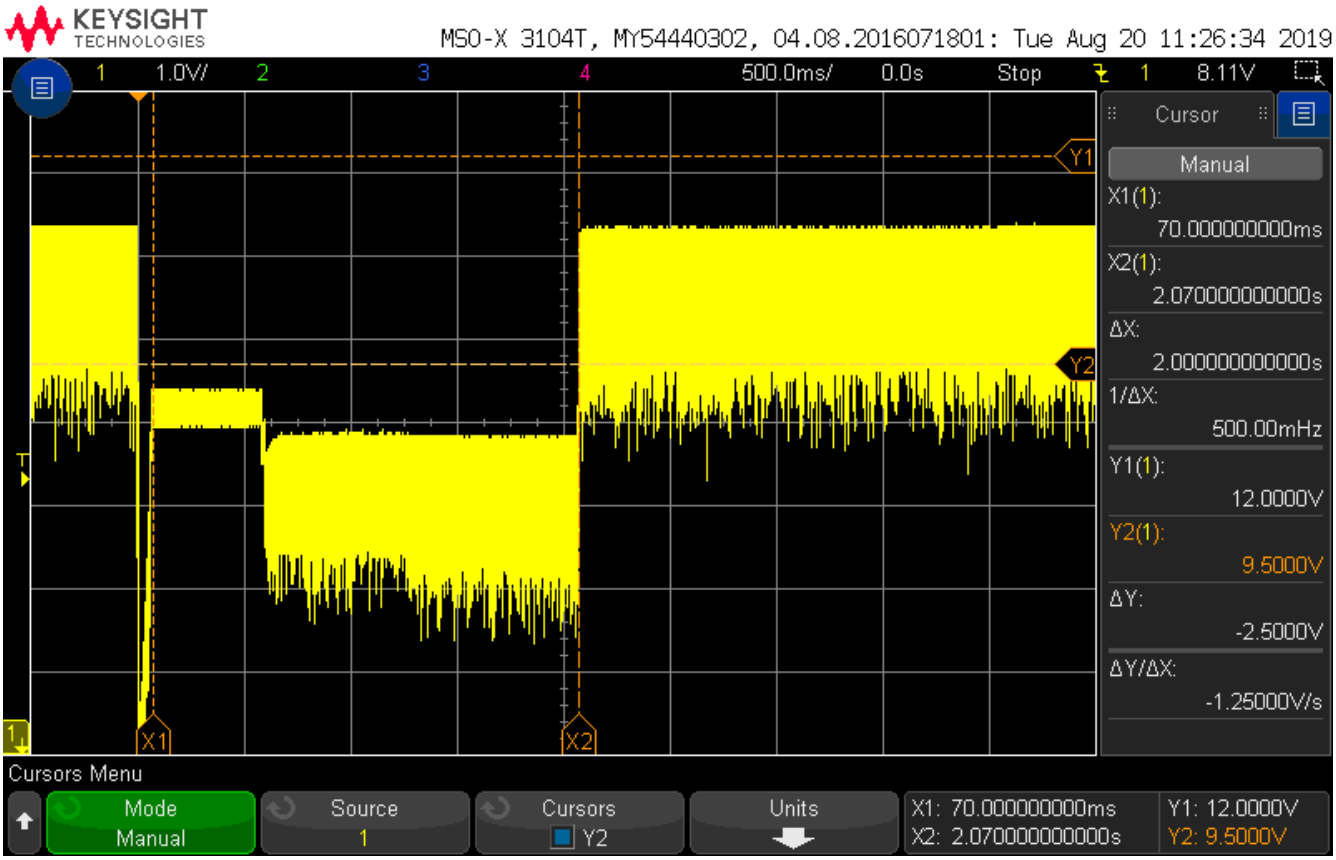


Figure 2.3.6.6-2 – Pulse 4 – EUT Load [12V DC]

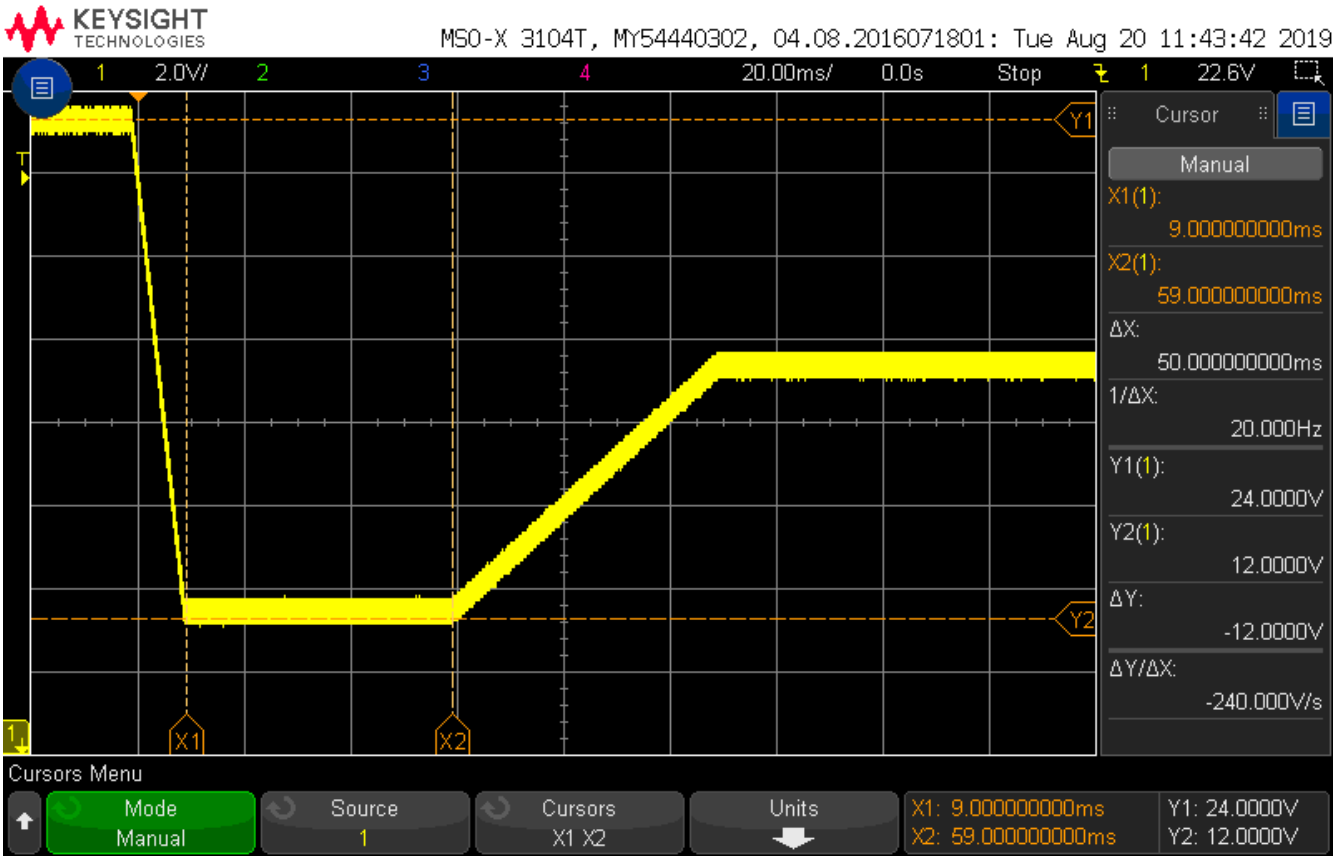


Figure 2.3.6.6-4 – Us & T6 – Open Circuit [24 VDC]

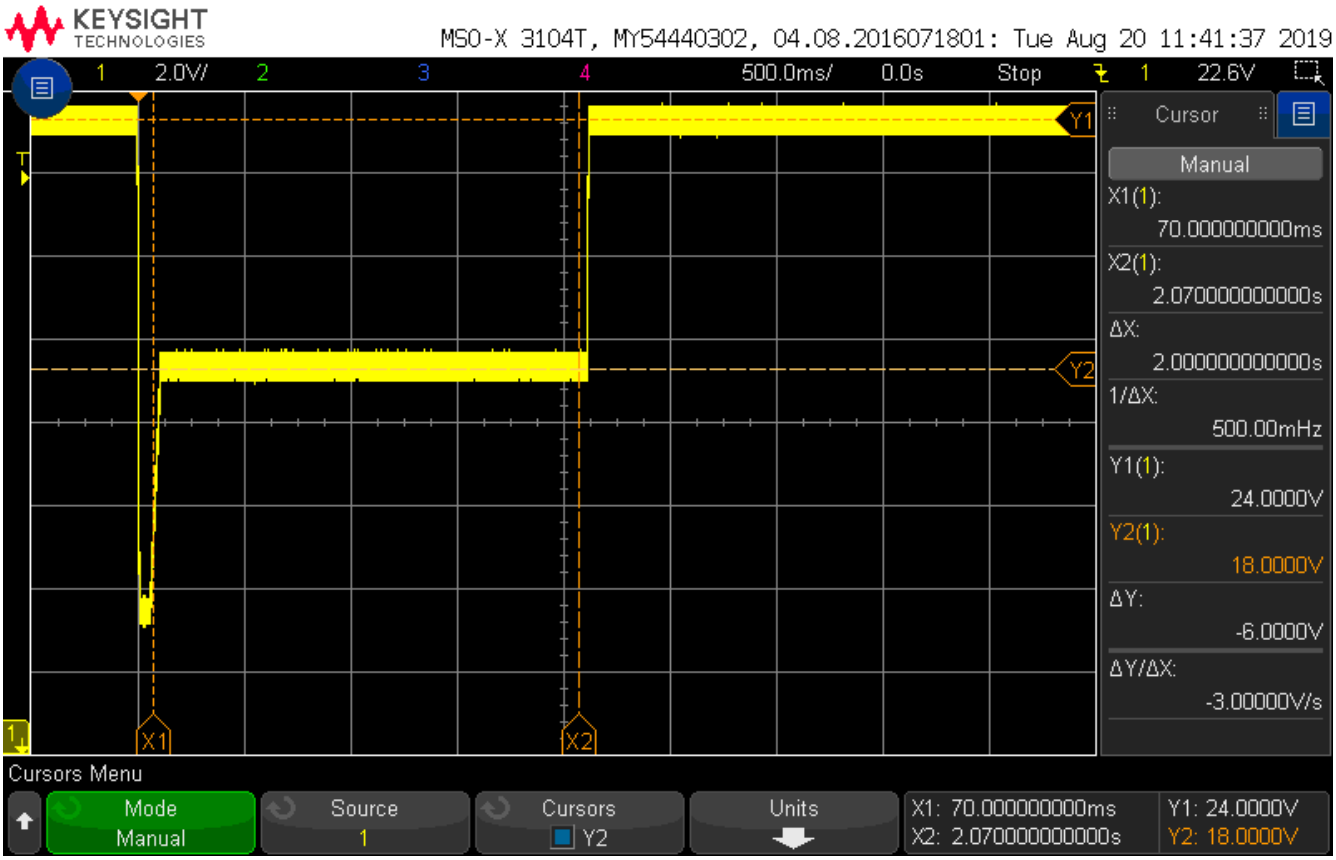


Figure 2.3.6.6-5 – Us6 & T8 – Open Circuit [24 VDC]

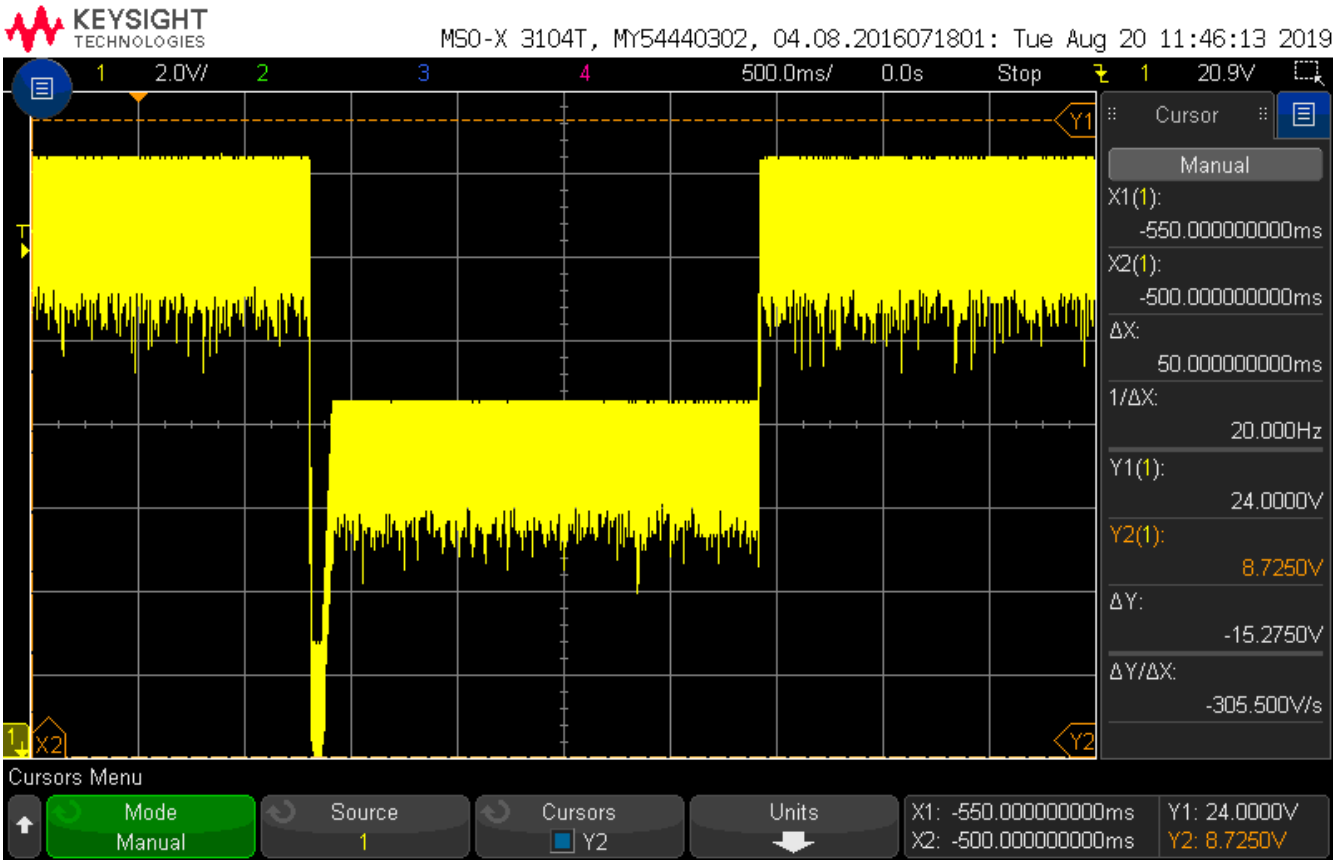


Figure 2.3.6.6-6 – Pulse 4 – EUT [24 VDC]

2.3.6.7 Starting Profile

Table 2.3.6.7-1 – Starting Profile Parameters

Test Voltage (Volts)	test Level (U_{S6})	Transient Time (mSec)	Test Level (U_s)	Transient Time (Sec)	Source Impedance (Ohms)	Repetitions
12	6	50	9	1	0	10
24	8	50	15	1	0	10

Remarks: EUT powers down with each transient, returns to normal operation when test is completed. The EUT was tested using 12V and 24Vdc power input.

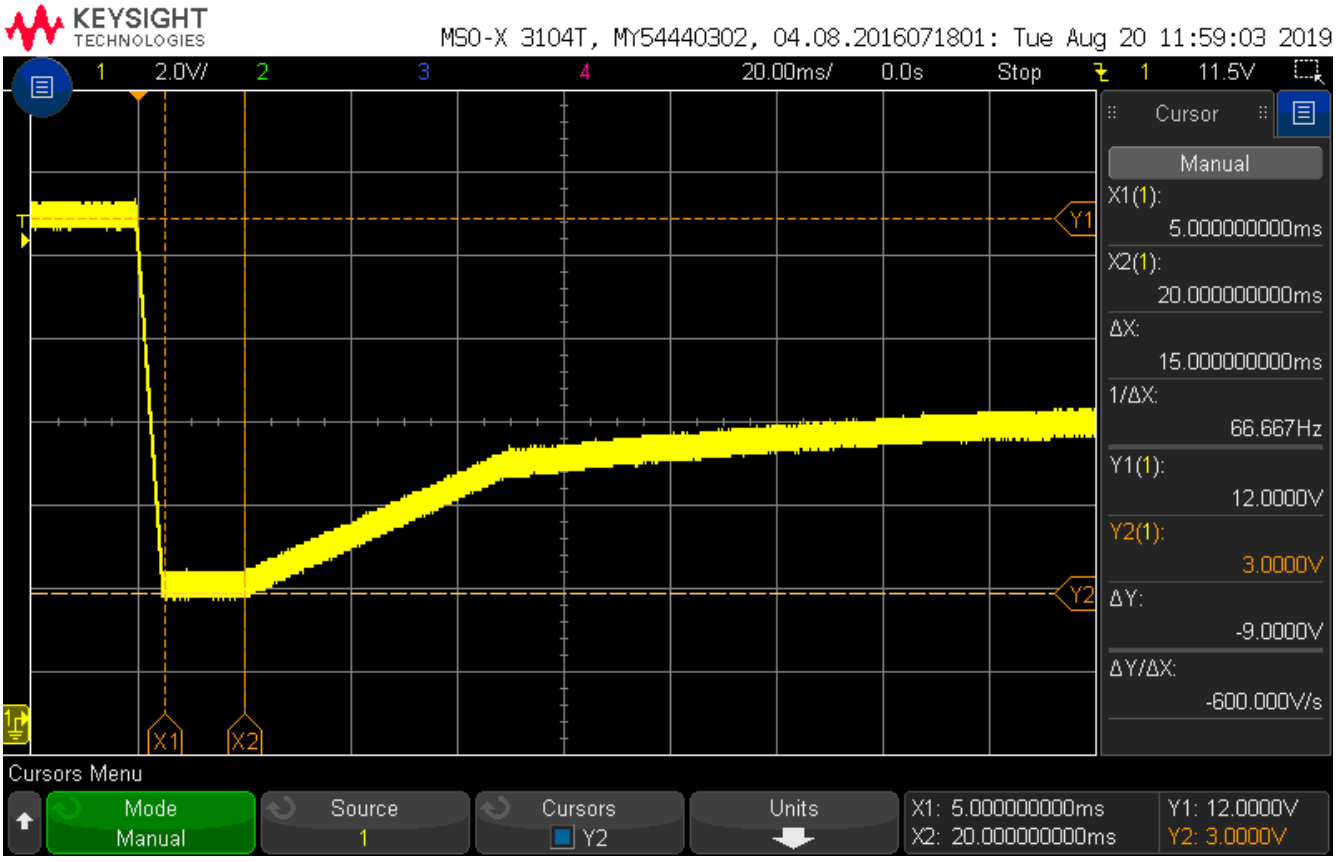


Figure 2.3.6.7-1 - Pulse 4 – Us & T6 – Open Circuit [12V DC]

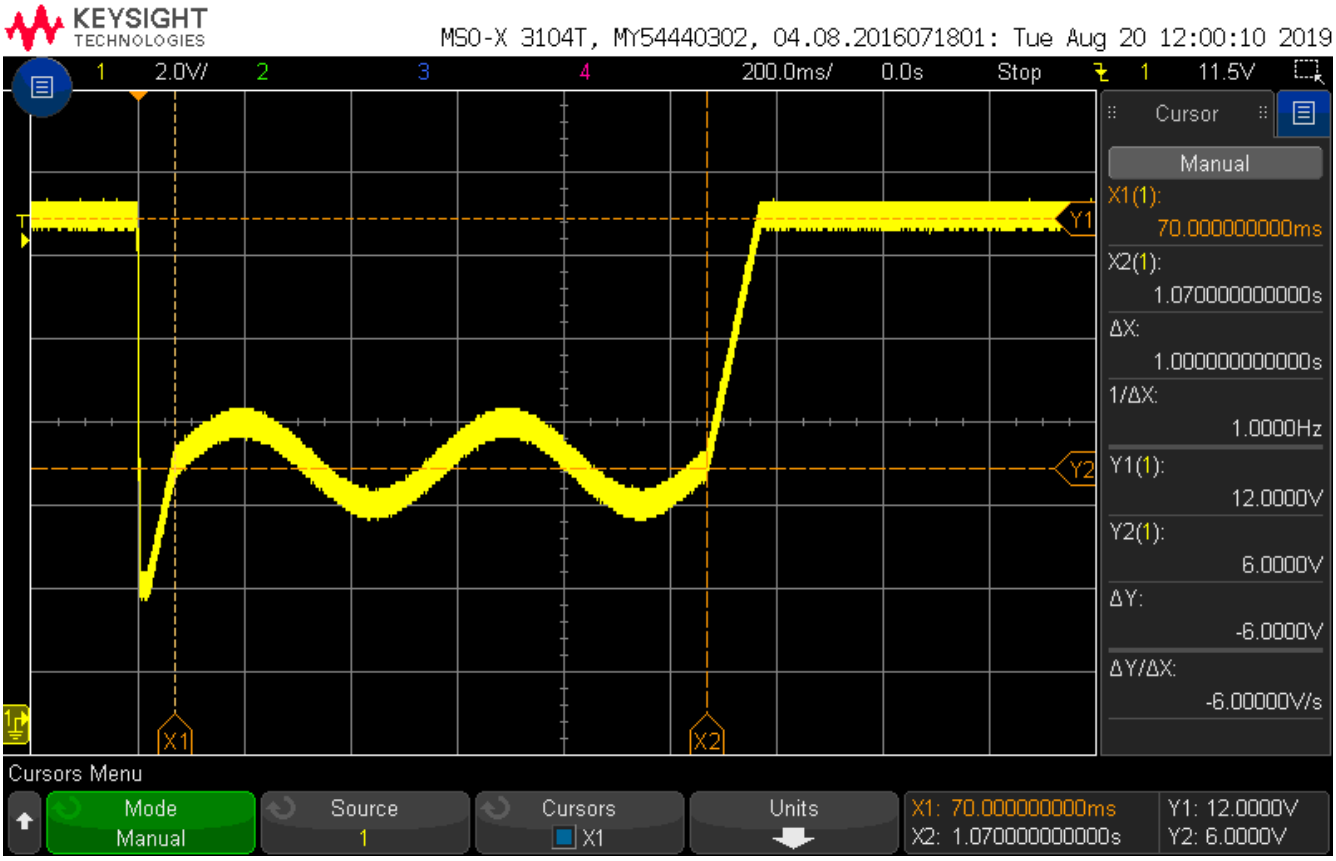


Figure 2.3.6.7-2 - Pulse 4 – Us6 & T8 – Open Circuit [12V DC]

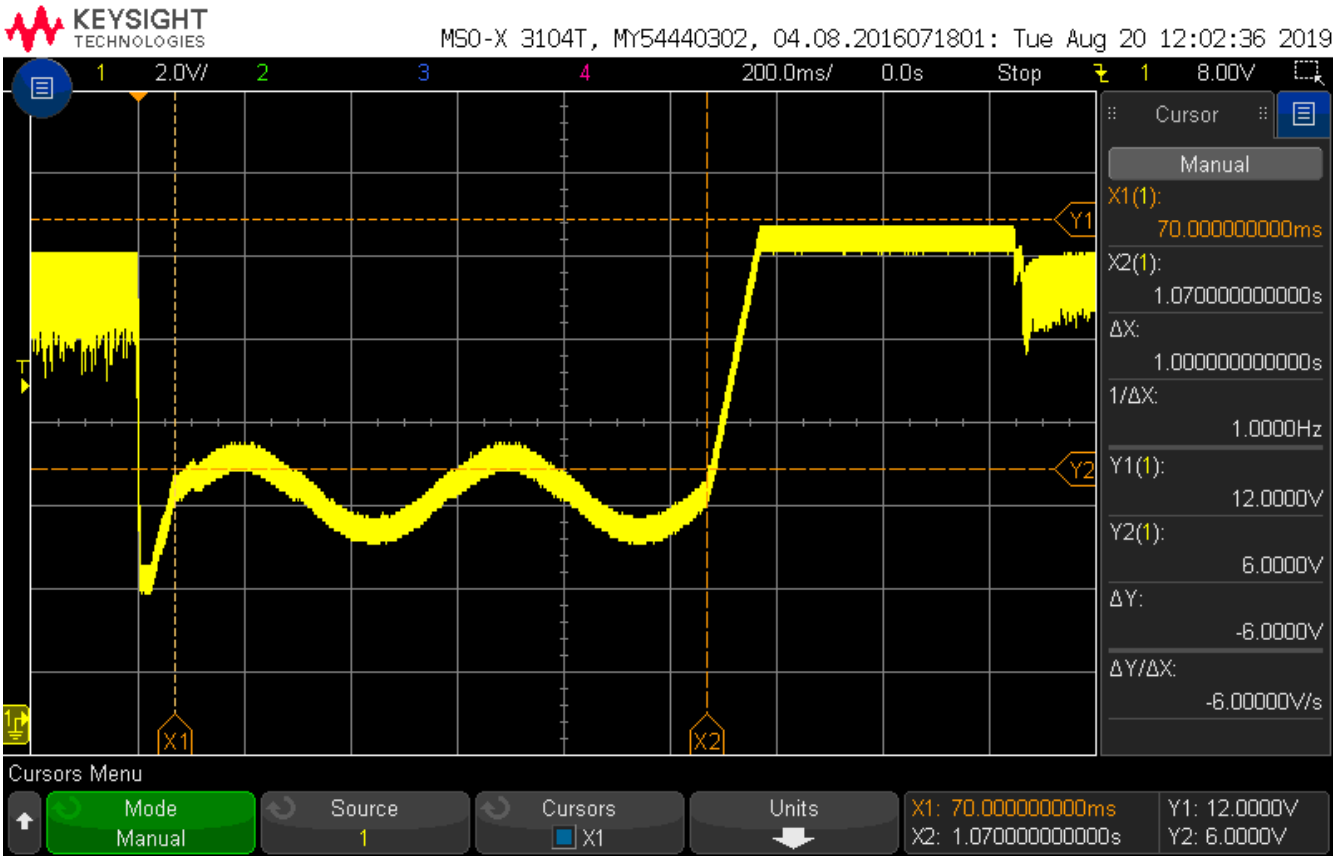


Figure 2.3.6.7-3 - Pulse 4 – EUT Load [12V DC]

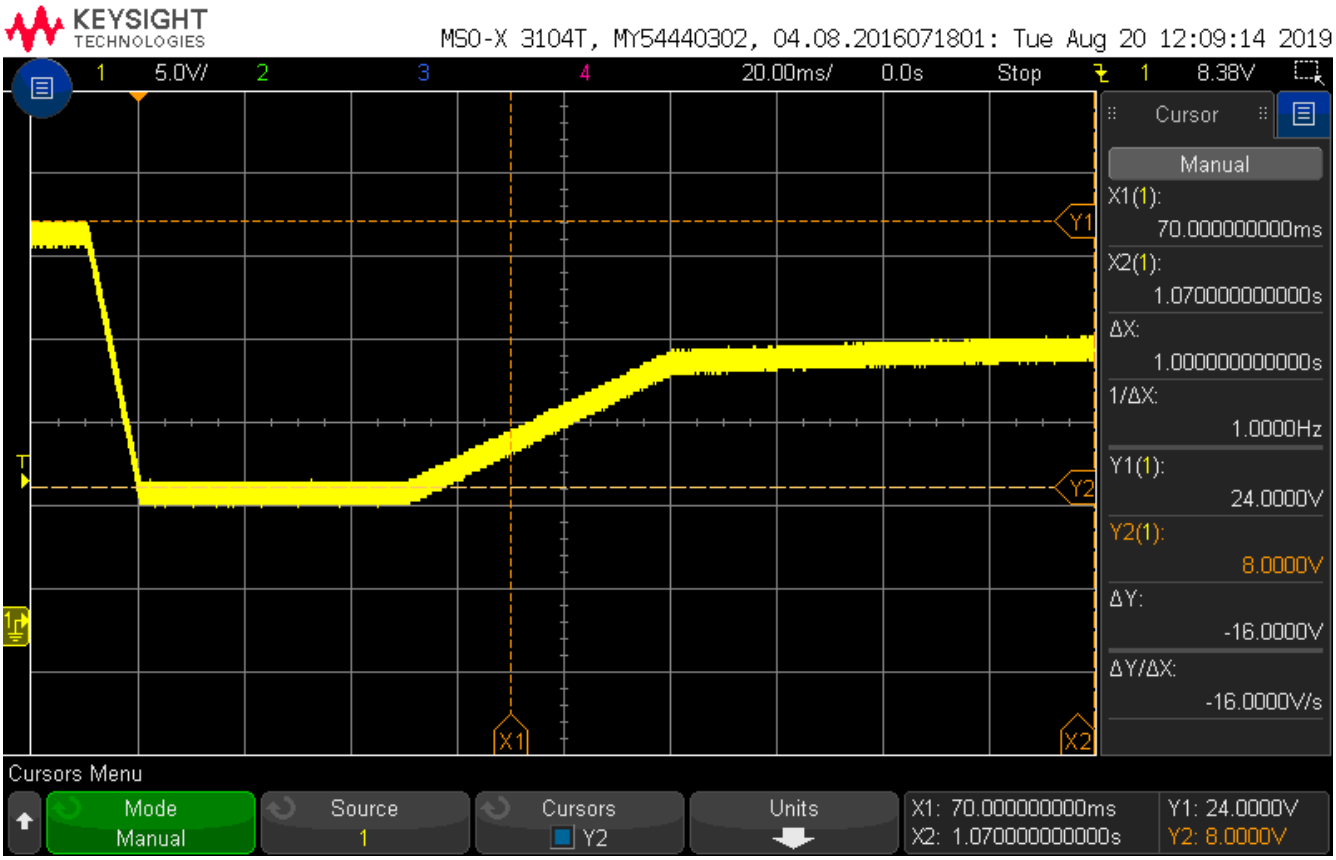


Figure 2.3.6.7-4 – Us6 & T6 – Open Circuit [24 VDC]

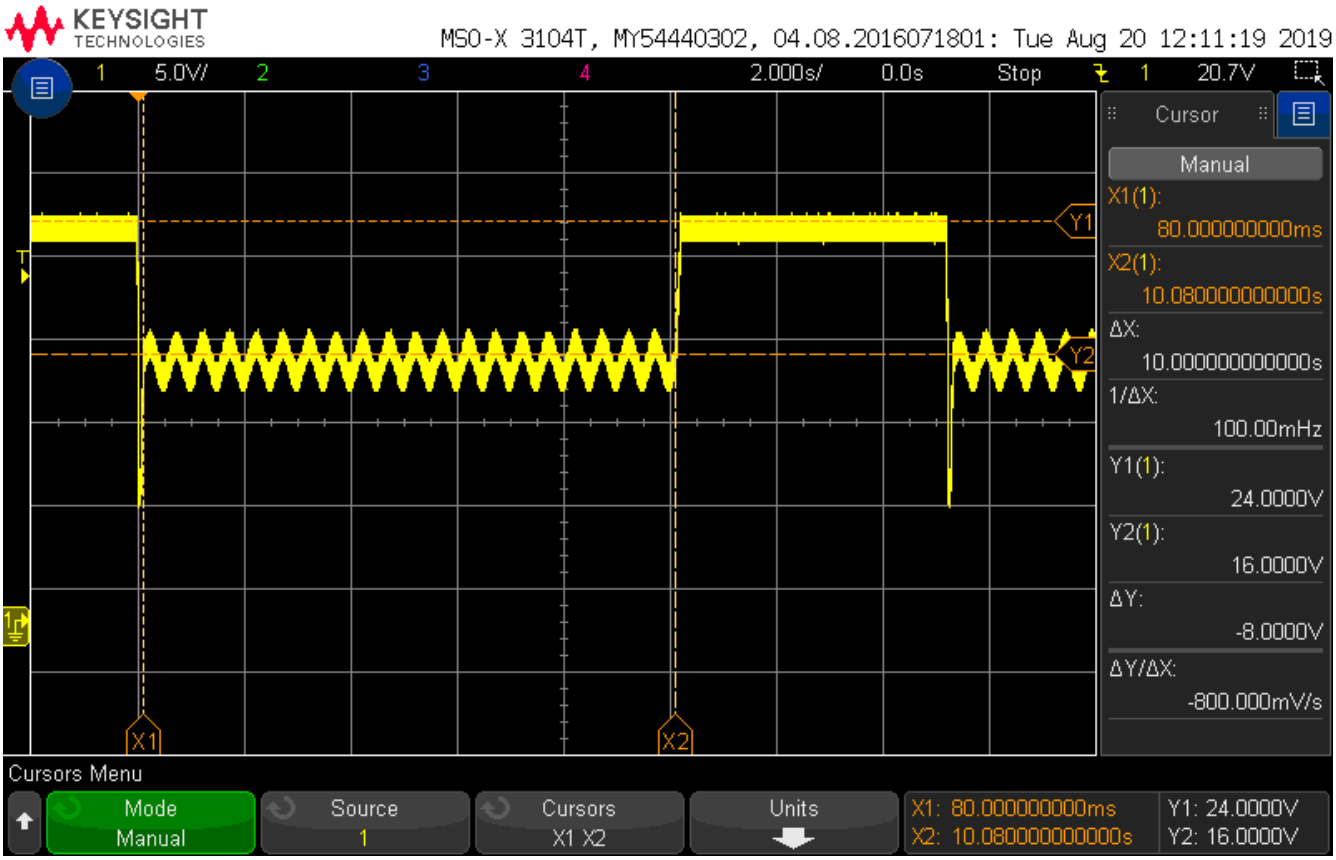


Figure 2.3.6.7-5 – Us & T8 – Open Circuit [24 VDC]

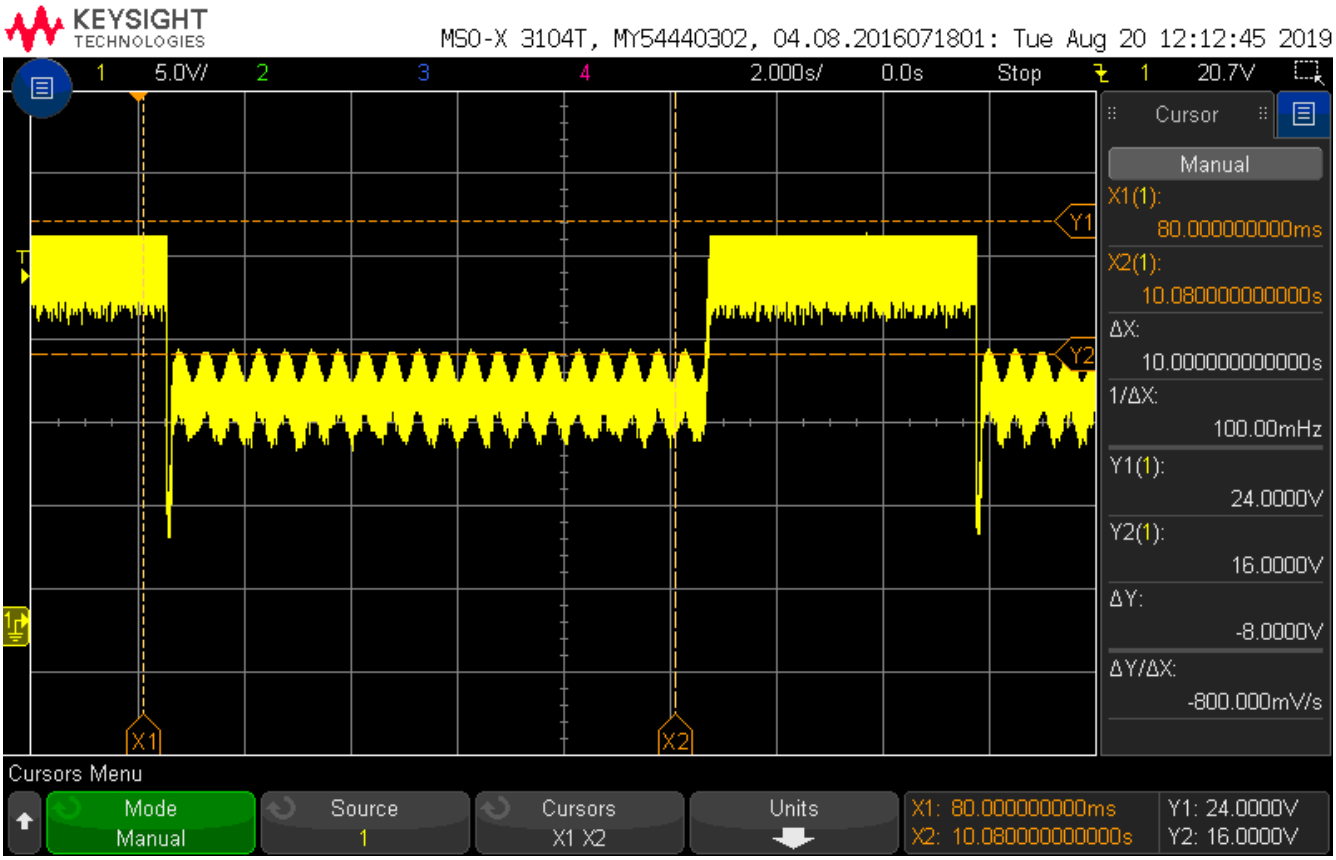


Figure 2.3.6.7-6 – Starting Profile – EUT [24 VDC]

2.3.6.8 Load Dump (Unclamped)

Table 2.3.6.8-1 – Load Dump (Unclamped) Parameters

Test Voltage (Volts)	test Level (Volts)	Source Impedance (Ohms)	Rep Rate (Sec)	Transient Duration (mSec)	Repetitions
27	+151	8	60	200	10

Remarks: None.

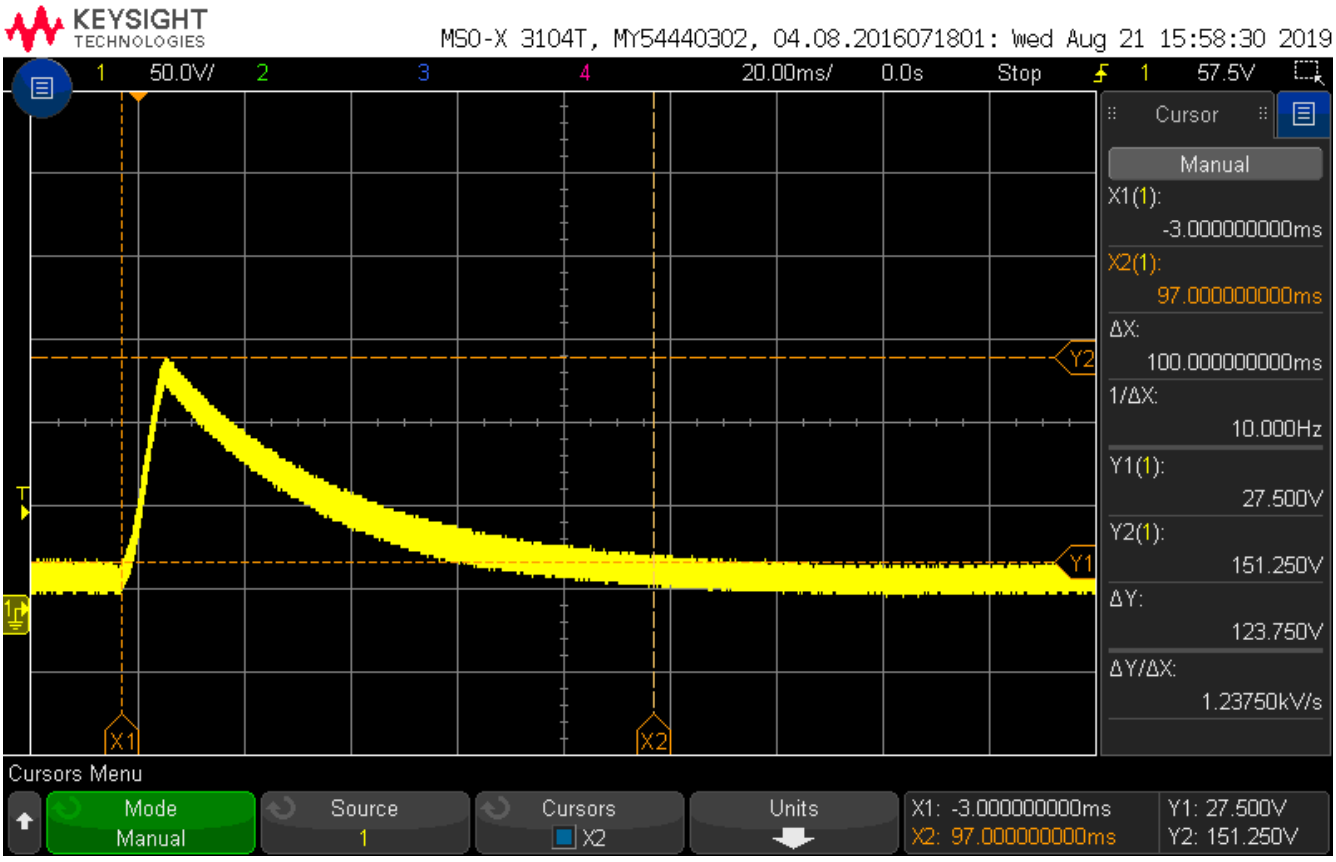


Figure 2.3.6.8-1 – Load Dump (Unclamped) – Open Circuit

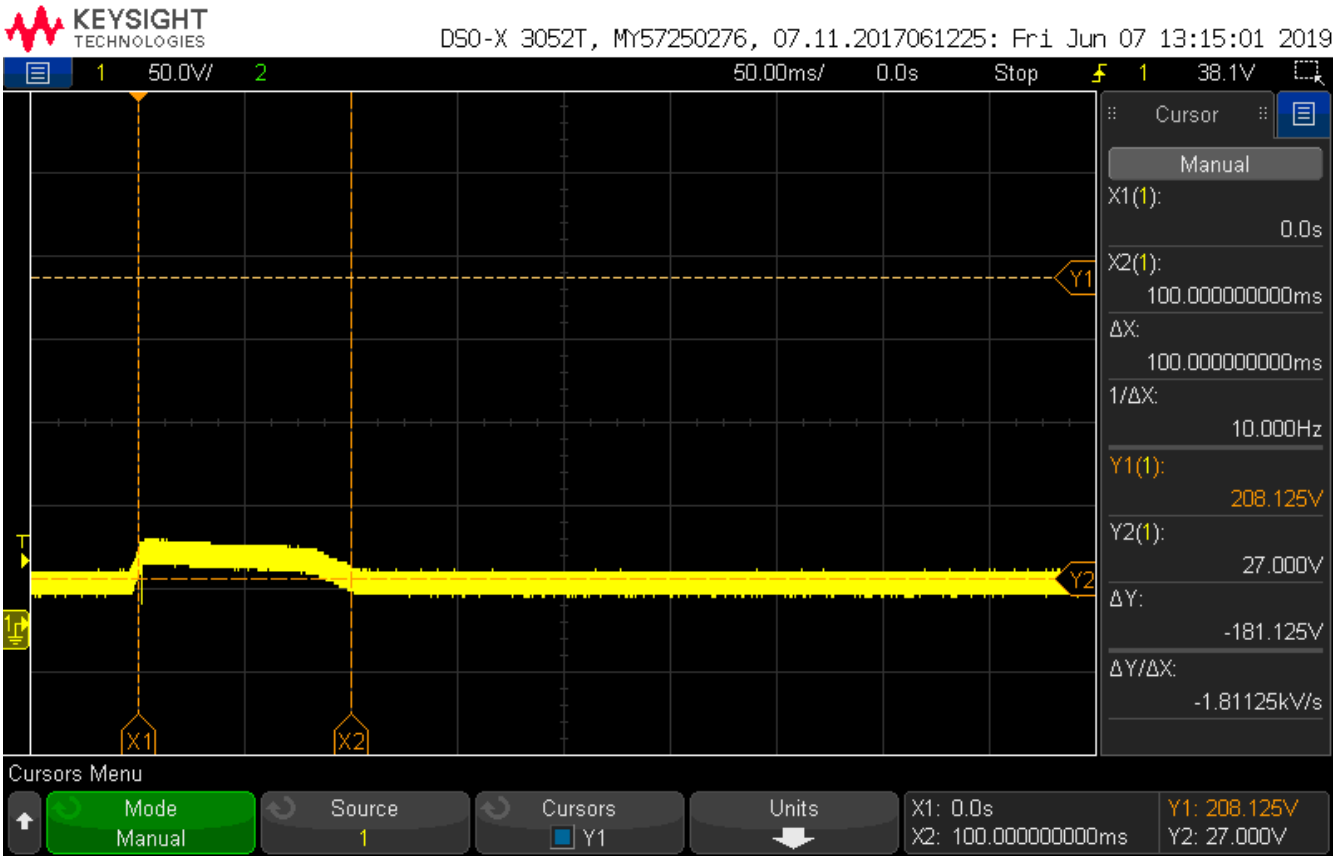


Figure 2.3.6.8-2 – Load Dump (Unclamped) – EUT

2.3.6.9 Fast 3a (CCC Method)

Table 2.3.6.9-1 – Fast 3a Parameters

Test Voltage (Volts)	test Level (Volts)	Rep Rate (uSec)	Burst Width (mSec)	Burst Period (mSec)	Source Impedance (Ohms)
27	-110	100	10	100	50

Remarks: Tested on both Cable Harness and Auxiliary I/O cables.

Figure 2.3.6.9-1 - CCC – Us & Td – Open Circuit

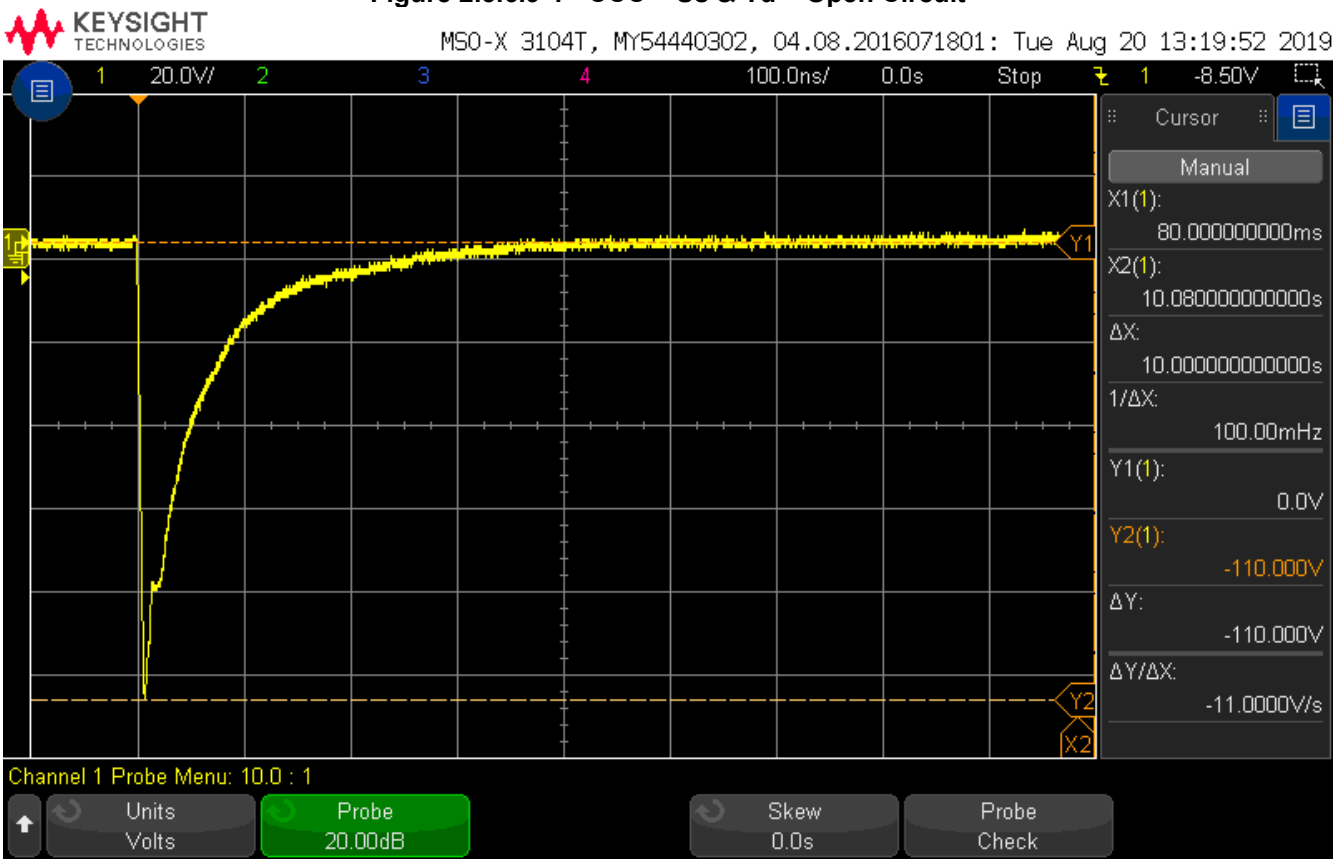


Figure 2.3.6.9-2 - CCC – T1 – Open Circuit

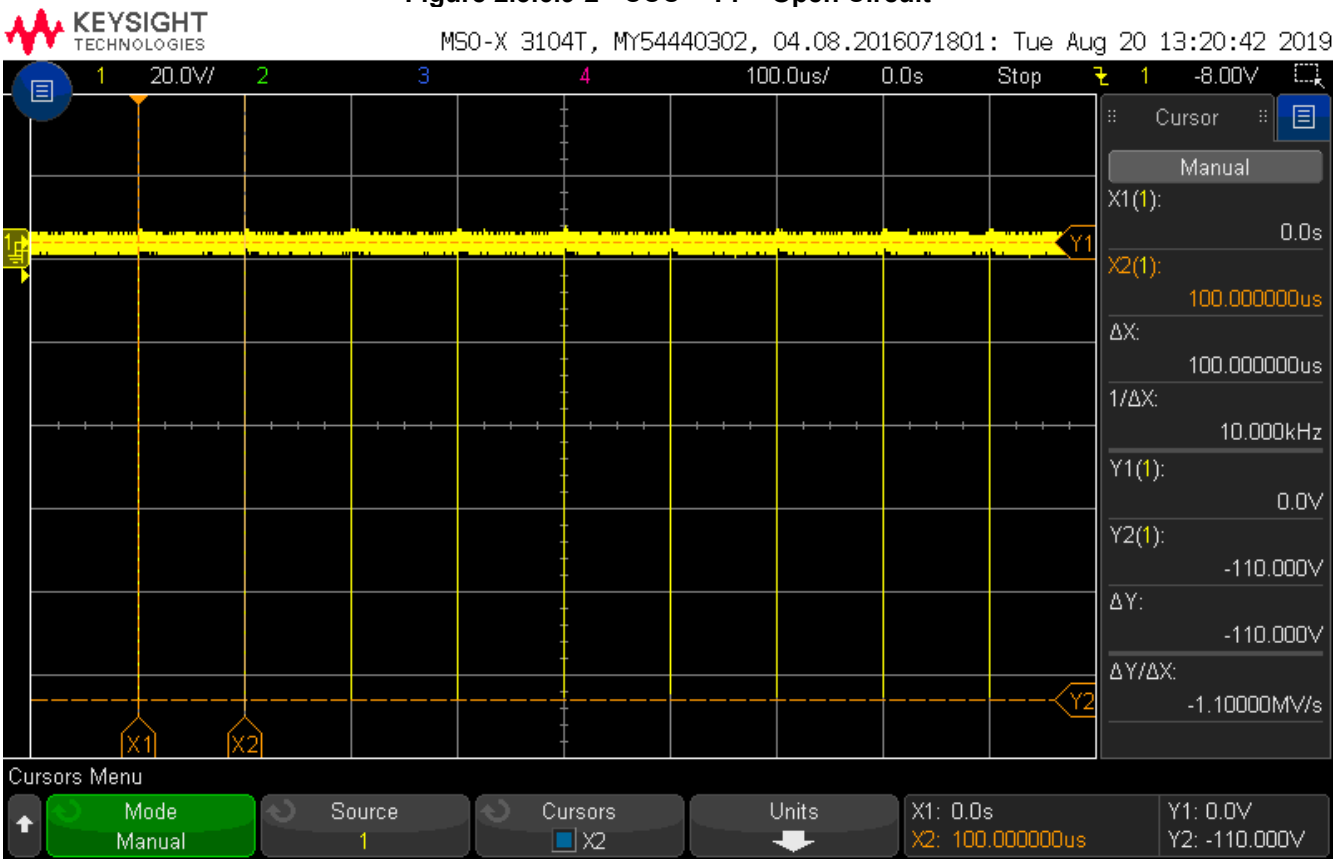


Figure 2.3.6.9-3 - CCC – T4 + T5 – Open Circuit

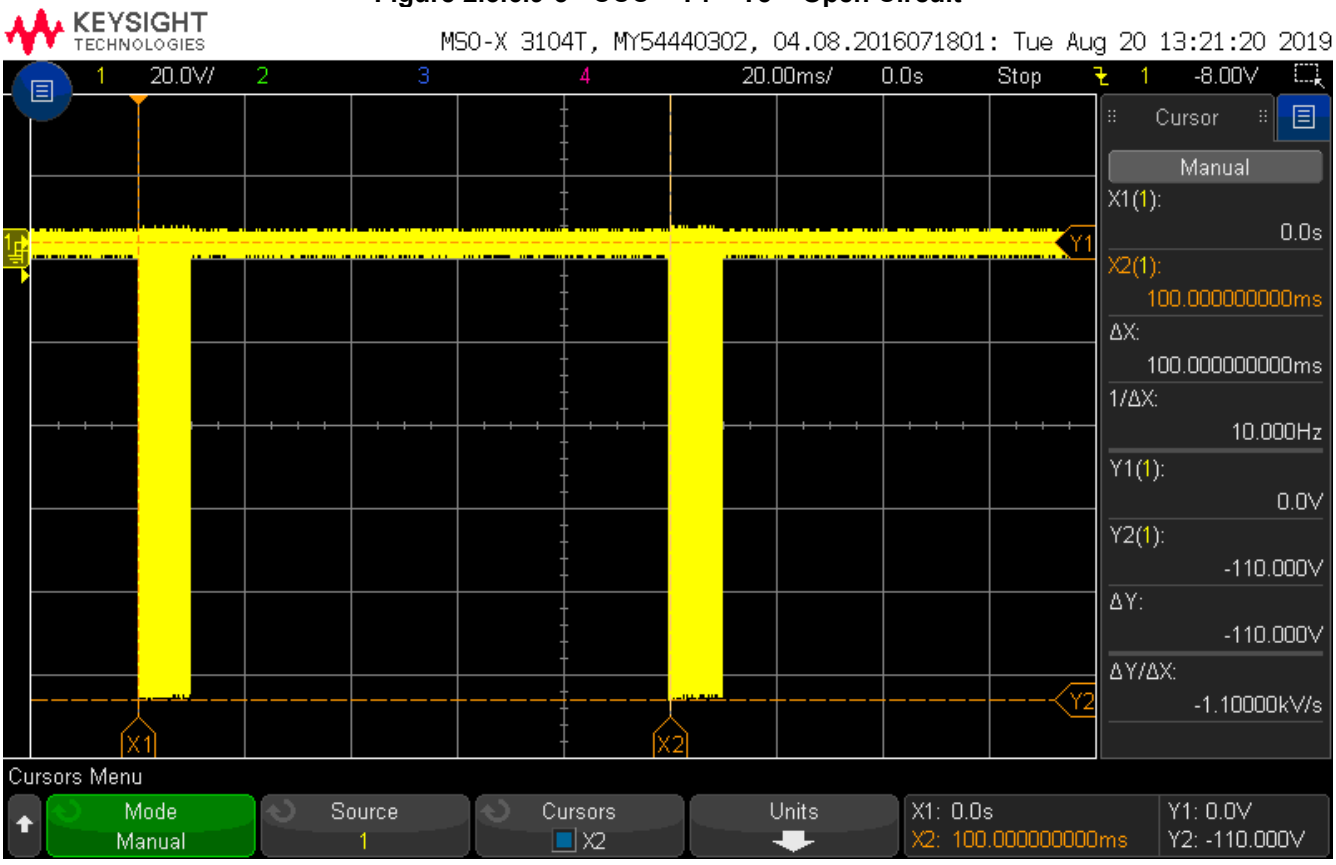


Figure 2.3.6.9-4 - CCC – Us & Td – EUT Load – Cable Harness

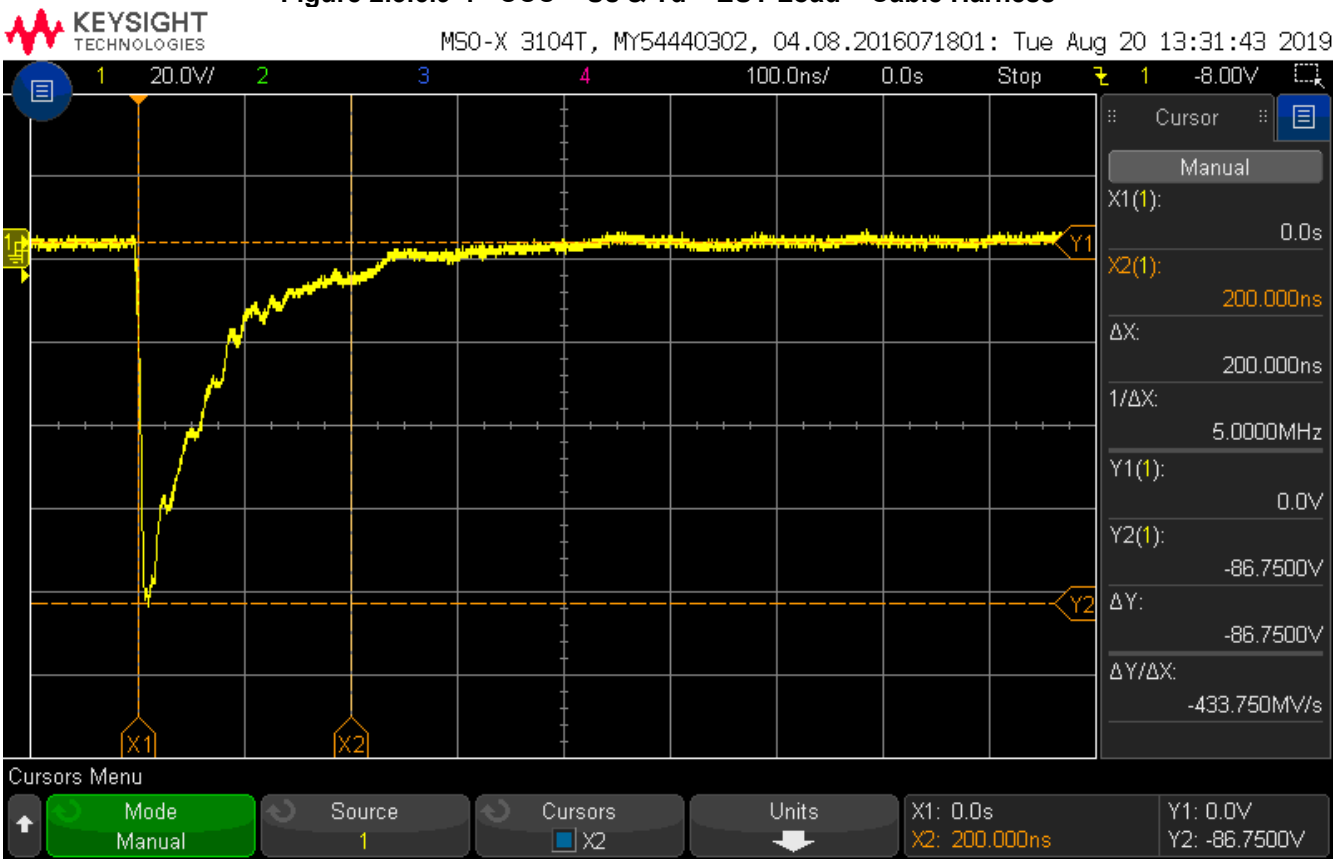


Figure 2.3.6.9-5 - CCC – T1 – EUT Load – Cable Harness

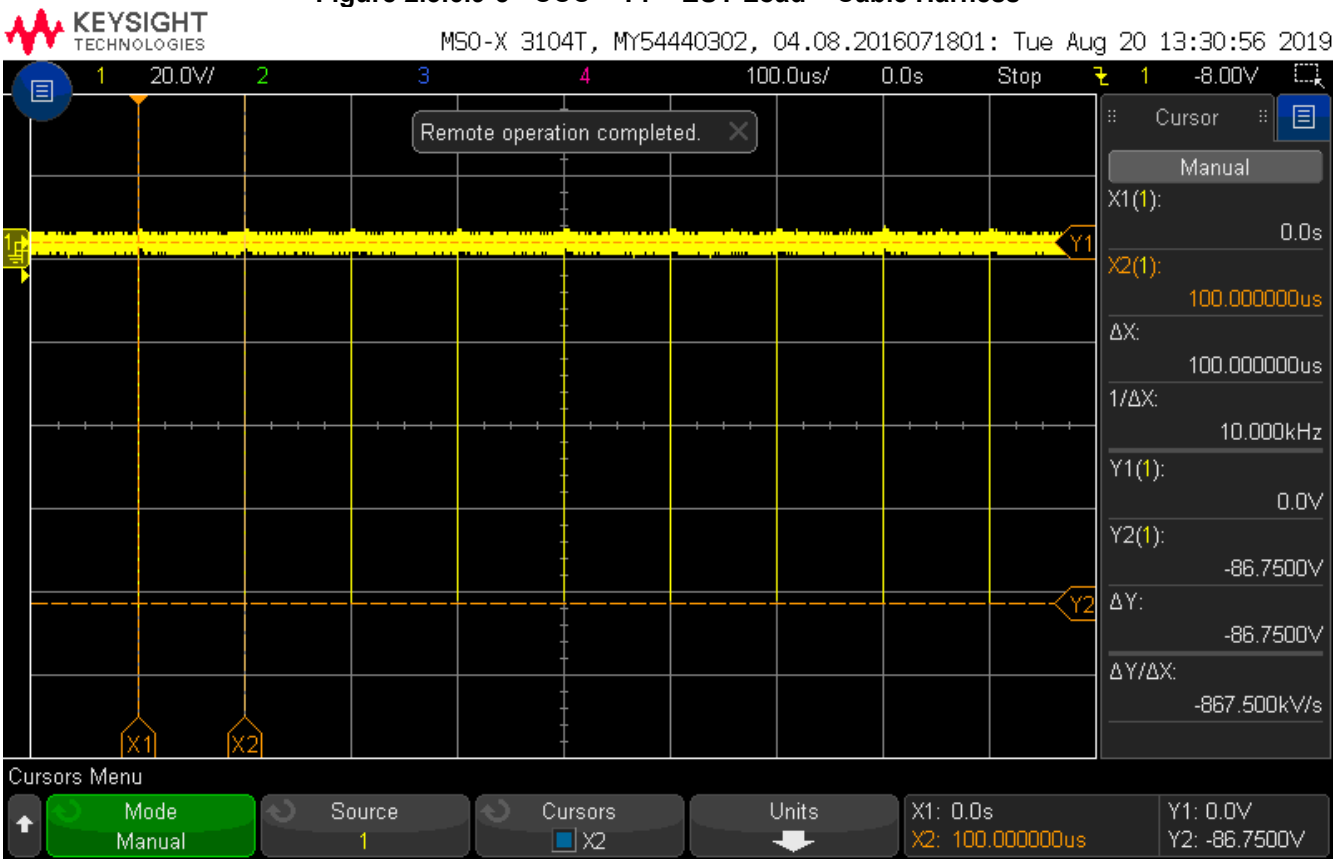


Figure 2.3.6.9-6 - CCC – T4 + T5 – EUT Load – Cable Harness

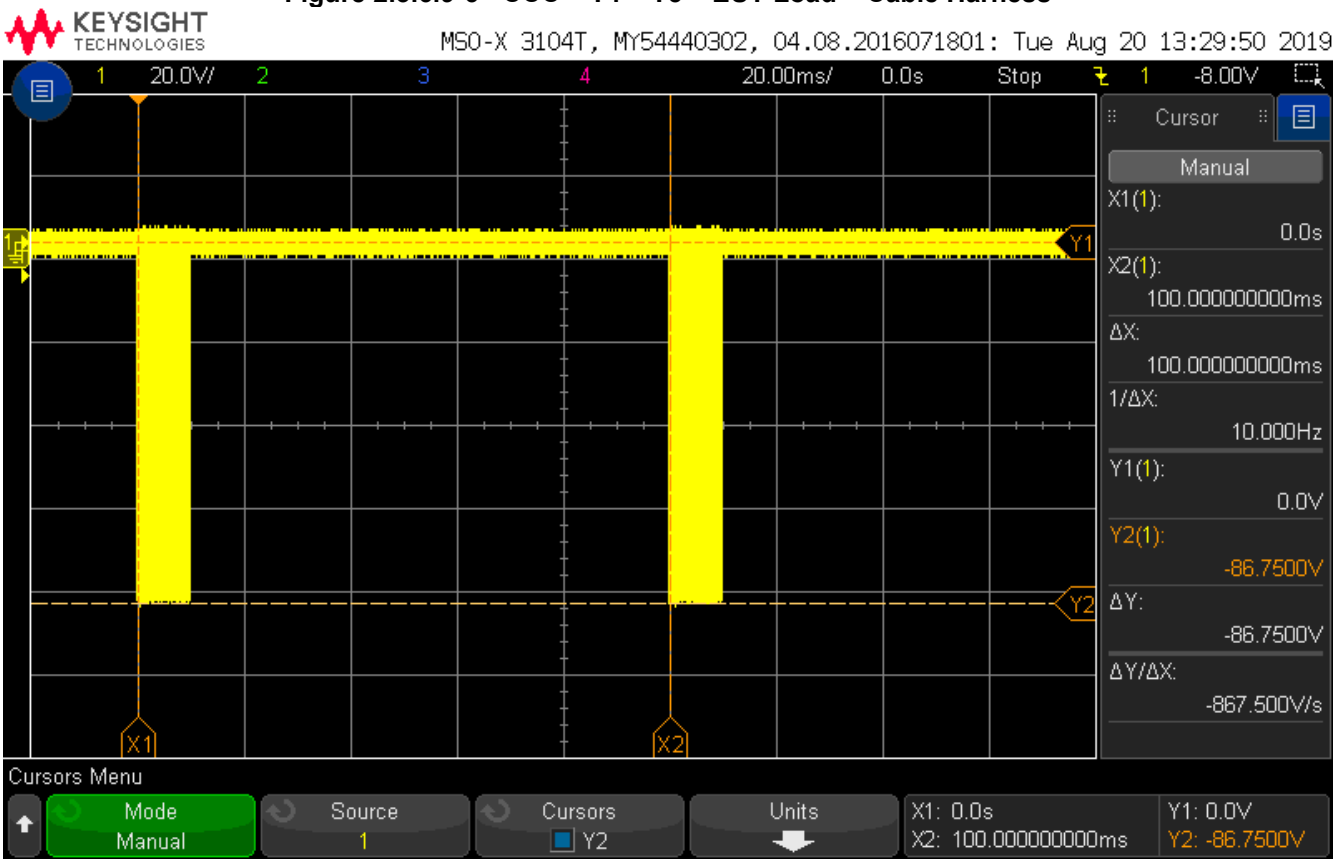


Figure 2.3.6.9-7 - CCC – Us & Td – EUT Load – Auxiliary I/O

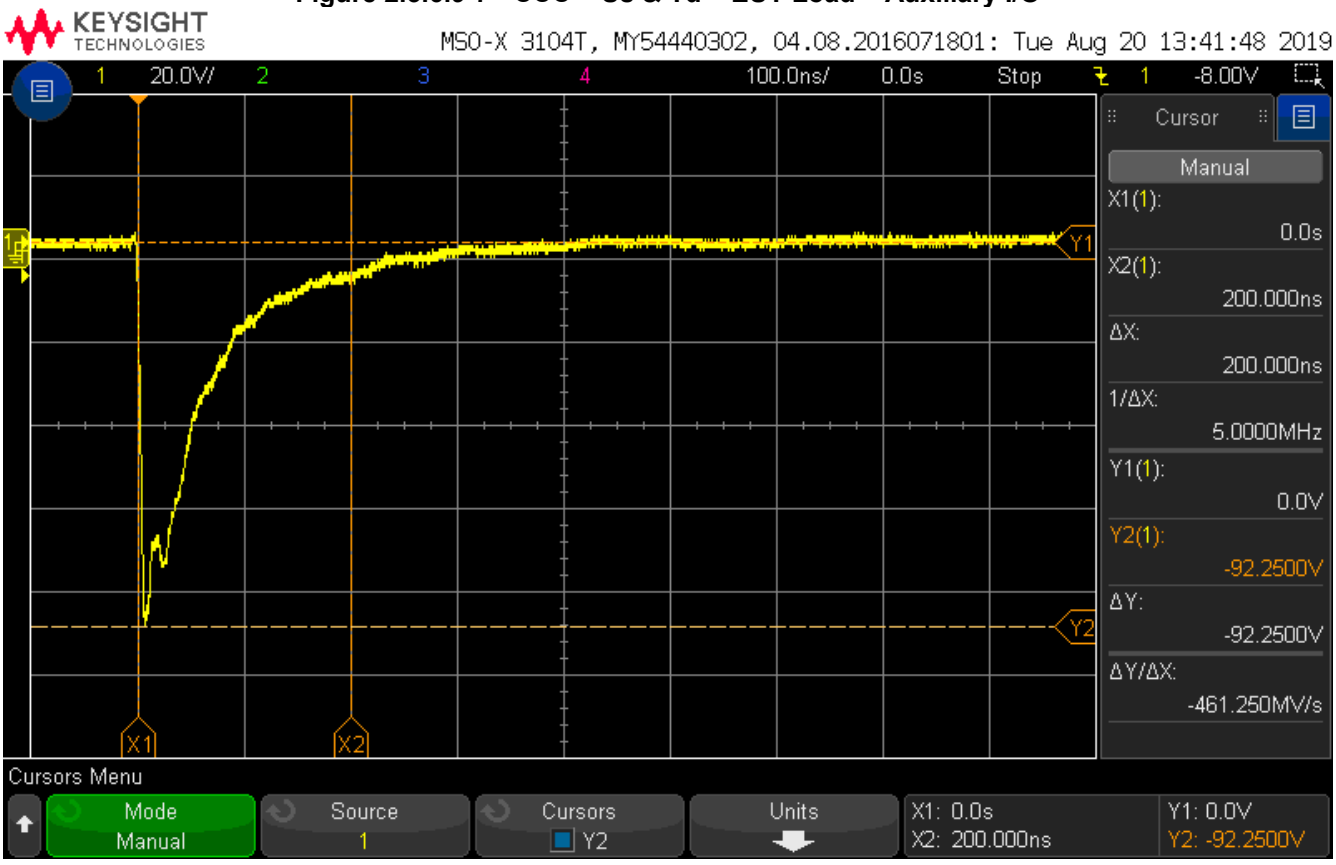


Figure 2.3.6.9-8 - CCC – T1 – EUT Load – Auxiliary I/O

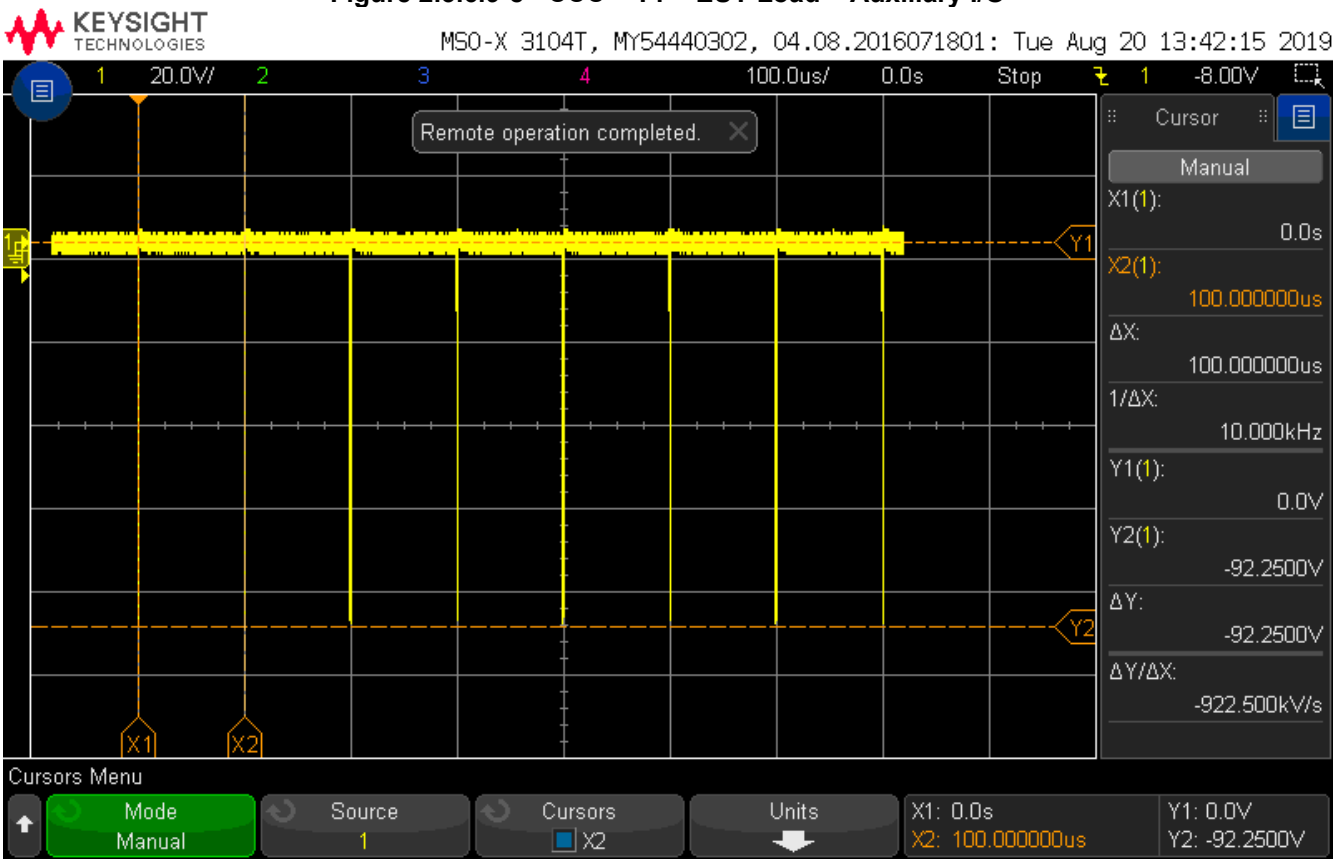
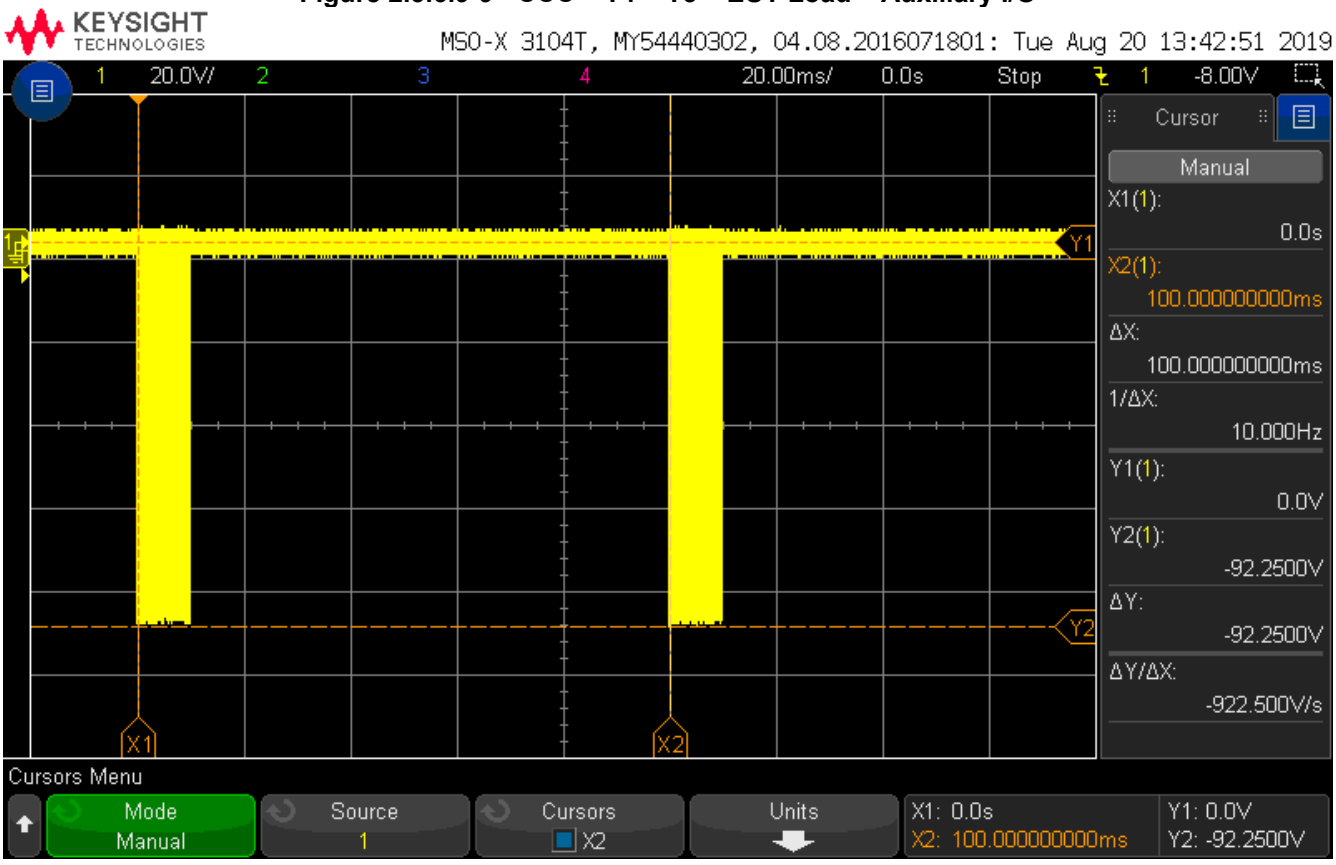


Figure 2.3.6.9-9 - CCC – T4 + T5 – EUT Load – Auxiliary I/O



2.3.6.10 Fast 3b (CCC Method)

Table 2.3.6.10-1 – Fast 3b Parameters

Test Voltage (Volts)	test Level (Volts)	Rep Rate (uSec)	Burst Width (mSec)	Burst Period (mSec)	Source Impedance (Ohms)
27	110	100	10	100	50

Remarks: Tested on both Cable Harness and Auxiliary I/O cables.

Figure 2.3.6.10-1 - CCC – Us & Td – Open Circuit

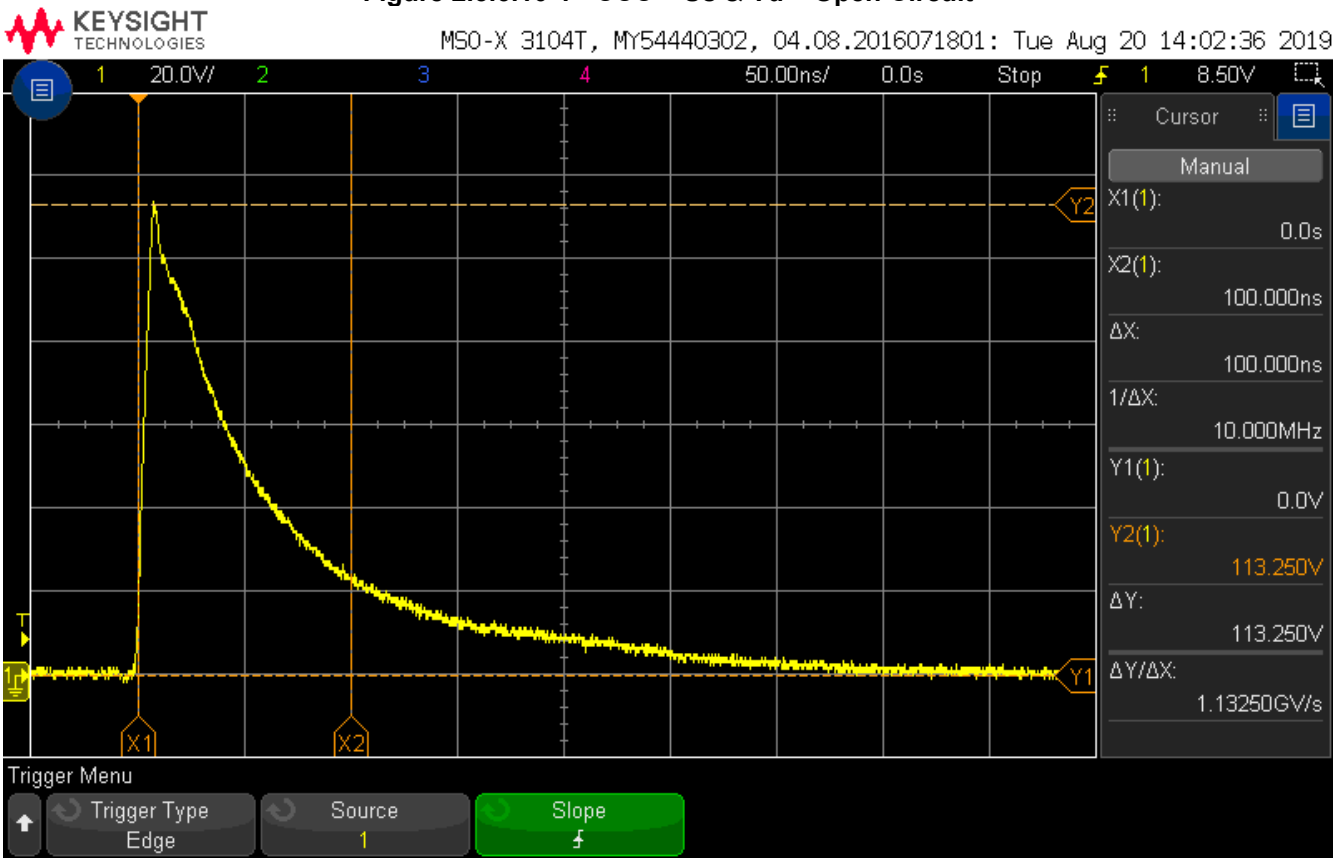


Figure 2.3.6.10-2 - CCC – T1 – Open Circuit

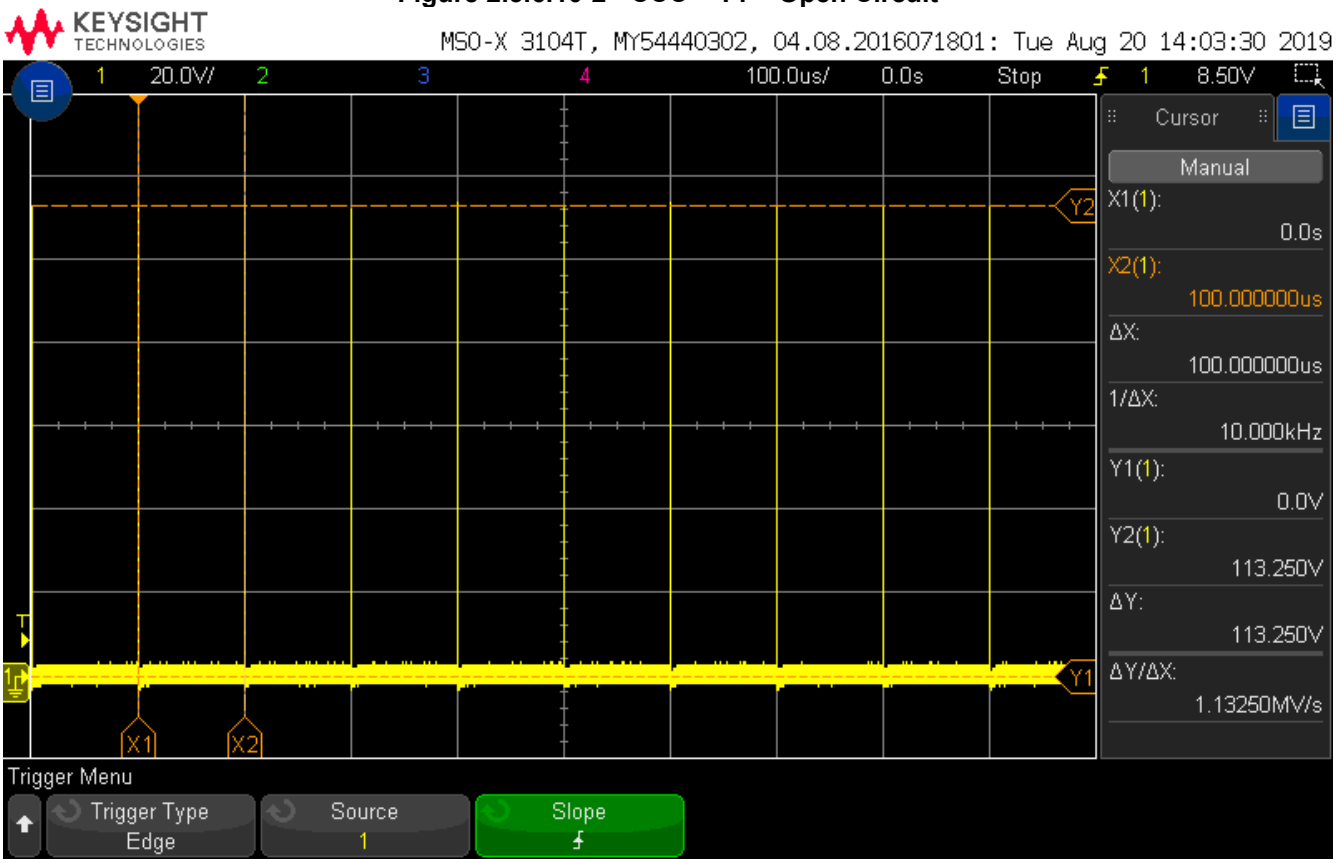


Figure 2.3.6.10-3 - CCC – T4 + T5 – Open Circuit

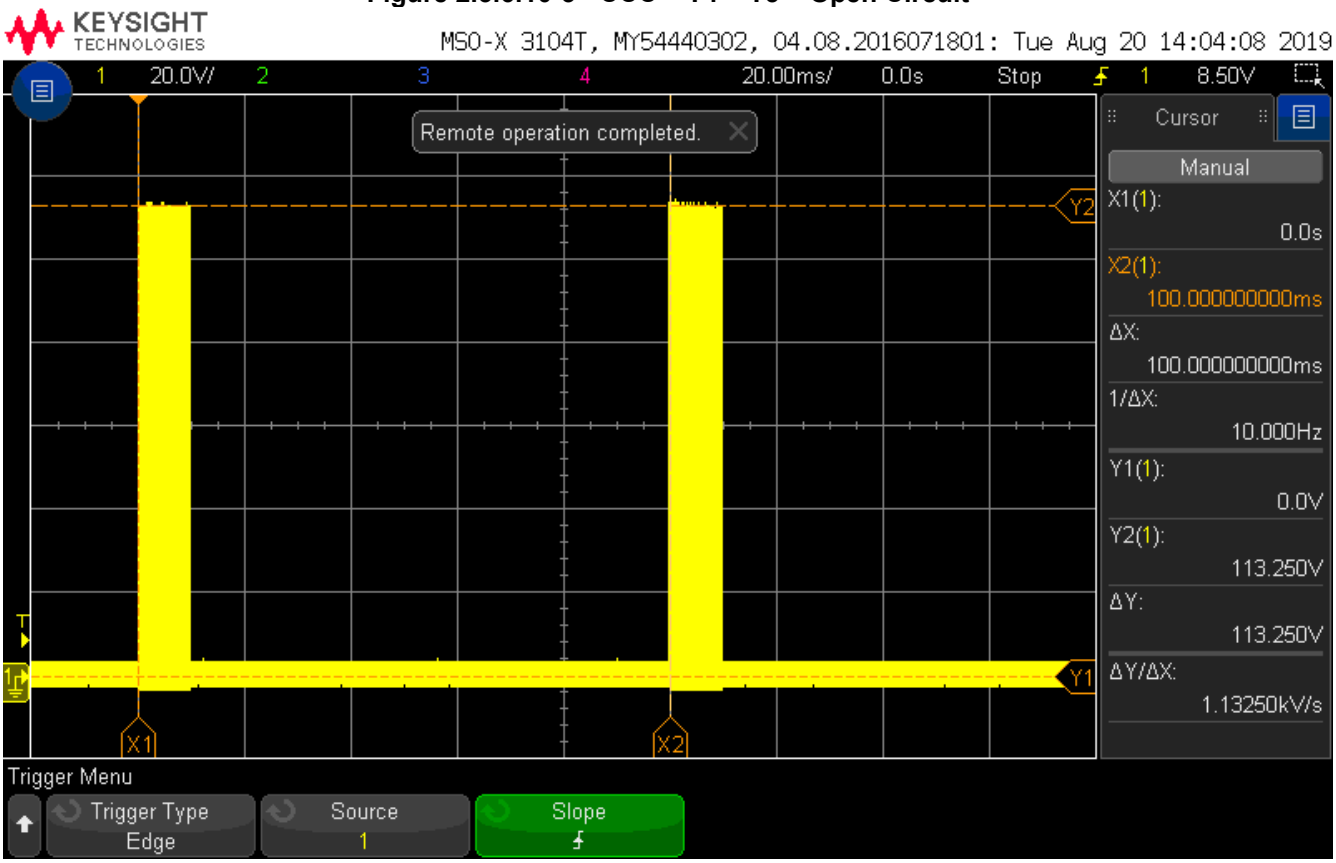


Figure 2.3.6.10-4 - CCC – Us & Td – EUT Load – Cable Harness

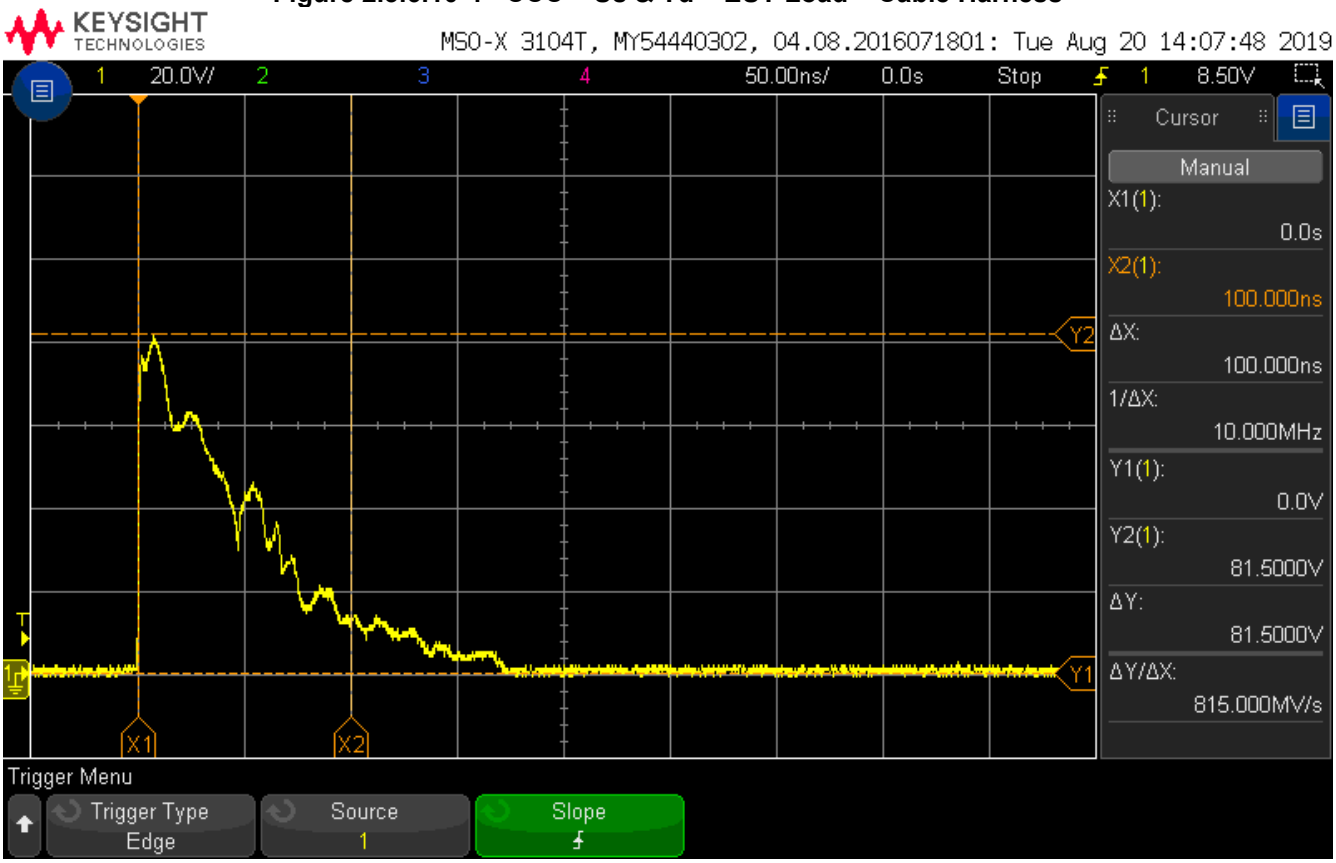


Figure 2.3.6.10-5 - CCC – T1 – EUT Load – Cable Harness

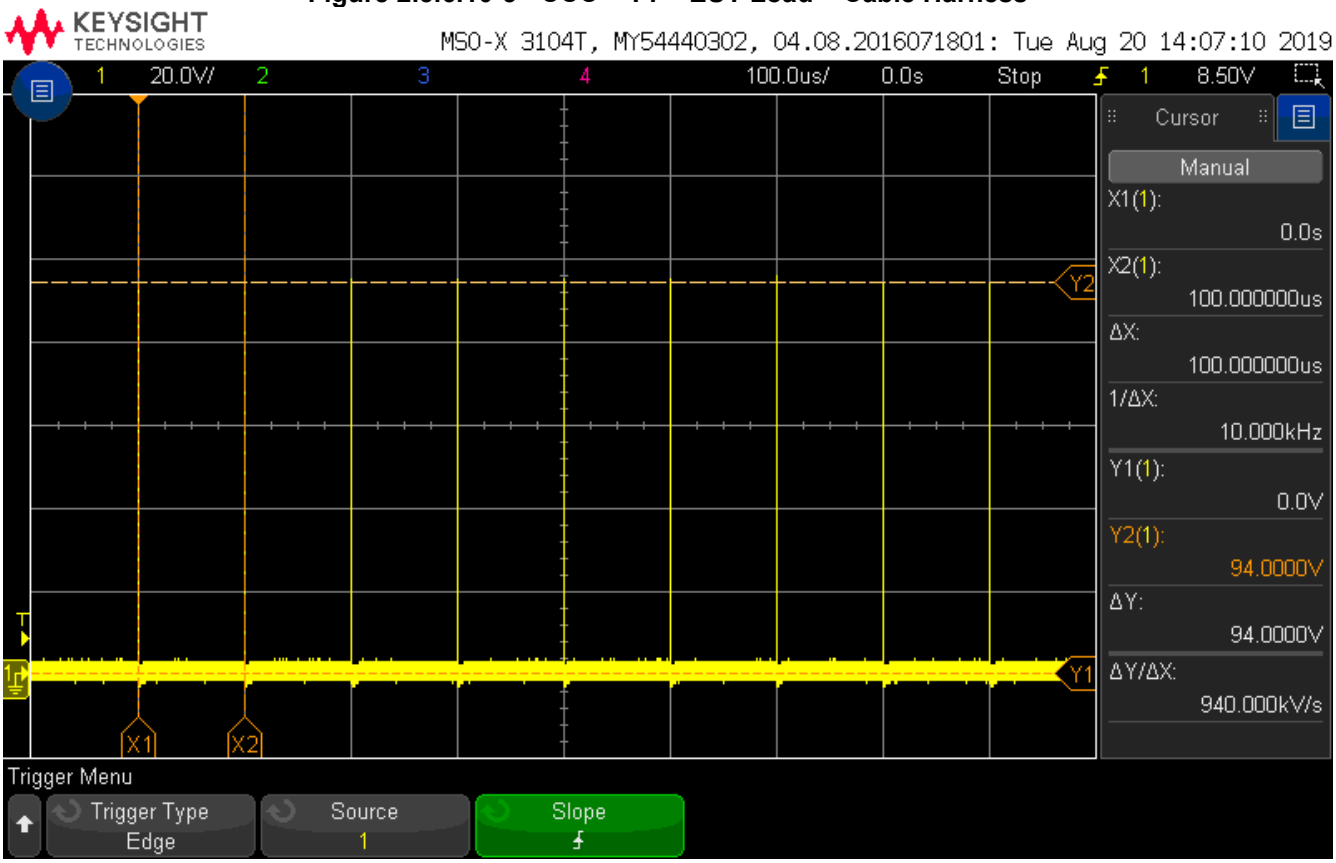


Figure 2.3.6.10-6 - CCC – T4 + T5 – EUT Load – Cable Harness

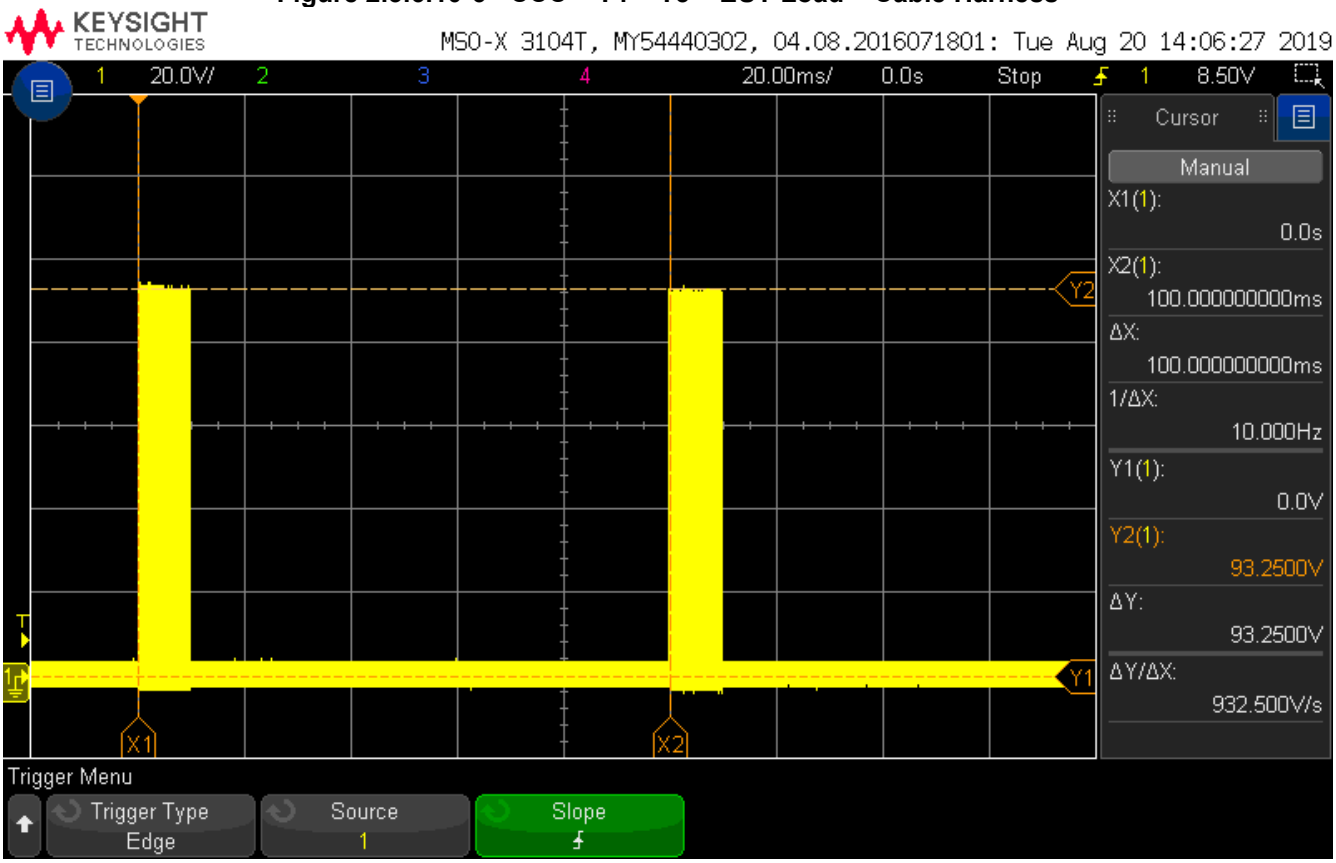


Figure 2.3.6.10-7 - CCC – Us & Td – EUT Load – Auxiliary I/O

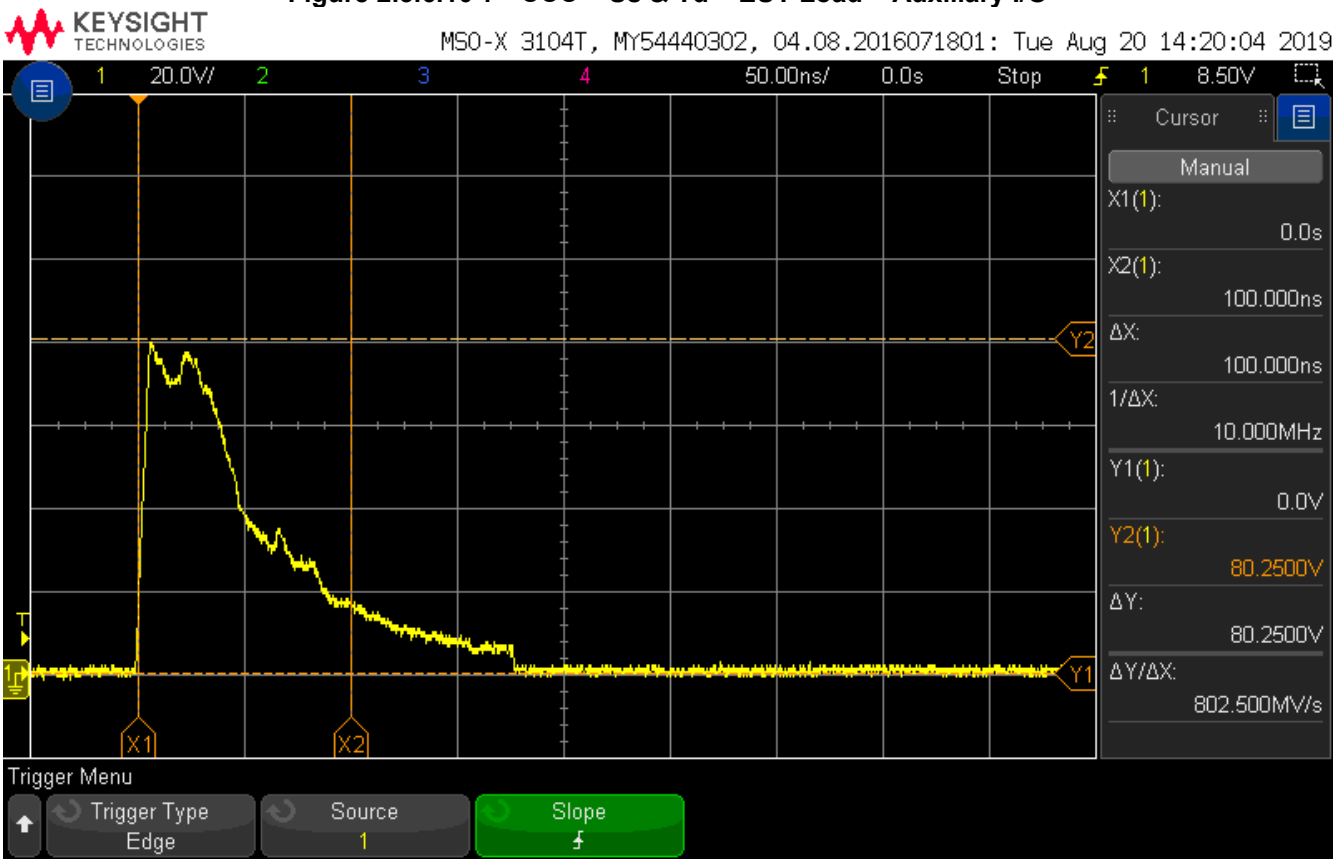


Figure 2.3.6.10-8 - CCC – T1 – EUT Load – Auxiliary I/O

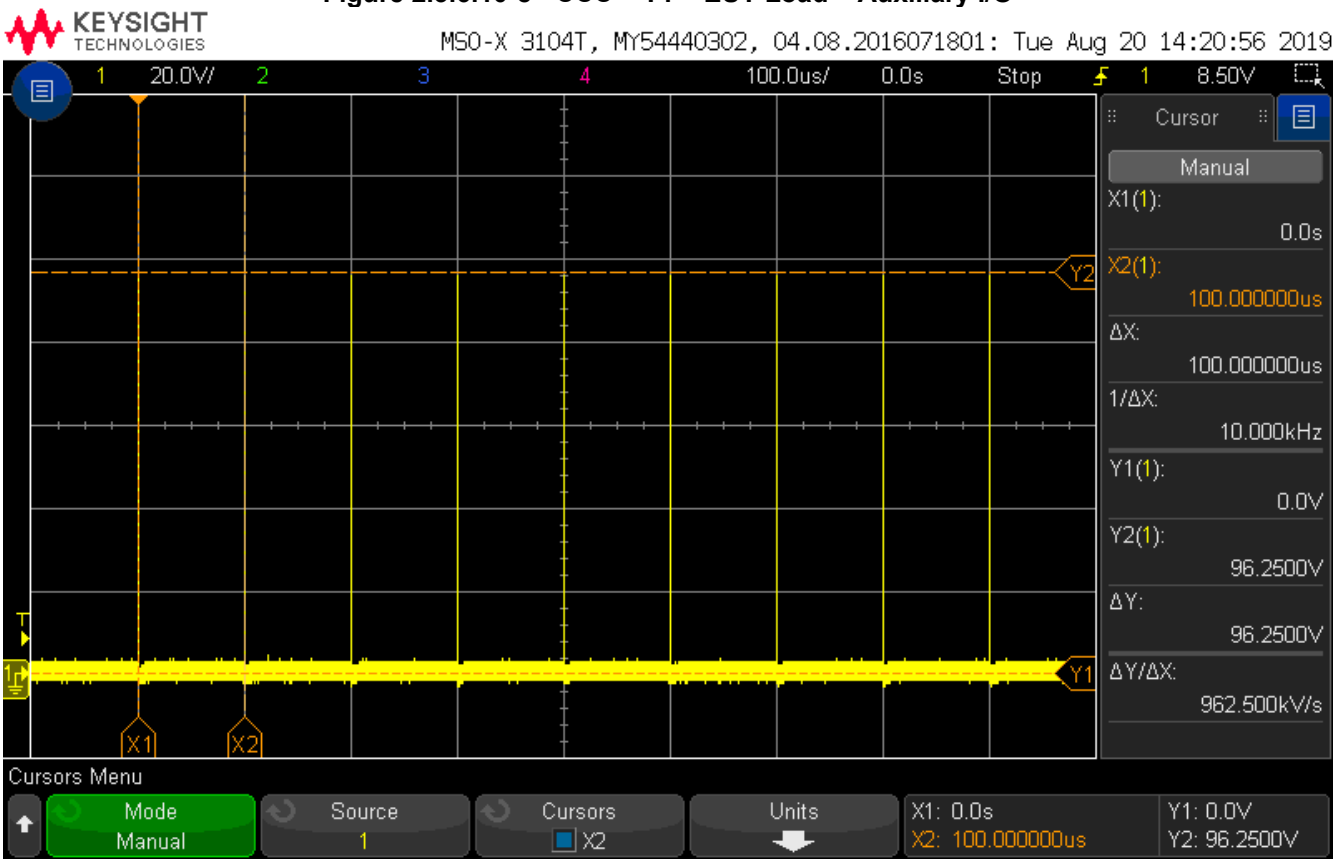
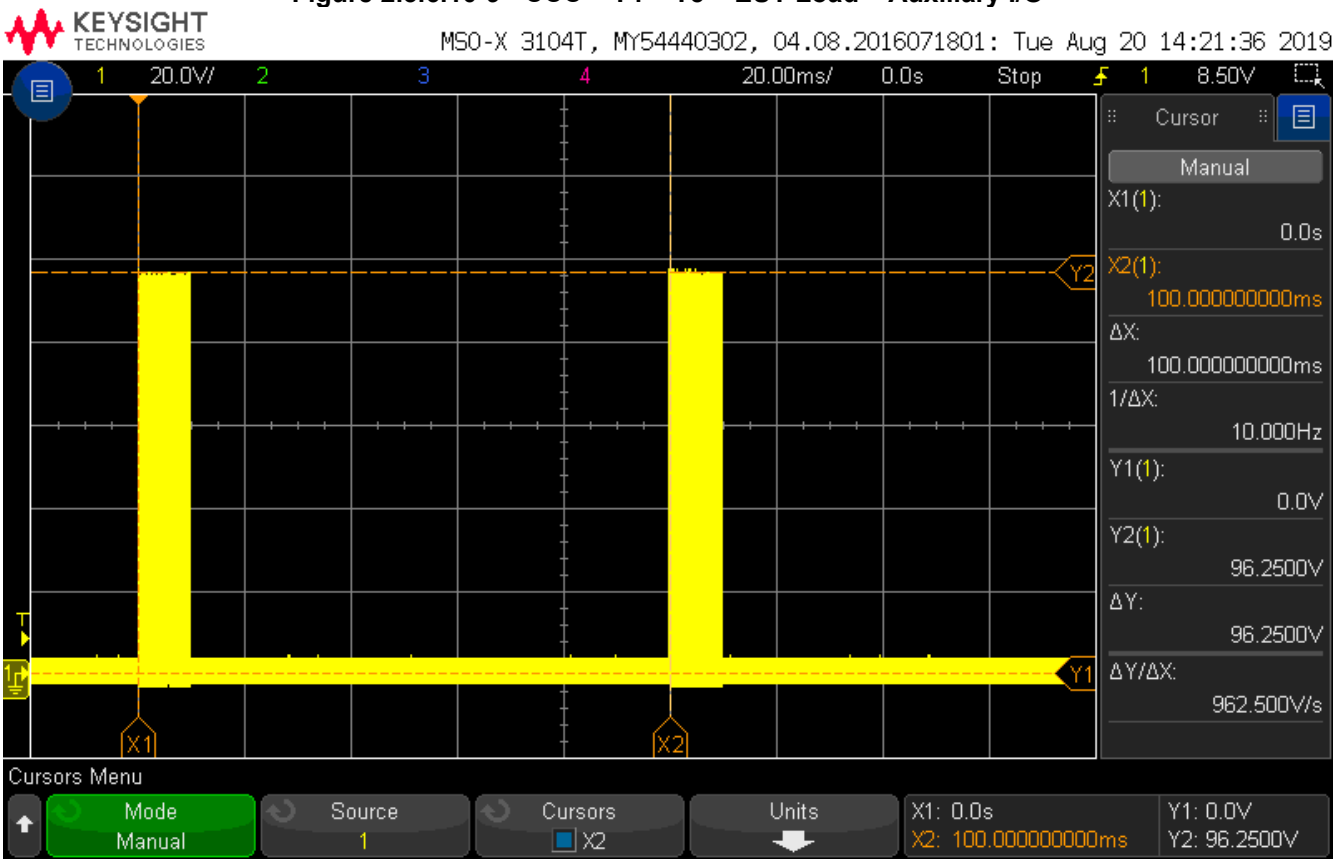


Figure 2.3.6.10-9 - CCC – T4 + T5 – EUT Load – Auxiliary I/O



2.3.6.11 Slow Positive 2a (ICC Method)

Table 2.3.6.11-1 – Slow Positive 2a Parameters

TEST VOLTAGE (VOLTS)	TEST LEVEL (VOLTS)	PULSE Width (mSec)	PULSE Period (Sec)	SOURCE IMPEDANCE (OHMS)	REPETITIONS
27	8	0.05	1	2	300

Remarks: Tested on both Cable Harness and Auxiliary I/O cables.

Figure 2.3.6.11-1 -Td – Open Circuit

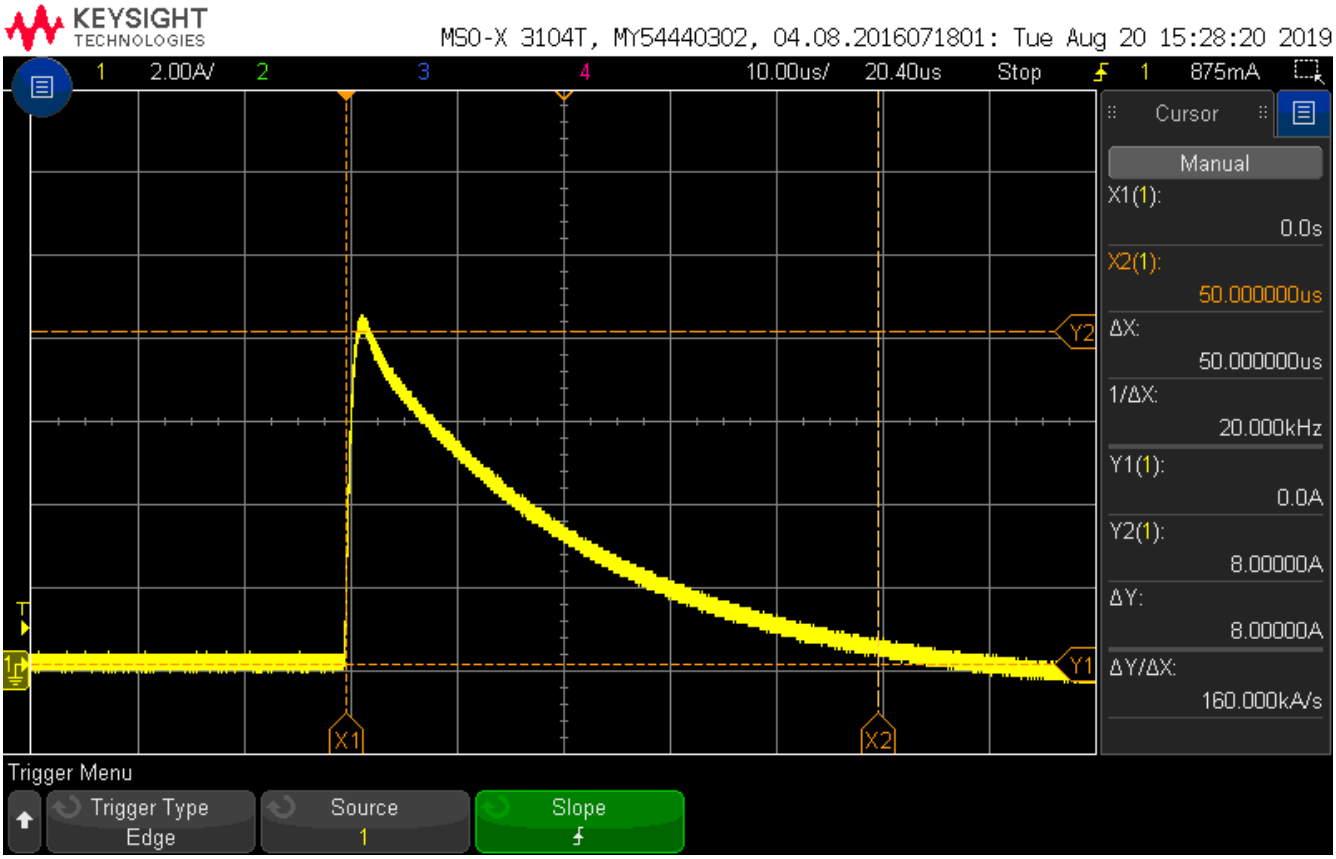
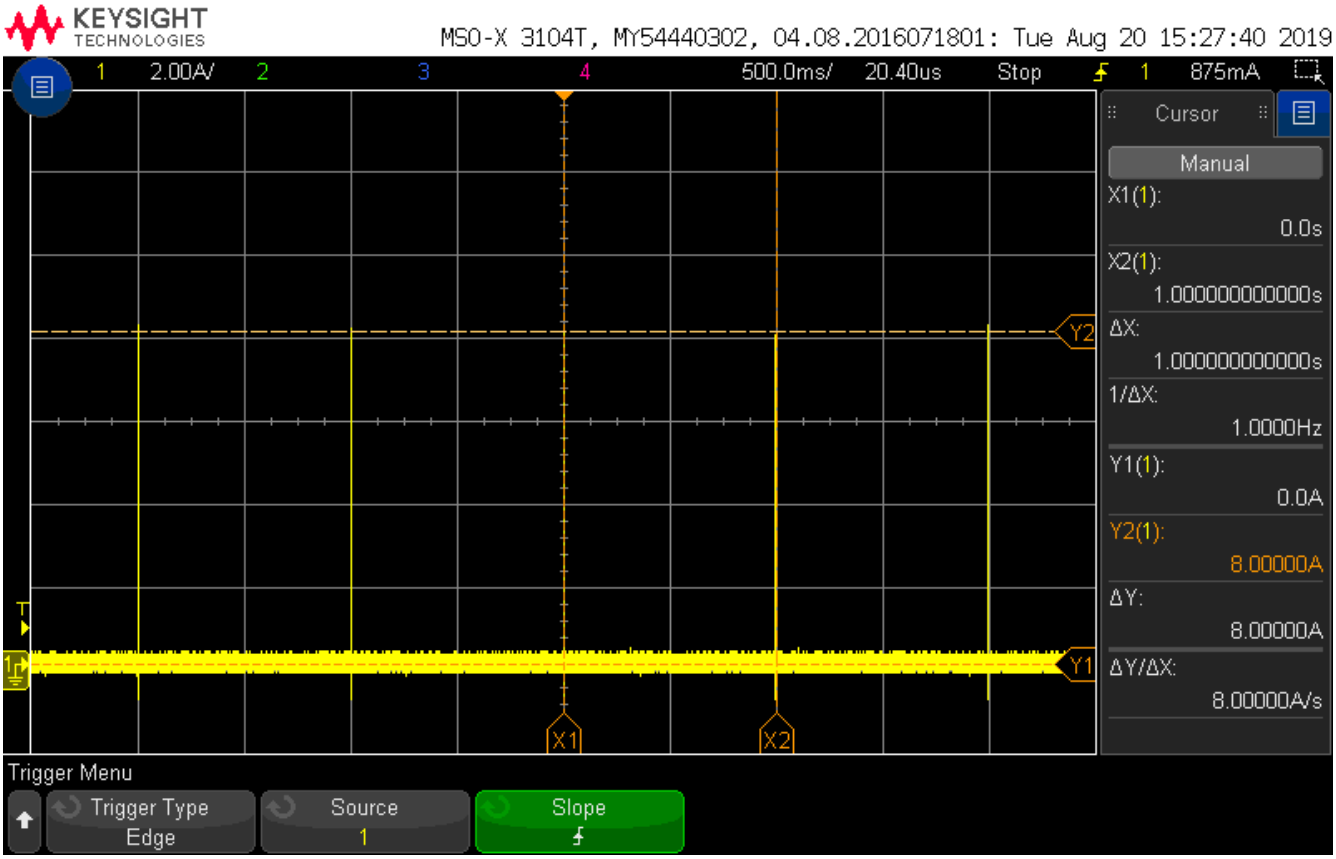


Figure 2.3.6.11-2 - T1 – Open Circuit



2.3.6.12 Slow Negative 2a (ICC Method)

Table 2.3.6.12-1 – Slow Negative 2a Parameters

TEST VOLTAGE (VOLTS)	TEST LEVEL (VOLTS)	PULSE Width (mSec)	PULSE Period (Sec)	SOURCE IMPEDANCE (OHMS)	REPETITIONS
27	-8	0.05	1	2	300

Remarks: Tested on both Cable Harness and Auxiliary I/O cables.

Figure 2.3.6.12-1 -Td – Open Circuit

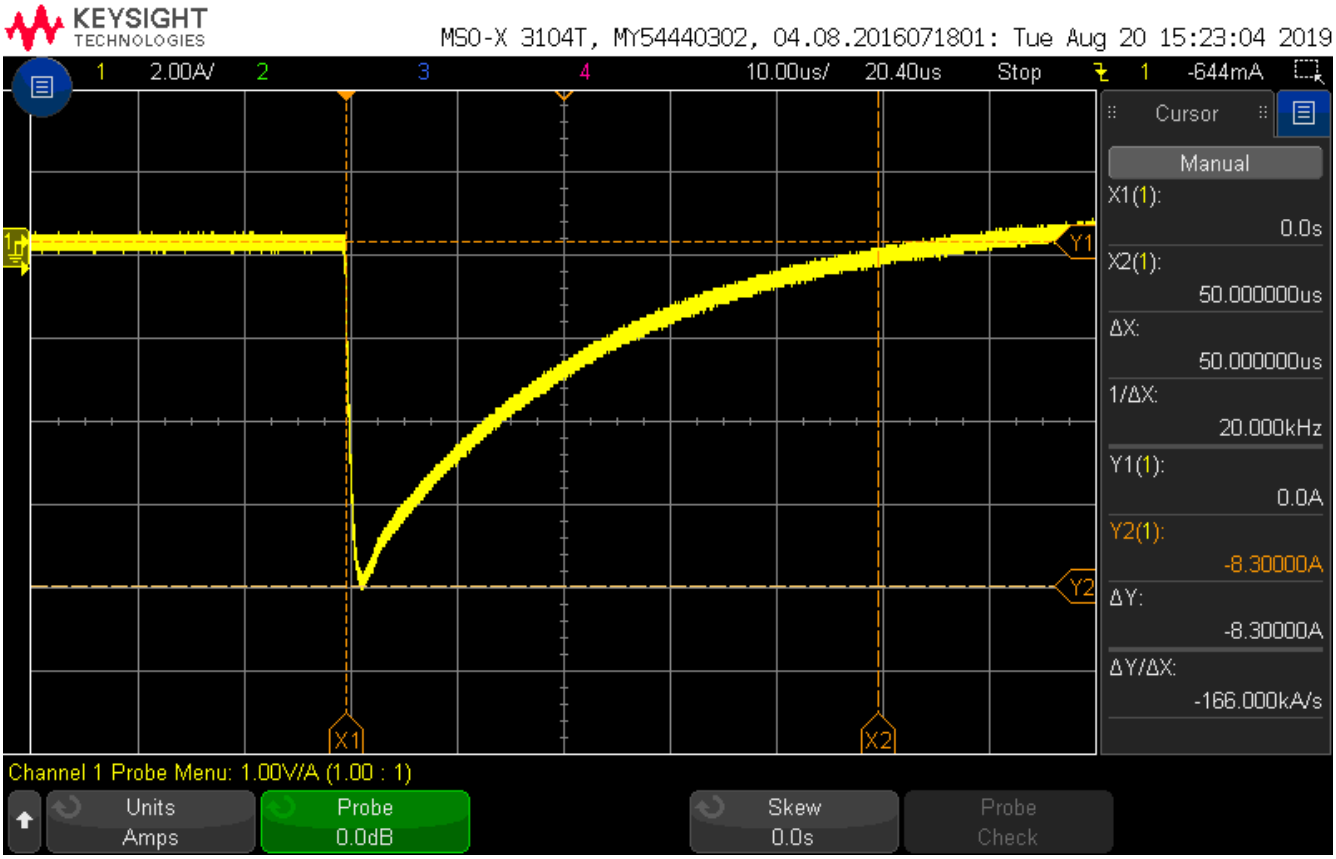
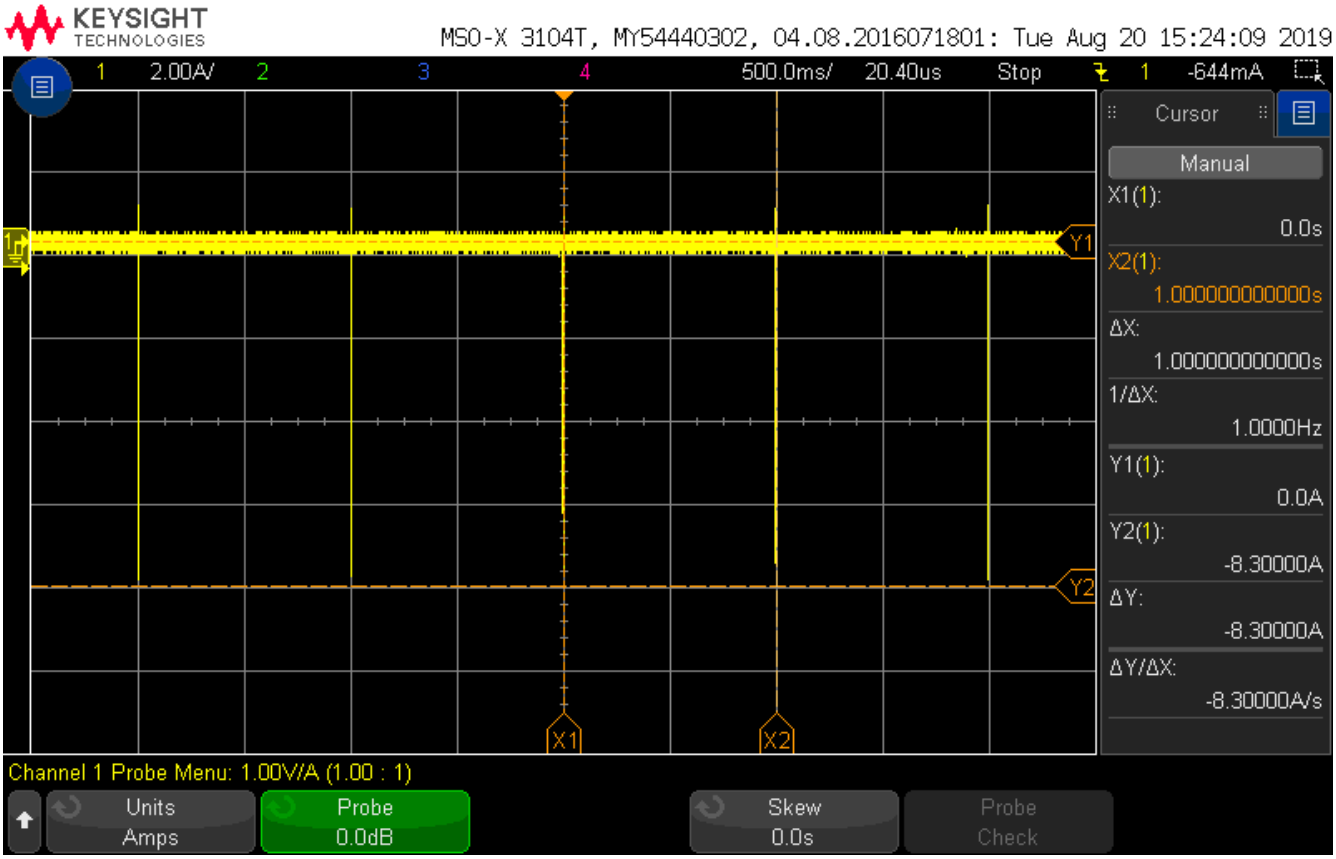


Figure 2.3.6.12-2 - T1 – Open Circuit



2.3.7 Test Location and Test Equipment Used

This test was carried out in New Brighton, MN.
Test Area: TRN1

Table 2.3.7-1 – Equipment List – Conducted Transients

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE02822	Hewlett-Packard	Oscilloscope, 500 MHz 2-CH	54615B	US35421312	G	01/22/2019	01/22/2020
NBLE02858	Solar	Current Probe, 0.01-108 MHz	6741-1	735-22	B	03/01/2019	03/01/2020
NBLE08056	EM Test	Ind Load Disconnect Trans	MPG 200	0497-06	Y	N/A	N/A
NBLE10502	Solar	Calibration Fixture	9330-1	None	Y	N/A	N/A
NBLE10554	Amplifier Research	Capacitive Coupling Clamp	---	23524	Y	N/A	N/A
NBLE11363	Tektronix	Scope Probe, 100:1	P5100A	C005799	G	10/25/2018	10/25/2019
NBLE11408	EM Test	Battery Vltg Variation Arb Gen	AutoWave	P1551169051	B	05/13/2019	05/13/2020
NBLE11409	EM Test	Voltage Drop Simulator, TP 2b/4	VDS 200Q100	P1607181941	B	05/13/2019	05/13/2020
NBLE11410	EM Test	Transient Rack AutoWave/VDS200Q (Tall)	None	None	Y	N/A	N/A
NBLE11411	EM Test	Ultra-Compact Simulator	UCS 200N100	P1548168213	B	05/13/2019	05/13/2020
NBLE11412	EM Test	Load Dump Generator, TP5/7	LD 200N	P1551169016	B	05/13/2019	05/13/2020
NBLE11413	EM Test	Transient Rack UCS200N & LD 200N (short rack)	None	None	Y	N/A	N/A

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.3.8 Test Set-up Photo

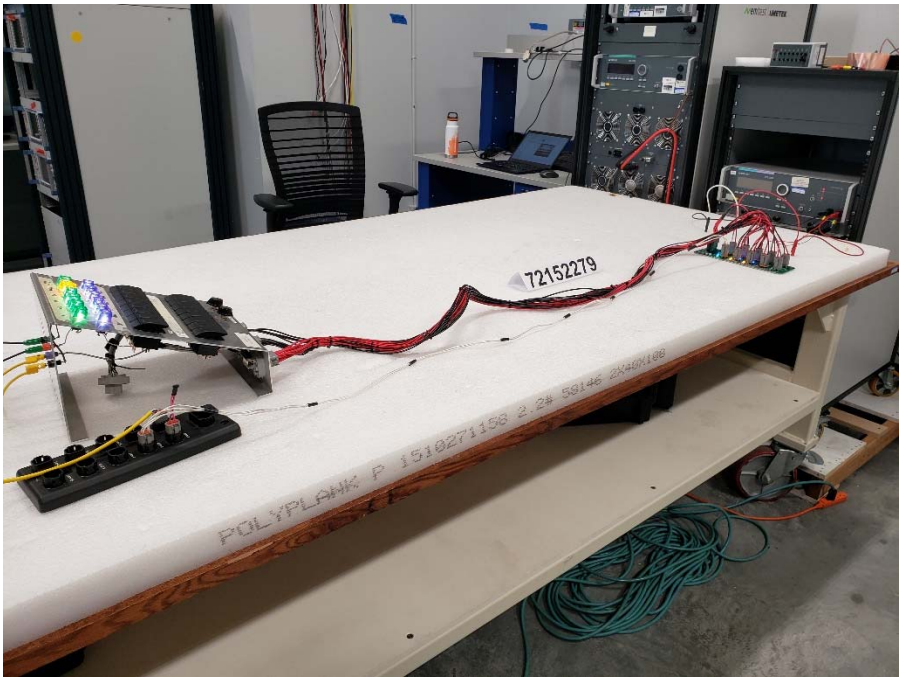


Photo 2.3.8-1 – Immunity to Conducted Transients on Power Leads

Photo 2.3.8-2 – Immunity to Conducted Transients [CCC Method]

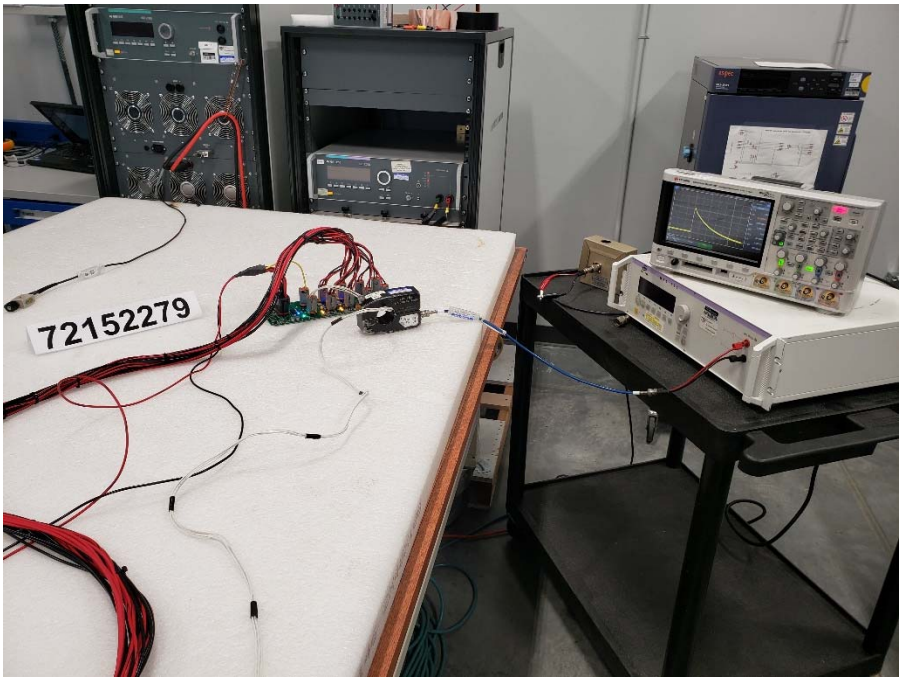


Photo 2.3.8-3 – Immunity to Conducted Transients [ICC Method]

2.4 Electrostatic Discharges

2.4.1 Specification Reference

See Section 1.3 for specification references.

2.4.2 Equipment Under Test and Modification State

N/A

2.4.3 Date of Test

Test not performed due to customer request

2.4.4 Test Method

The method described in ISO 10605 will be used as the method of measurement of the construction machinery in such areas where an ESD in standard us is possible (i.e. by touching by the operator). A R/C network of 330pF / 2kΩ will be used for locations that can easily be accessed from inside the construction machinery and a R/C network of 150pF / 2 kΩ will be used for areas that can easily be touched only from the outside of the construction machinery.

During this testing any anomalies in the equipment under test's performance were recorded.

2.4.5 Environmental Conditions

The EUT was evaluated within the temperature, humidity and pressure range of the EUT as specified by the standard. The laboratory shall have an ambient temperature range of 15°C to 35°C, relative humidity range of 30% to 60% and atmospheric pressure range of 86 kPa to 106 kPa.

Ambient Temperature	N/A
Relative Humidity	N/A
Atmospheric Pressure	N/A

2.4.6 Test Results

Table 2.4.6-1 – Requirements

Required Test Levels (ISO 13766-2, EN 13309 per ISO 10605:2008)						Performance Criteria
Discharge type	Discharge Level (kV)		Number of discharges per location (each polarity)	Generator Resistance and Capacitance		
	Positive	Negative		Inside	Outside	
Contact	4.0	4.0	3	330 pF 2 kΩ	150 pF 2 kΩ	A
Contact	6.0	6.0	3	330 pF 2 kΩ	150 pF 2 kΩ	C
Air	4.0	4.0	3	330 pF 2 kΩ	150 pF 2 kΩ	A
Air	8.0	8.0	3	330 pF 2 kΩ	150 pF 2 kΩ	C

The overall test verdict for the EUT to the Enclosure Port - Electrostatic Discharge requirements is: **N/A. Per Customer Request.**

Detailed results are shown below.

2.5 Immunity to Electromagnetic Radiation [ALSE Method]

2.5.1 Specification Reference

See §1.3 for the specification references.

2.5.2 Equipment Under Test and Modification State

As shown in §1.5 with **no modifications** as Listed in §1.7.

2.5.1 Date of Test

19 August 2019

2.5.2 Test Method

The EUT was setup in a semi-anechoic chamber and laid on a non-conductive support 5cm above a copper ground plane table with a height of 90cm (± 10cm). The EUT was placed 20cm from the front edge of the ground plane while the stretched-out cable bundle was 10cm from the front edge. Each transmit antenna had a height of 10cm above the ground plane table and a measurement distance of 1m from the front edge of the routed cabling. For the frequency range of 20-1000MHz the antenna was centered on the test setup and focused on the cable bundle, while for frequencies above 1GHz a horn antenna was centered on the EUT enclosure.

Prior to testing each applicable frequency range, a field strength calibration was performed for both vertical and horizontal antenna orientations. During the calibration an isotropic field probe was placed within the antenna beamwidth and the RF field was increased until the required field strength was measured. Once the required field strength was measured the forward power was recorded for test playback. This procedure was performed each frequency step within the required frequency range.

During testing, each frequency step is increased in amplitude until the calibrated forward power is reached. Once the forward power is reached, the frequency is set to dwell at that RF amplitude for a minimum of 2sec. This process is repeated for each frequency within the required range(s), then again for each required modulation type. The whole process is performed in both horizontal and vertical transmit antenna orientations. See the requirements table below for exact step sizes, dwell times, and modulations used during testing

During this testing any anomalies in the equipment under test’s performance were recorded.

2.5.3 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.5.4 Test Results

Required Test Levels [Harshest of Tested Standards]					Performance Criteria
Frequency Range (MHz)	Level (V/m)	Modulation	Step Size (%)	Dwell (s)	
400 to 800	100	AM (80 %,1 kHz, sine wave)	2 %	2	A
800 to 1000	100	PM (577/4600µs)	2 %	2	A
1000-2400	10	PM (577/4600µs)	2 %	2	A
2400-2700	5	PM (577/4600µs)	2 %	2	A

Table 2.5.4-1 - Requirements

The overall test verdict for the EUT when tested in the **Configuration and Mode 1** as described in Section 1.5.2 of this test report.

Performance assessment of the EUT made during this test: **Pass**

Detailed results are shown below.

Actual Test Levels							Performance Criteria Met
Frequency Range (MHz)	Level (V/m)	Modulation	Antenna Distance (Meters)	Step Size (%)	Dwell (sec)	EUT Side	
400 to 800	100	AM (80 %,1 kHz, sine wave)	1	2 %	2	Front	A
800 to 1000	100	PM (577/4600µs)	1	2 %	2	Front	A
1000-2400	10	PM (577/4600µs)	1	2 %	2	Front	A
2400-2700	5	PM (577/4600µs)	1	2 %	2	Front	A
Note: The test was performed for both vertical and horizontal antenna polarizations for all frequency ranges.							

Table 2.5.4-2 – Observations During Testing

2.5.5 Test Location and Test Equipment Used

This test was carried out in New Brighton, MN.
Test Area: SAC3

Table 2.5.5-1 – Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE03494	Amplifier Research	Amplifier, .8-4.2GHz	25S1G4A	310658	Y	N/A	N/A
NBLE11429	Amplifier Research	Amplifier, 80-1000 MHz	250W1000B	346080	Y	N/A	N/A
NBLE02355	Tensor	Antenna, 200 MHz-2 GHz	4106	2014	G	07/19/2018	07/19/2020
NBLE10370	Amplifier Research	Antenna, Horn 1-4.2 GHz	AT4510	27652	Y	N/A	N/A
NBLE03404	MAC Technology	Coupler, 30dB 1-4 GHz	C333330	104001	B	11/12/2018	11/12/2019
NBLE11378	Werlatone	Coupler, 40dB 20-1000 MHz	C9446-10	108925	B	10/22/2018	10/22/2019
NBLE03473	Hewlett-Packard	Signal Generator, 10 MHz-26.5 GHz	83630B	3722A00441	G	05/23/2019	05/23/2020
NBLE11000	Agilent Technologies	Spectrum Analyzer	E4440A-M75	MY44303856	G	01/23/2019	01/23/2020

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

2.5.6 Test Set-up Photo

Photo 2.5.6-1 – Electromagnetic Field Immunity Test Set-up – 400-1000MHz

Photo 2.5.6-2 – Electromagnetic Field Immunity Test Set-up – 1000-2700MHz

2.6 Immunity to Electromagnetic Radiation [BCI Method]

2.6.1 Specification Reference

See §1.3 for the specification references.

2.6.2 Equipment Under Test

As shown in §1.5 with **no modifications** as Listed in §1.7

2.6.3 Date of Test

21 August 2019

2.6.4 EUT Power

27VDC

2.6.5 Test Method

The EUT was setup on a conductive test bench 50 mm (±10 mm) above the ground plane on top of an insulating support with 1.5 m (+0.5 / -0 m) of cable harness laid out for test.

Prior to testing each applicable frequency range, a calibration was performed. During the calibration a current injection probe was placed into a calibration fixture and the induced RF was increased until the required test level was measured. Once the required test level was measured, the forward power was recorded for test playback. This procedure was performed each frequency step within the required frequency range.

During testing each frequency step (1-400 MHz) was increased in amplitude until the calibrated forward power is reached. Once the forward power is reached the frequency is set to dwell at that RF amplitude for a minimum of 2sec. This process is repeated for each frequency within the required range(s), then again for each required modulation type. The whole process is performed at 3 locations, per the Substitution Method, as described in ISO 11452-4. See the requirement table below for exact step sizes, dwell times, and modulations used during testing

During this testing any anomalies in the equipment under test's performance were recorded.

2.6.6 Environmental Conditions

The EUT was evaluated within the climatic range of the EUT as specified by the manufacturer. When the manufacturer does not specify climatic parameters for the EUT, all tests are performed within the ambient climatic conditions of the laboratory.

2.6.7 Test Results

Table 2.6.7-1 - Requirements

Required Test Levels						Result
Frequency Range (MHz)	Level (mA)	Modulation	Injection Probe Distance (cm)	Step Size (%)	Dwell (sec)	
1 to 10	100	AM (80 %,1 kHz, sine wave) CW	15, 45, 75	10 %	2	A
10 to 400	100	AM (80 %,1 kHz, sine wave) CW	15, 45, 75	5 %	2	A
Notes: Testing performed at 3 cable harness positions, 15cm, 45cm, and 75cm from EUT cable port.						

The overall test verdict for the EUT when tested in **Configuration and Mode 1** as described in Section 1.5.2 of this test report is shown below.

Performance assessment of the EUT made during this test: **Pass**

Detailed results are shown below.

Table 2.6.7-2 – Observations During Testing

Test Frequency (MHz)	Test Level (mA)	Modulation Type (See Key)	Injection Method	Lead Description (Type)	Step Size (%)	Dwell Time (sec.)	Complies		Criteria Met	Remarks
							Yes	No		
										DC Input
1	100	1	BCI	Harness – 15cm	10	2	✓		A	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	5	↓	↓		↓	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
400	↓	↓	↓	↓	↓	↓	↓		↓	
1	100	1	BCI	Harness – 45cm	10	2	✓		A	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	5	↓	↓		↓	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
400	↓	↓	↓	↓	↓	↓	↓		↓	
1	100	1	BCI	Harness – 75cm	10	2	✓		A	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	5	↓	↓		↓	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
400	↓	↓	↓	↓	↓	↓	↓		↓	
										I/O Lines (Tested Together)
1	100	1	BCI	Harness – 15cm	10	2	✓		A	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	5	↓	↓		↓	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
400	↓	↓	↓	↓	↓	↓	↓		↓	
1	100	1	BCI	Harness – 45cm	10	2	✓		A	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	5	↓	↓		↓	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
400	↓	↓	↓	↓	↓	↓	↓		↓	
1	100	1	BCI	Harness – 75cm	10	2	✓		A	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	↓	↓	↓		↓	
10	↓	↓	↓	↓	5	↓	↓		↓	
↓	↓	↓	↓	↓	↓	↓	↓		↓	
400	↓	↓	↓	↓	↓	↓	↓		↓	

2.6.8 Test Set-up Photo

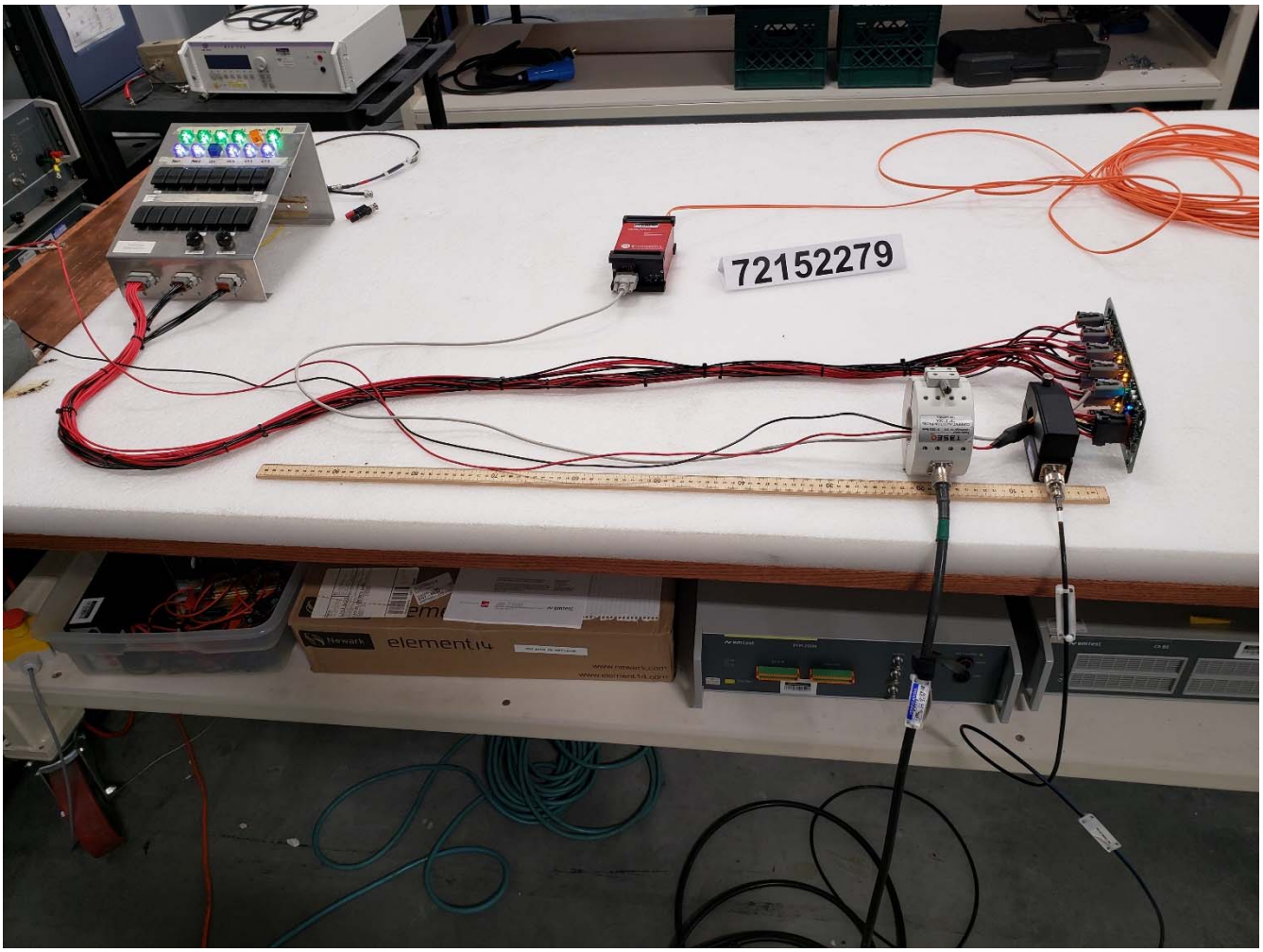


Photo 2.6.8-1 – Conducted Immunity Test Set-up - 1-400 MHz

2.6.9 Test Location and Test Equipment Used

This test was carried out in New Brighton, MN.
Test Area: TRN1

Table 2.6.9-1 – Equipment List

Device #	Manufacturer	Description	Model	Serial #	Cal Code	Cal Date	Cal Due
NBLE02034	Amplifier Research	Amplifier, 100-1000MHz	25W1000M7	9106	Y	N/A	N/A
NBLE03366	Agilent Technologies	Spectrum Analyzer	E4440A	MY42510427	G	10/23/2018	10/23/2019
NBLE10618	Amplifier Research	Amplifier, 10 kHz-250 MHz	250A250A	311619	Y	N/A	N/A
NBLE10917	Rohde & Schwarz	Signal Generator, 9 kHz-2.08 GHz	SMY02	DE22168	G	05/23/2019	05/23/2020
NBLE11038	Agilent Technologies	Power Meter	E4419B	GB43316903	G	01/22/2019	01/22/2020
NBLE11244	Werlatone	Coupler, 30dB 10 kHz-1 GHz	C6934-10	105794	B	07/24/2019	07/24/2020
NBLE11288	Teseq	Injection Probe	CIP 9136A	39276	Y	N/A	N/A
NBLE11350	Solar	Current Probe, 100 Hz-500 MHz	9215-1N	9215150501	B	11/02/2018	11/02/2019

Cal Code G = Calibration performed by an accredited outside source.
Cal Code B = Calibration verification performed internally.
Cal Code Y = Passive Device, or Calibration not required when used with other calibrated equipment.

3 Measurement Uncertainty

STATEMENT OF MEASUREMENT UNCERTAINTY – Immunity

The data and results referenced in this document are accurate. The reader is cautioned that there is some measurement variability due to the tolerances of the test equipment that can contribute to a nominal product measurement uncertainty. Furthermore, component differences and manufacturing process variability of production units similar to that tested may result in additional product uncertainty. If necessary, refer to the test lab for the actual measurement uncertainty for specific tests.

STATEMENT OF MEASUREMENT UNCERTAINTY – Emissions

The test system for conducted emissions is defined as the LISN, tuned receiver or spectrum analyzer, and coaxial cable. This test system has a measurement uncertainty of ±3.30 dB. The test system for radiated emissions is defined as the antenna, the pre-amplifier, the spectrum analyzer and the coaxial cable. This test system for 30 MHz – 1000 MHz has a measurement uncertainty of ±5.88 dB and above 1 GHz a measurement uncertainty of ±4.47 dB. The measurement uncertainty values for conducted and radiated emissions meet the requirements as expressed in CISPR 16-4-2. The equipment comprising the test systems is calibrated on an annual basis.

TEST EQUIPMENT

All measurement instrumentation is traceable to the National Institute of Standards and Technology and is calibrated to meet test method standard requirements and/or manufacturer's specifications.

4 Accreditation, Disclaimers and Copyright

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