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Report Date: 5/13/2022

National Aeronautics and
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Contents

1. INTRODUCTION

This study is to determine the heavy ion induced single event effect (SEE) susceptibility of the Qorvo's NBB-400 cascadable broadband GaAs amplifier DC to 8GHz. These parts were irradiated with the 16MeV/amu heavy ion cocktail at the Berkeley Accelerator Space Effects (BASE) Facility at the Lawrence Berkeley National Laboratory (LBNL). The testing occurred on April 6, 2022.

2. DEVICES TESTED

2.1. Part Background

The NBB-400 is a cascadable broadband GaAs MMIC (monolithic microwave integrated circuit) amplifier is a solution for general purpose RF and microwave amplification needs. This 50-ohm gain block is based on a reliable HBT (heterojunction bipolar transistor) proprietary MMIC design for small-signal applications.

2.2. Device Under Test (DUT) Information

Three (3) parts were provided to Code 561 for single event transient (SET) testing. All three were prepared for irradiation. More information about the part identification can be found in Table 1. Information about the NB-400's pinouts can be found in Figure 1 and Table 2. The parts were prepared for testing by mechanically delidding each device. The delidded device can be seen in Figure 2. The parts were then soldered to small, printed circuit boards (PCBs) that were designed specifically for this testing. Since the number of overlayers used in the fabrication processes is unknown, linear energy transfer calculations were determined based on the top-surface incident ion species and kinetic energy.

Table 1: Part Identification Information

Qty	Generic Part Number	Flight Part Number	LDC	REAG Identifier
3	NBB-400	5962-00-E17-4010	2045	21-036

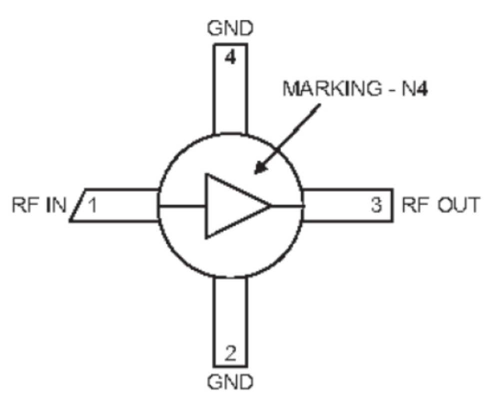

Figure 1: Schematic of the NBB-400[1].

Table 2: Pinout for the NBB-400

Pin	Name	Description
1	RFIN	RF input pin
2	GND	Ground connection
3	ROUT	RF output and bias pin
4	GND	Ground connection

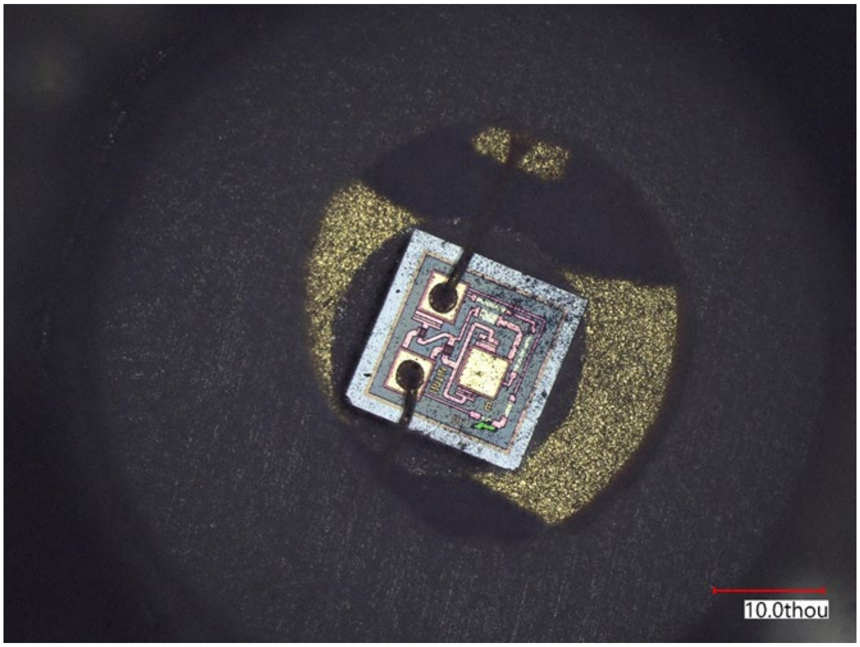

Figure 2: Image of NBB-400 Die.

3. Test Setup

The test circuit for the NBB-400 were built to model/approximate the intended application. Figure 3 shows the circuit diagram implemented on the PCB.

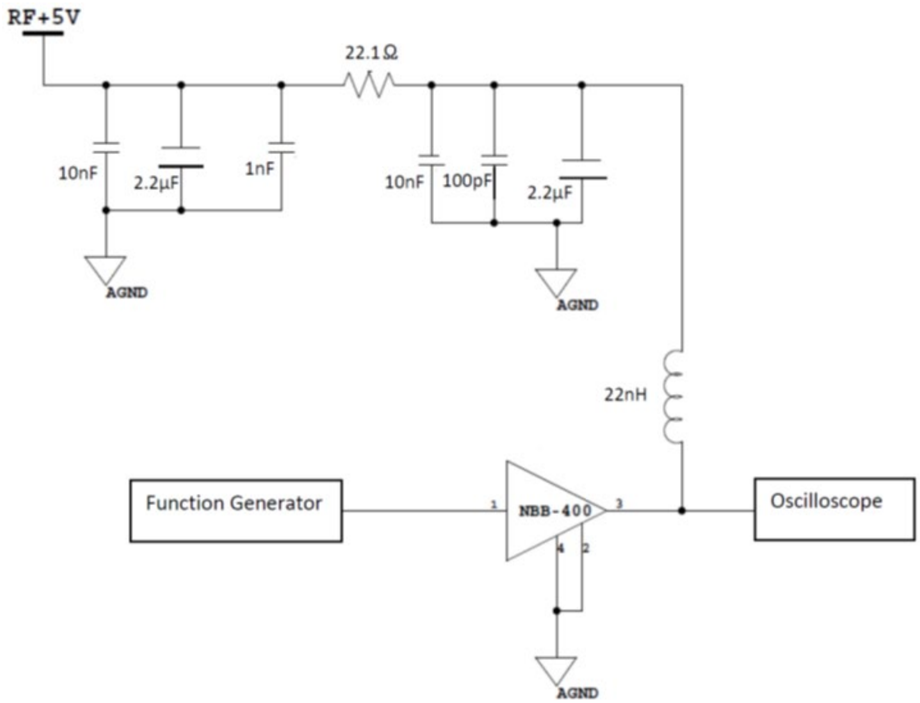

Figure 3: Schematic of the NBB-400 test circuit.

The test setup required a DC power supply, a function generator, an oscilloscope for capturing the transients on the output, and a laptop quipped with LabVIEW for saving the transients. Parts were serialized randomly. Figure 4 shows a block diagram of the experiment setup and Figure 5 shows a device under test (DUT) on the PCB in the beamline.

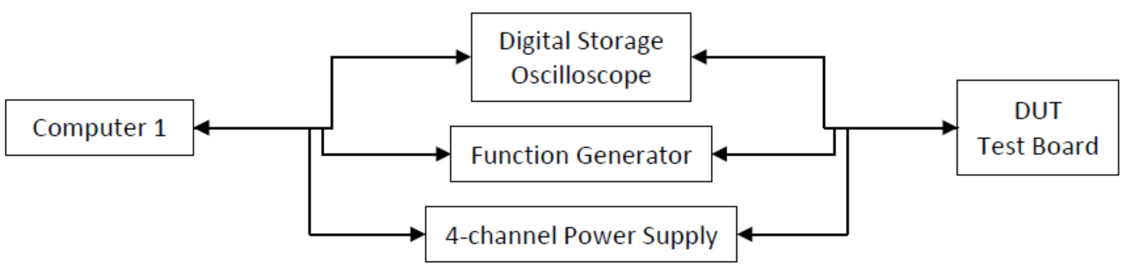

Figure 4: Block Diagram

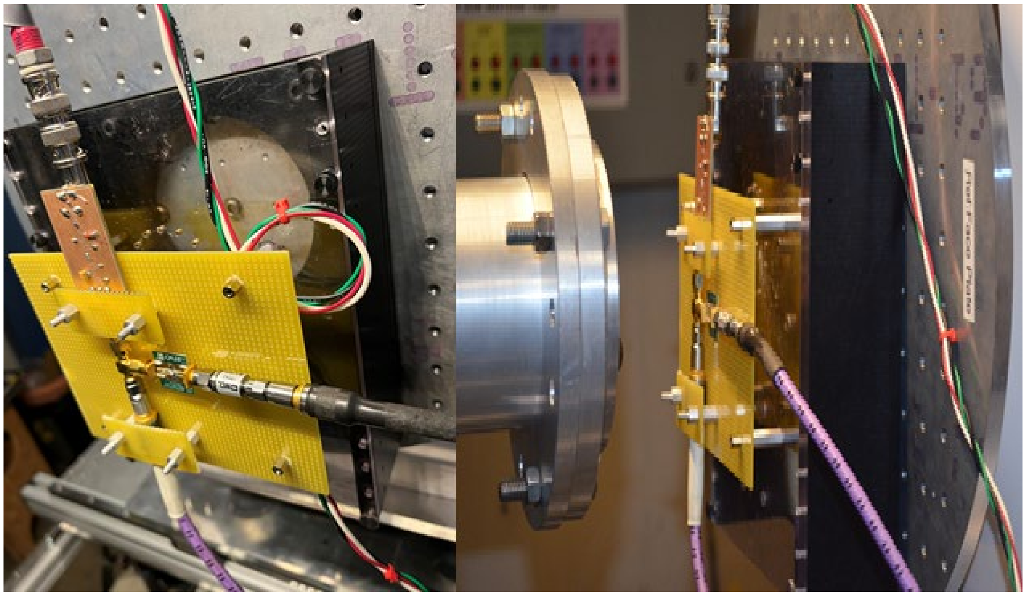

Figure 5: Experiment Test Set-up

The following equipment listed in table 3 will be used to create the test circuit:

Table 3: List of necessary equipment

Make	Model	NASA ECN	Comments
Hewlett Packard	8648C	M162852	Function generator
Tektronix	DSA 72004	2173383	Oscilloscope
Agilent Technologies	N6702A	M161871	Power supply
Mounting board	N/A	N/A	Mounting board
Cables	N/A	N/A	Various cables to make connections

4. Test Facility

Facility: Lawrence Berkeley National Laboratory 88" Cyclotron Facility, 16 MeV/amu in air
Flux: 1 x 10^3 to 1 x 10^5 particles/cm^2/s
Fluence: All tests will be run to the lesser of 1 x 10^7 ions/cm^2 or more than 100 single event transients are collected
Ion Species: Table 4 shows the surface-incident beam properties

Table 4: Notional Energy, Range, and LET* Estimates for Accelerated Ions at 16 MeV/amu

Ion	Tilt Angle (°)	Energy (MeV)	Range (μm)	Nominal Incident LET (MeV-cm2/mg)
^{78}Kr	0	1225.5	103	31
^{124}Xe	0	1954.7	93	55

5. TEST CONDITIONS

Test Temperature: Room temperature
Vacuum: No
Input Power: -10dBm and -5dBm
Frequency: 1500MHz
Bias Voltage: 5V
Waveform: Sine wave
Load Resistance: 50Ω
Error Modes: The primary purpose of this test to identify the worst-case transients. All transients will be captured by the oscilloscope

For all conditions tested, transients with positive and negative amplitudes were captured.

6. RESULTS

As shown in the run log, the NBB-400 was irradiated with Xe (LET of 55 MeV-cm^2/mg) and Kr (LET of 31MeV-cm^2/mg) with two different input powers (-5dBm and -10dBm) and a 1500 MHz sine wave. Transients occurred during all runs with different ions and input power conditions. Positive transients were observed on a rising edge oscilloscope trigger while negative transients were observed with a falling edge oscilloscope trigger.

The maximum voltage amplitude, minimum voltage amplitude, and number of occurrences where the voltage exceeds 1V or where the voltage is less than -1V for each test condition is documented in table 5. For every testing condition there was a transient that was either larger than 1V or less than -1V. At an input power of -5dBm while using the Xe ion produced multiple transients with amplitudes greater than 1V and amplitudes less than -1V. Even when the NBB-400 was irradiated with Kr ions, the output sine wave yielded transients great than 1V and transients less than -1V with an input power of -5dBm. The largest voltage transient experienced by the NBB-400 was -1.26V which occurred using Xe ions and an input power of -5dBm. When the input power was -10dBm there were no transients larger than 1V for either ion.

Table 5: Maximum and Minimum Voltages for Different Test Conditions

	Input power -5dBm, Rising		Input power -10dBm, Rising		Input power -5dBm, Falling		Input power -10dBm, Falling	
LET (MeV-cm^2/mg)	55 (Xe)	31 (Kr)	55 (Xe)	31 (Kr)	55 (Xe)	31 (Kr)	55 (Xe)	31 (Kr)
Max Voltage (V)	1.16	1.15	0.70	0.60	1.01	0.92	0.74	0.64
Min Voltage (V)	-1.19	-0.98	-1.02	-0.96	-1.26	-1.18	-1.01	-0.88
Number of Pulses ≥1V	4	3	0	0	1	0	0	0
Number of Pulses ≤ -1V	9	0	2	0	25	7	2	0

Figures 6 and 7 show histograms for the transients with input powers of -5dBm and -10dBm. Both histograms show that Xe (55 MeV-cm^2/mg) produces more transients than Kr (31 MeV-cm^2/mg) for both input power conditions. At an input power -10dBm no ion produces a transient larger than 0.8V. This can be seen in Figure 7.

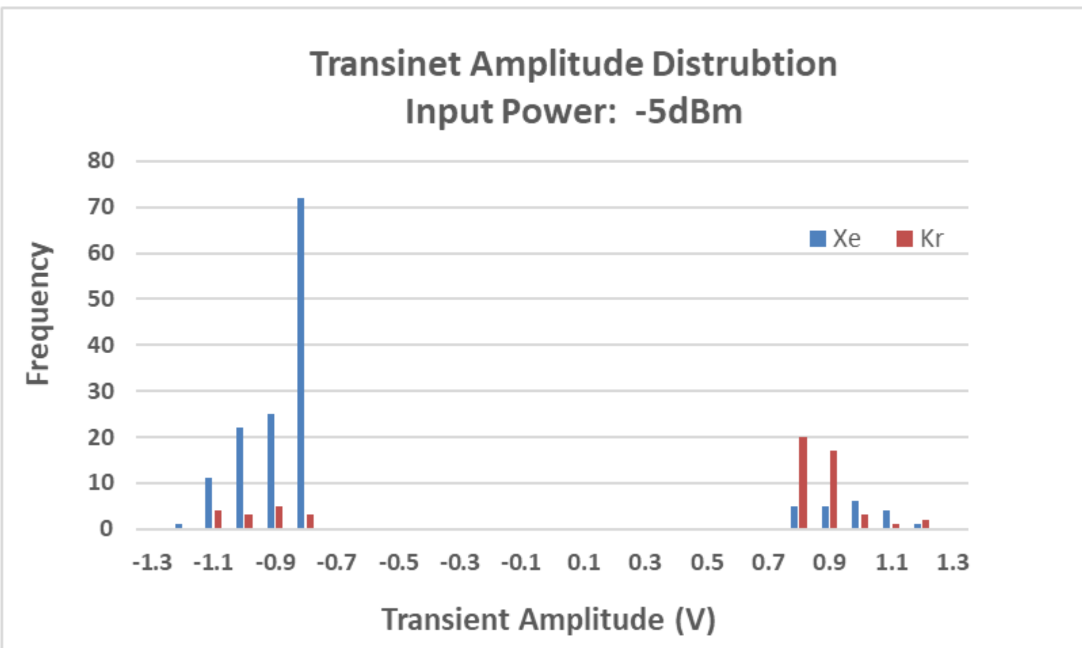

Figure 6: Transient Distribution for -5dBm Input Power with Xe and Kr Ions

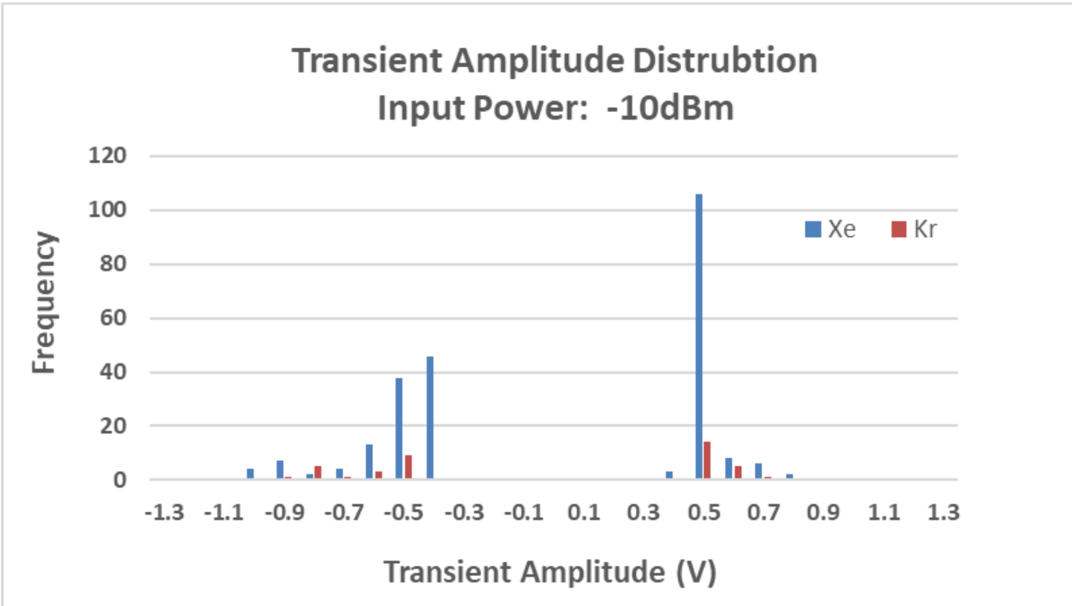

Figure 7: Transient Distribution for -10dBm Input Power with Xe and Kr

Examples of different types of transients can be seen in Figures 8 -18. Transients appear on the NBB-400's output voltage in different sizes and shapes. For instance, Figure 8 show ringing on the output voltage. Figures 9 -11 show ringing to a lesser degree superimposed on a sine wave. Other transients can cause changes to the period to the output signal and can change the voltage amplitude. These changes to the period and amplitude can be seen in Figures 12- 18. The same ion and input power can produce many different transients' shapes. This can be seen in Figures 9-13 where different transients occurred for the same DUT being irradiated with Xe under a constant input power of -5dBm.

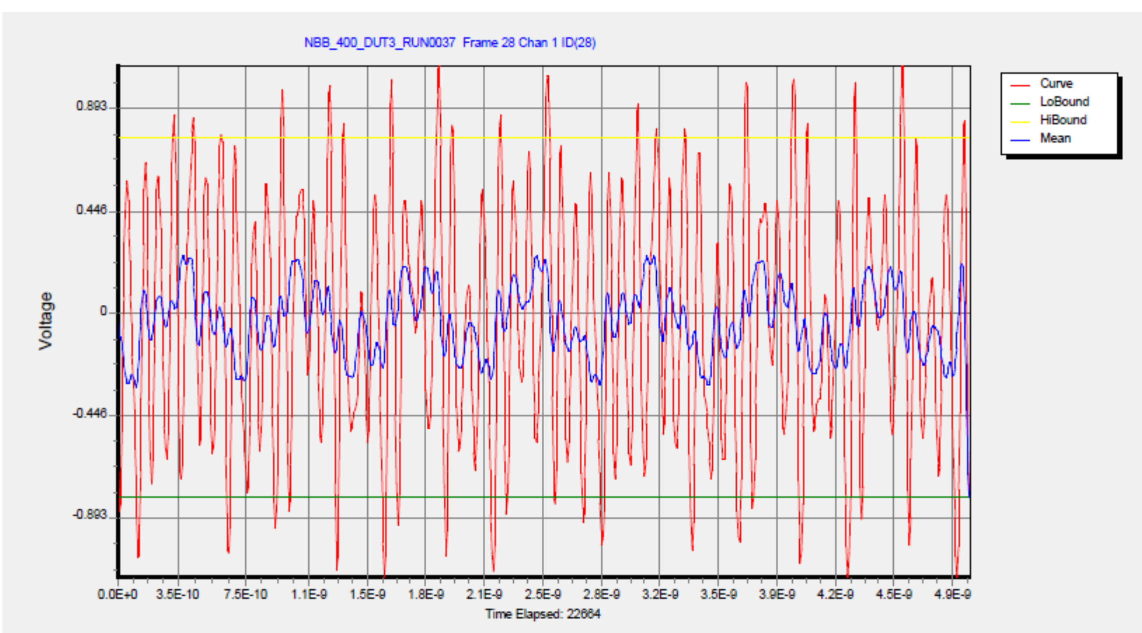

Figure 8: Test Run 37 Transient Response, Ion: Xe, Input Power: -5dBm

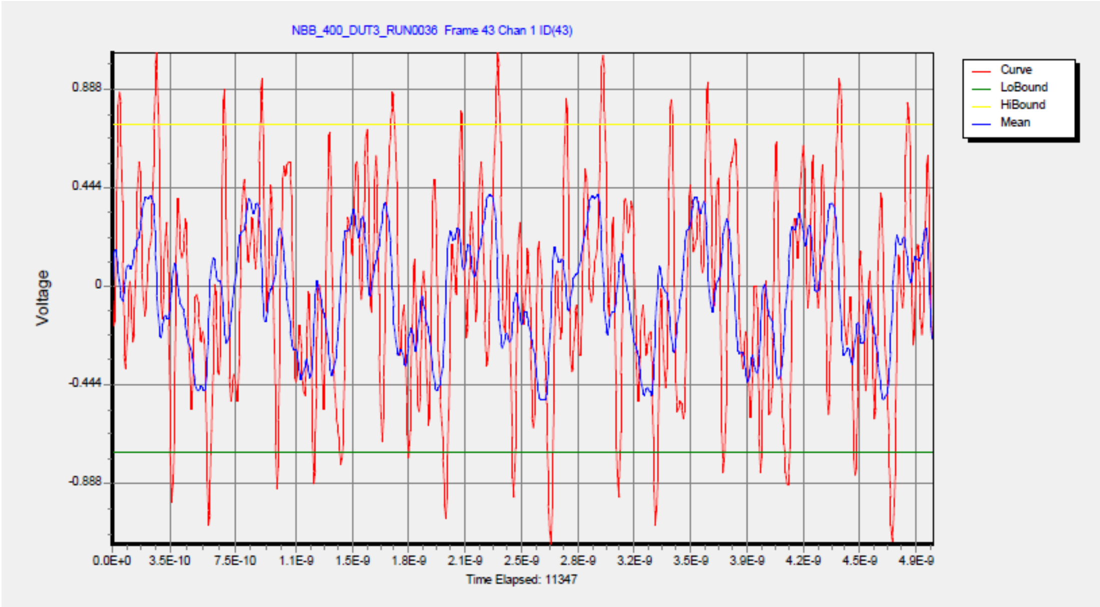

Figure 9: Test Run 36 Transient Response 1, Ion: Xe, Input Power: -5dBm

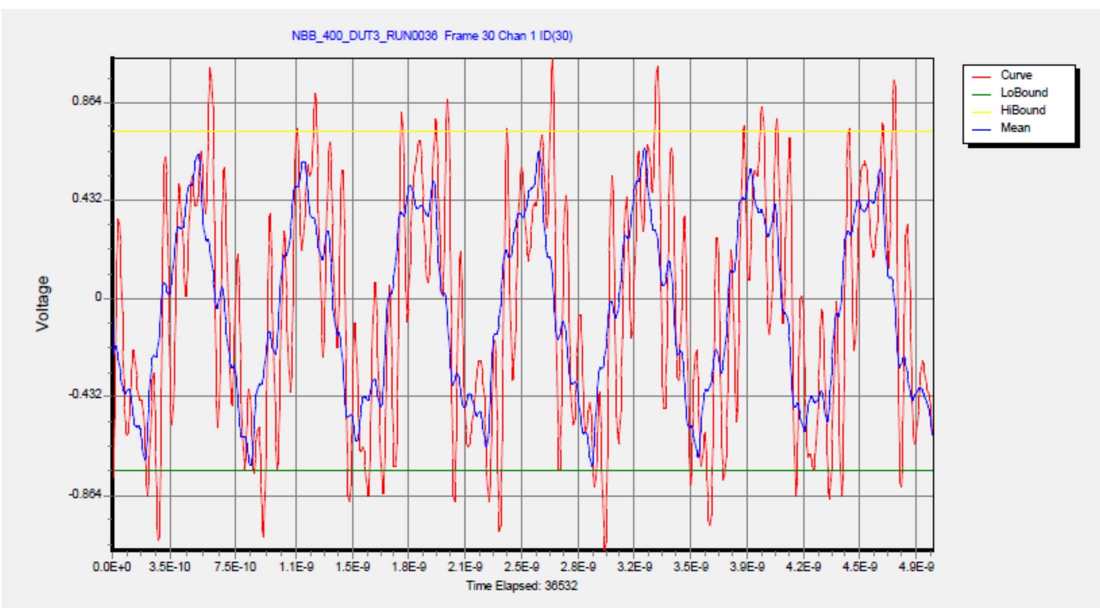

Figure 10: Test Run 36 Transient Response 2, Ion: Xe, Input Power: -5dBm

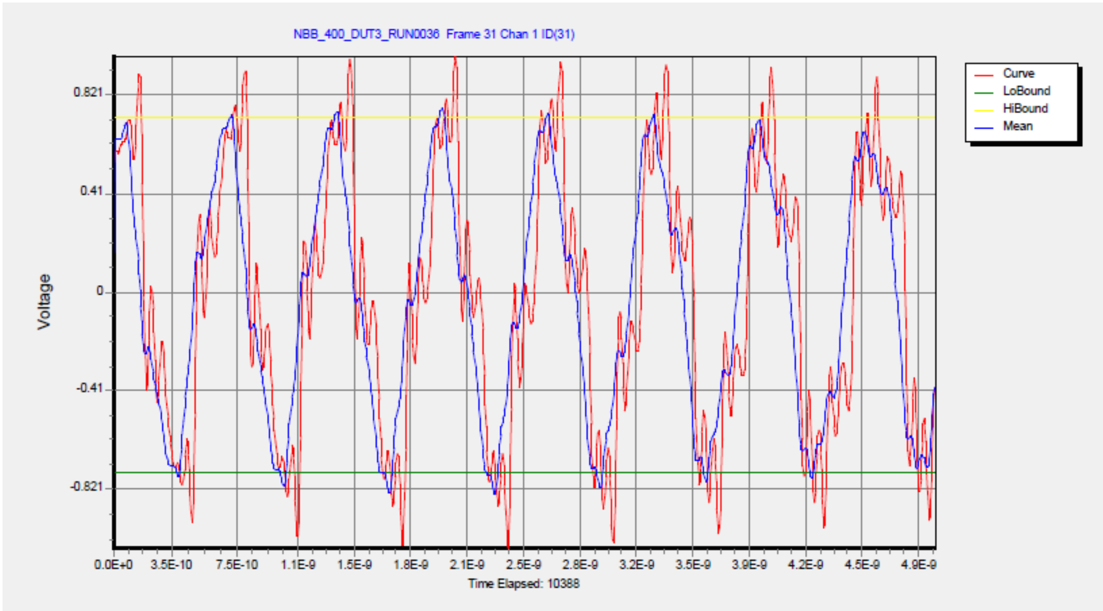

Figure 11: Test Run 36 Transient Response 3, Ion: Xe, Input Power: -5dBm

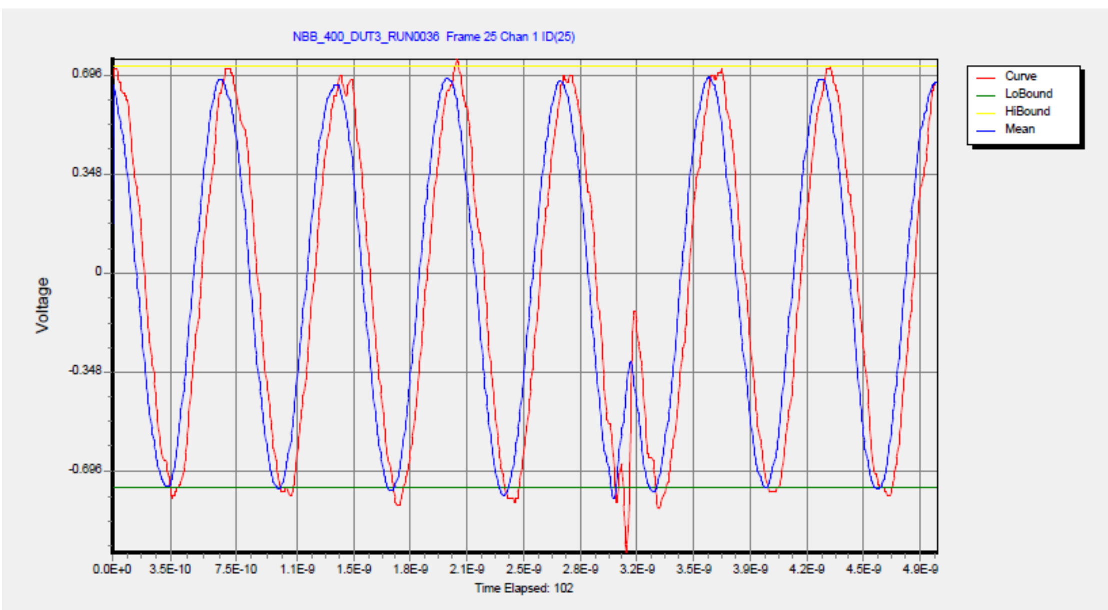

Figure 12: Test Run 36 Transient Response 4, Ion: Xe, Input Power: -5dBm

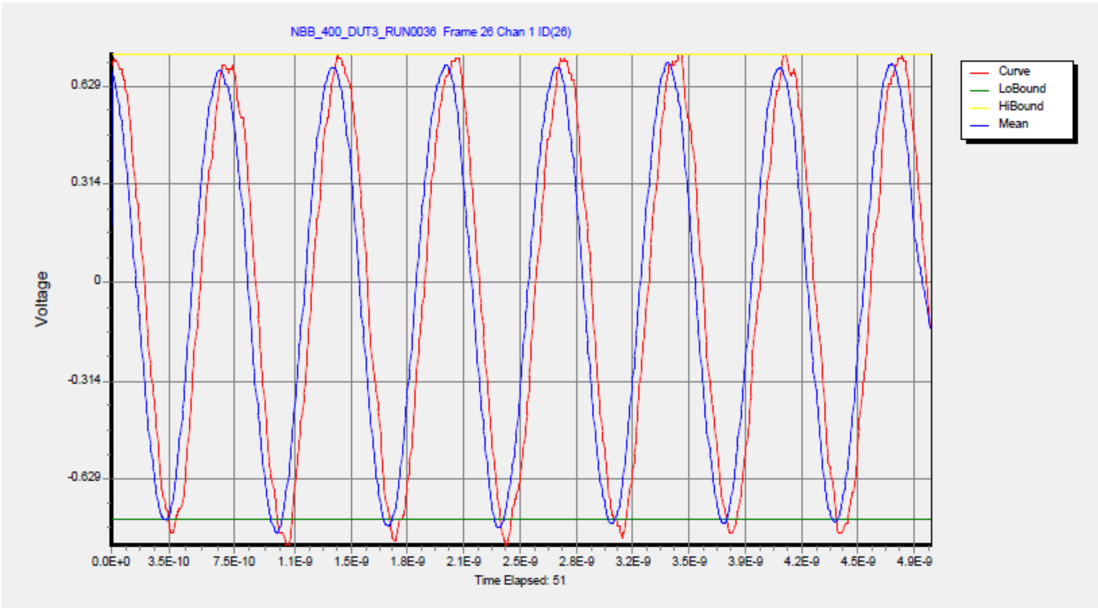

Figure 13: Test Run 36 Transient Response 5, Ion: Xe, Input Power: -5dBm

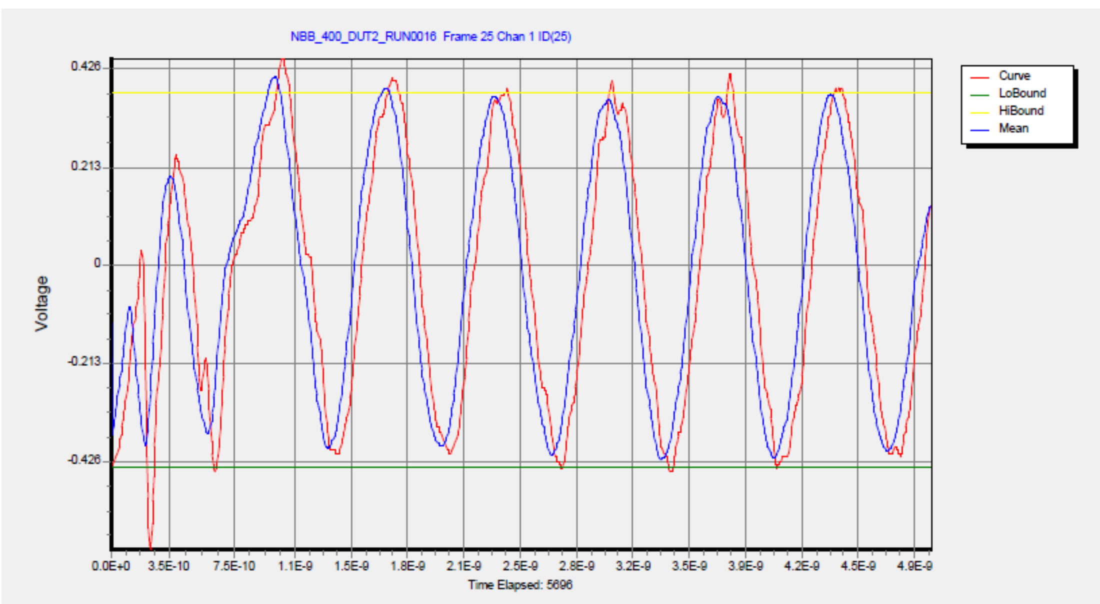

Figure 14: Test Run 16 Transient Response 1, Ion: Xe, Input Power: -10dBm

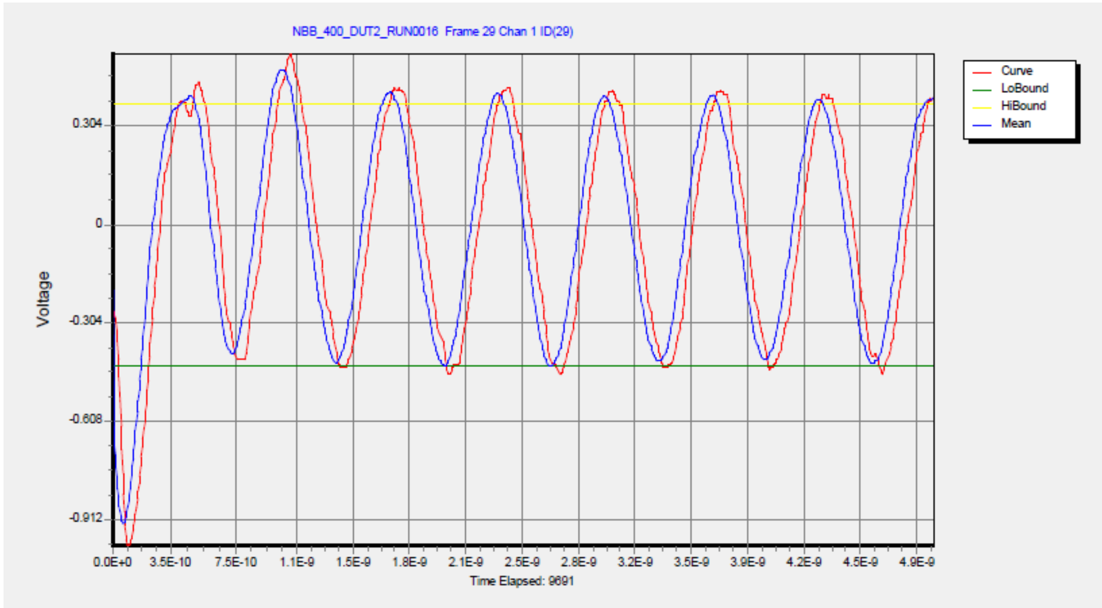

Figure 15: Test Run 16 Transient Response 2, Ion: Xe, Input Power: -10dBm

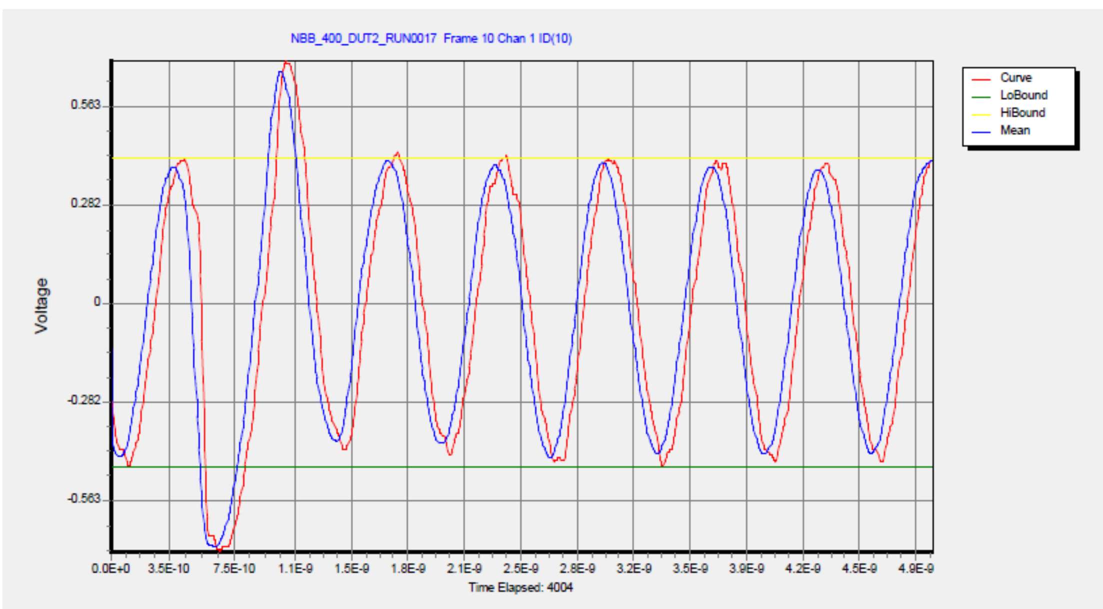

Figure 16: Test Run 17 Transient Response, Ion: Xe, Input Power: -10dBm

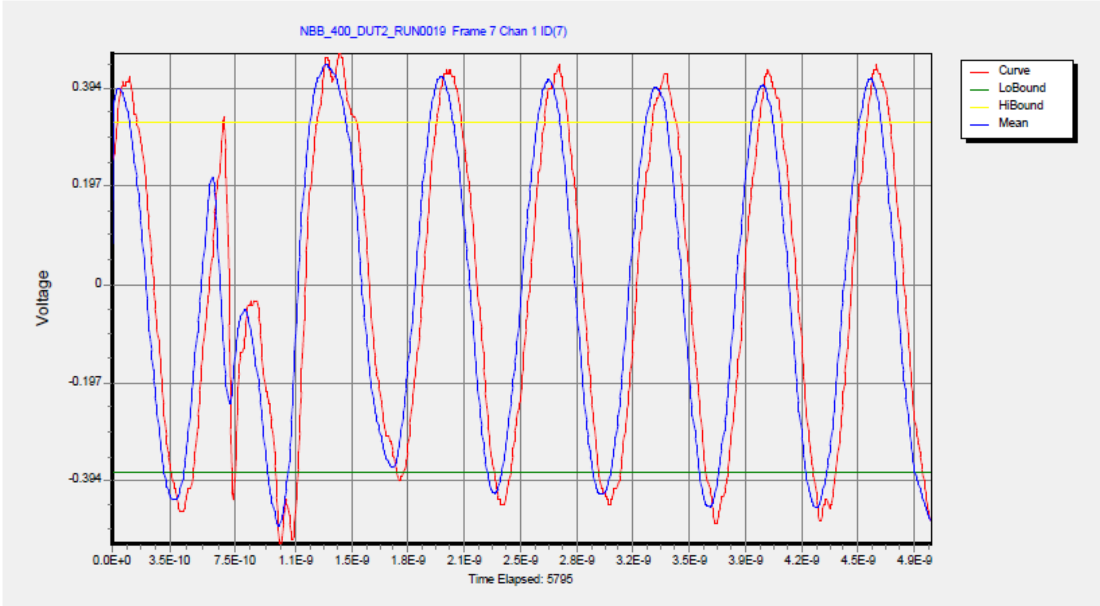

Figure 17: Test Run 19 Transient Response, Ion: Xe, Input Power: -10dBm

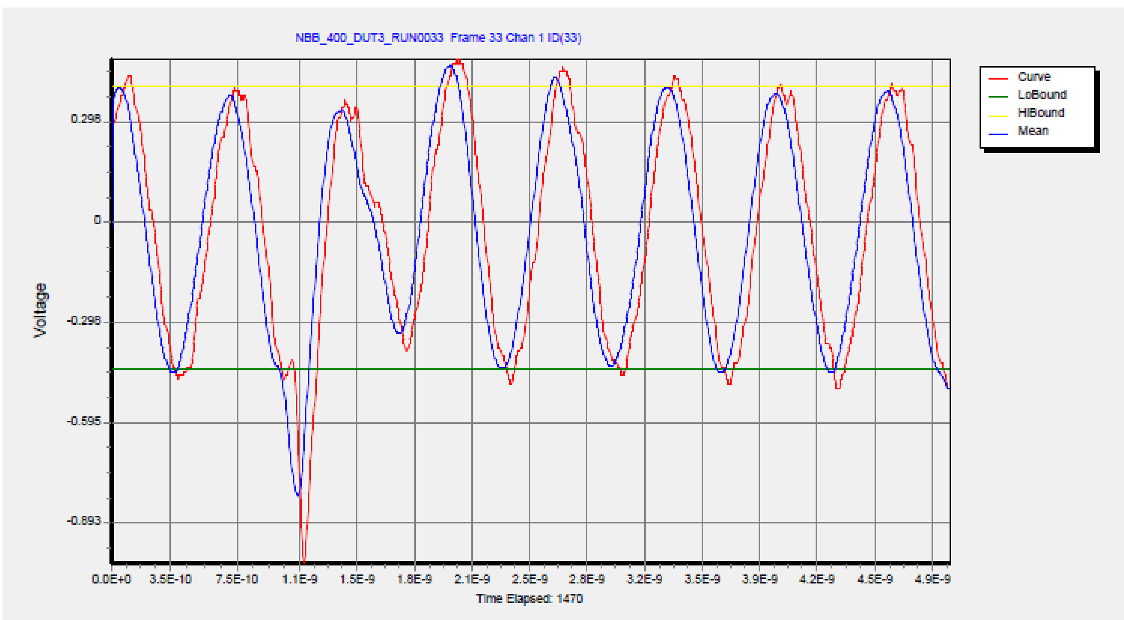

Figure 18: Test Run 33 Transient Response, Ion: Xe, Input Power: -10dBm

7. SUMMARY

Transients occurred during all tested ions and input powers. The individual transients can take many different forms causing changes to the period and amplitude to the output voltage. Some of these transients can have amplitudes larger than 1V or less than -1V.

8. REFERENCES

[1] Qorvo, “NBB-400 Cascadable Broadband GaAs MMIC Amplifier DC to 8GHz,” NBB-400 datasheet, 7/26/2017.

APRIL 2022 LBNL BEAM RUN LOG

Beam Characteristics														
Run #	Date	Time	Temperature	Air or Vacuum	Ion	MeV/amu	Energy (MeV)	Angle (°)	Air Gap (cm)	Range (µm)	Nominal Incident LET (MeV-cm2/mg)	Run Time (sec)	Average Flux (#/cm^{2*}s)	Fluence (#/cm^2)
1	4/6/22	10:06 AM	Room	Air	Xe	16	1954.7	0	7	93	55	178.55	5.82E+03	1.00E+06
2	4/6/22	10:15 AM	Room	Air	Xe	16	1954.7	0	7	93	55	54	1.87E+04	1.00E+06
3	4/6/22	10:37 AM	Room	Air	Xe	16	1954.7	0	7	93	55	144.62	6.90E+03	1.00E+06
4	4/6/22	10:48 AM	Room	Air	Xe	16	1954.7	0	7	93	55	2.2	7.00E+04	2.00E+05
5	4/6/22	10:50 AM	Room	Air	Xe	16	1954.7	0	7	93	55	100.9	8.90E+04	7.03E+06
6	4/6/22	11:02 AM	Room	Air	Xe	16	1954.7	0	7	93	55	145.92	6.87E+04	1.00E+07
7	4/6/22	11:07 AM	Room	Air	Xe	16	1954.7	0	7	93	55	158	6.30E+04	1.00E+07
8	4/6/22	11:17 AM	Room	Air	Xe	16	1954.7	0	7	93	55	144	6.90E+04	1.00E+07
9	4/6/22	11:24 AM	Room	Air	Xe	16	1954.7	0	7	93	55	140	7.10E+04	1.00E+07
10	4/6/22	11:32 AM	Room	Air	Xe	16	1954.7	0	7	93	55	144.1	6.96E+04	1.00E+07
11	4/6/22	11:37 AM	Room	Air	Xe	16	1954.7	0	7	93	55	148	6.70E+04	1.00E+07
12	4/6/22	11:45 AM	Room	Air	Xe	16	1954.7	0	7	93	55	140	6.80E+04	1.00E+07
13	4/6/22	11:50 AM	Room	Air	Xe	16	1954.7	0	7	93	55	146	6.85E+04	1.00E+07
14	4/6/22	12:00 PM	Room	Air	Xe	16	1954.7	0	7	93	55	149.6	6.70E+04	1.00E+07
15	4/6/22	12:15 PM	Room	Air	Xe	16	1954.7	0	7	93	55	140.9	6.65E+04	9.37E+06
16	4/6/22	1:54 PM	Room	Air	Xe	16	1954.7	0	7	93	55	104.87	9.50E+04	1.00E+07
17	4/6/22	1:58 PM	Room	Air	Xe	16	1954.7	0	7	93	55	111	9.00E+04	1.00E+07
18	4/6/22	2:04 PM	Room	Air	Xe	16	1954.7	0	7	93	55	107	9.30E+04	1.00E+07
19	4/6/22	2:07 PM	Room	Air	Xe	16	1954.7	0	7	93	55	120	8.30E+04	1.00E+07
20	4/6/22	2:14 PM	Room	Air	Xe	16	1954.7	0	7	93	55	119	8.40E+04	1.00E+07
21	4/6/22	2:16 PM	Room	Air	Xe	16	1954.7	0	7	93	55	117	8.50E+04	1.00E+07
22	4/6/22	2:23 PM	Room	Air	Xe	16	1954.7	0	7	93	55	118.4	8.40E+04	1.00E+07
23	4/6/22	2:26 PM	Room	Air	Xe	16	1954.7	0	7	93	55	114.6	8.77E+04	1.01E+07
24	4/6/22	2:31 PM	Room	Air	Xe	16	1954.7	0	7	93	55	38.69	8.88E+04	3.44E+06
25	4/6/22	2:34 PM	Room	Air	Xe	16	1954.7	0	7	93	55	111	9.00E+04	1.00E+07
26	4/6/22	2:37 PM	Room	Air	Xe	16	1954.7	0	7	93	55	108.7	9.20E+04	1.00E+07
27	4/6/22	2:45 PM	Room	Air	Xe	16	1954.7	0	7	93	55	102.3	9.80E+04	1.00E+07
28	4/6/22	2:50 PM	Room	Air	Xe	16	1954.7	0	7	93	55	104	9.60E+04	1.00E+07
29	4/6/22	3:14 PM	Room	Air	Xe	16	1954.7	0	7	93	55	0	0.00E+00	0.00E+00
30	4/6/22	3:18 PM	Room	Air	Xe	16	1954.7	0	7	93	55	98	1.10E+05	1.02E+07
31	4/6/22	3:21 PM	Room	Air	Xe	16	1954.7	0	7	93	55	102.1	9.80E+04	1.00E+07
32	4/6/22	3:24 PM	Room	Air	Xe	16	1954.7	0	7	93	55	103.7	9.67E+04	1.00E+07
33	4/6/22	3:28 PM	Room	Air	Xe	16	1954.7	0	7	93	55	107	9.30E+04	1.00E+07
34	4/6/22	3:33 PM	Room	Air	Xe	16	1954.7	0	7	93	55	124	8.00E+04	1.00E+07
35	4/6/22	3:36 PM	Room	Air	Xe	16	1954.7	0	7	93	55	108	9.30E+04	1.00E+07
36	4/6/22	3:41 PM	Room	Air	Xe	16	1954.7	0	7	93	55	104	9.67E+04	1.01E+07
37	4/6/22	3:44 PM	Room	Air	Xe	16	1954.7	0	7	93	55	104.3	9.60E+04	1.01E+07
38	4/6/22	3:48 PM	Room	Air	Xe	16	1954.7	0	7	93	55	102.63	9.70E+04	1.00E+07
39	4/6/22	4:48 PM	Room	Air	Kr	16	1225.5	0	7	103	31	108	9.50E+04	1.00E+07
40	4/6/22	4:52 PM	Room	Air	Kr	16	1225.5	0	7	103	31	113	9.45E+04	1.00E+07
41	4/6/22	4:58 PM	Room	Air	Kr	16	1225.5	0	7	103	31	107	9.64E+04	1.00E+07
42	4/6/22	5:01 PM	Room	Air	Kr	16	1225.5	0	7	103	31	109.6	9.10E+04	1.01E+07
43	4/6/22	5:06 PM	Room	Air	Kr	16	1225.5	0	7	103	31	112.56	8.90E+04	1.00E+07
44	4/6/22	5:09 PM	Room	Air	Kr	16	1225.5	0	7	103	31	112	8.95E+04	1.01E+07
45	4/6/22	5:13 PM	Room	Air	Kr	16	1225.5	0	7	103	31	114	8.78E+04	1.00E+07
46	4/6/22	5:16 PM	Room	Air	Kr	16	1225.5	0	7	103	31			1.00E+07

Trigger																
Filter Voltage (V)	Channel	Sample Rate	Record Length	Download #	Time Scale	Voltage Scale	Trigger Condition(Pulse Width/Edge)	Slope	Trigger Level	Trigger Mode	Threshold	Polarity (Positive/Negative)	Trig When	HighL	LowL	Load (Ω)
5	1	100G	1000	1000	1n	100mV/div	Pulse width	NA	NA	Normal	0	Postive	More than	1.02n	920p	50
5	1	100G	1000	1000	1n	100mV/div	Edge	Rise	340mV	NA	NA	NA	NA	NA	NA	50
5	1	100G	1000	1000	1n	100mV/div	Edge	Rise	340mV	NA	NA	NA	NA	NA	NA	50
5	1	100G	1000	1000	1n	100mV/div	Edge	Rise	340mV	NA	NA	NA	NA	NA	NA	50
5	1	100G	1000	1000	1n	100mV/div	Edge	Rise	340mV	NA	NA	NA	NA	NA	NA	50
5	1	500G	1000	1000	200p	100mV/div	Edge	Rise	350mV	NA	NA	NA	NA	NA	NA	50
5	1	500G	1000	1000	200p	100mV/div	Edge	Fall	-380mV	NA	NA	NA	NA	NA	NA	50
5	1	500G	1000	1000	200p	200mV/div	Edge	Fall	-380mV	NA	NA	NA	NA	NA	NA	50
5	1	100G	1000	1000	1n	200mV/div	Edge	Fall	-380mV	NA	NA	NA	NA	NA	NA	50
5	1	100G	1000	1000	1n	200mV/div	Edge	Rise	620mV	NA	NA	NA	NA	NA	NA	50
5	1	100G	1000	1000	1n	200mV/div	Edge	Fall	-680mV	NA	NA	NA	NA	NA	NA	50
5	1	50G	1000	1000	2n	200mV/div	Edge	Fall	-680mV	NA	NA	NA	NA	NA	NA	50
5	1	6.25G	1000	1000	16n	200mV/div	Edge	Fall	-680mV	NA	NA	NA	NA	NA	NA	50
5	1	25G	1000	1000	4n	200mV/div	Pulse width	NA	NA	Normal	0	Postive	More than	360p	300p	50
5	1	200G	1000	1000	4n	200mV/div	Edge	Rise	620mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Rise	360mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Rise	360mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Fall	-390mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Fall	-390mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Rise	680mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Rise	680mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Fall	-700mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	200mV/div	Edge	Fall	-700mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	250mV/div	Edge	Fall	-700mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-714mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-714mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	675mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Pulse width	NA	NA	NA	NA	Postive	More than	3.60E-10	3.00E-10	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	360mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	360mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	360mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-390mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-390mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	660mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	660mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-700mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-700mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Pulse width	NA	NA	NA	NA	Postive	More than	3.60E-10	3.00E-10	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-730mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-730mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	690mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	690mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	390mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Rise	390mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-420mV	NA	NA	NA	NA	NA	NA	50
5	1	200G	1000	1000	500p	300mV/div	Edge	Fall	-420mV	NA	NA	NA	NA	NA	NA	50

Input			Results							
Waveform	Frequency (MHz)	Input Power (dBm)	DUT	# Acquisitions	Downloads	Cross Section (cm^{-2})	Dose (rads)	Comments	total aq pre	# download pre
Sine	500	-12	1				8.81E+02	nothing happen	4	2
Sine	500	-12	1				8.81E+02	1 event	92	47
Sine	500	-12	1				8.81E+02	trial	109	52
Sine	500	-12	1				1.76E+02	false start	175	85
Sine	500	-12	1	6	6	8.53E-07	6.19E+03	Real	40	19
Sine	1500	-10	1	12	12	1.20E-06	8.81E+03	Real	85	37
Sine	1500	-10	1	15	15	1.50E-06	8.81E+03		39	19
Sine	1500	-10	1	17	17	1.70E-06	8.81E+03		67	32
Sine	1500	-10	1	11	11	1.10E-06	8.81E+03		54	24
Sine	1500	-5	1	11	11	1.10E-06	8.81E+03		58	26
Sine	1500	-5	1	12	12	1.20E-06	8.81E+03		34	21
Sine	1500	-5	1	12	12	1.20E-06	8.81E+03		37	20
Sine	1500	-5	1	14	14	1.40E-06	8.81E+03		35	16
Sine	1500	-5	1	9	9	9.00E-07	8.81E+03		5	3
Sine	1500	-5	1	N/A	N/A	#VALUE!	8.25E+03	going to do a fr	N/A	N/A
Sine	1500	-10	2	10	10	1.00E-06	8.81E+03	start	44	20
Sine	1500	-10	2	13	13	1.30E-06	8.81E+03		1	0
Sine	1500	-10	2	10	10	1.00E-06	8.81E+03		1	0
Sine	1500	-10	2	18	18	1.80E-06	8.81E+03		1	0
Sine	1500	-5	2	6	6	6.00E-07	8.81E+03		1	0
Sine	1500	-5	2	8	8	8.00E-07	8.81E+03		1	0
Sine	1500	-5	2	13	13	1.30E-06	8.81E+03		57	28
Sine	1500	-5	2	13	13	1.29E-06	8.90E+03	saw wave clip	54	22
Sine	1500	-5	2			0.00E+00	3.03E+03	saw wave clip, s	40	24
Sine	1500	-5	2	19	19	1.90E-06	8.81E+03		5	4
Sine	1500	-5	2	4	4	4.00E-07	8.81E+03		4	3
Sine	1500	-5	2	11	11	1.10E-06	8.81E+03		1	0
Sine	1500	-5	2	N/A	N/A	#VALUE!	8.81E+03	going to do a fr	N/A	N/A
Sine	1500	-10	3			#DIV/0!	0.00E+00	no beam	1	0
Sine	1500	-10	3	8	8	7.84E-07	8.99E+03	start	88	62
Sine	1500	-10	3	16	17	1.60E-06	8.81E+03		43	24
Sine	1500	-10	3	12		1.20E-06	8.81E+03	need download	1	0
Sine	1500	-10	3	14	14	1.40E-06	8.81E+03		42	23
Sine	1500	-5	3	7	7	7.00E-07	8.81E+03		2	1
Sine	1500	-5	3	5	5	5.00E-07	8.81E+03		6	5
Sine	1500	-5	3	14	14	1.39E-06	8.90E+03		56	29
Sine	1500	-5	3	12	13	1.19E-06	8.90E+03		55	27
Sine	1500	-5	3	N/A	N/A	#VALUE!	8.81E+03	going to do a fr	N/A	N/A
Sine	1500	-5	3	2	2	2.00E-07	5.00E+03	1% potassium c	2	1
Sine	1500	-5	3	7	7	7.00E-07	5.00E+03	see above 1%K	4	3
Sine	1500	-5	3	1	1	1.00E-07	5.00E+03	see above 1%K	33	23
Sine	1500	-5	3	3	3	2.97E-07	5.05E+03	see above 1%K	16	14
Sine	1500	-10	3	3	3	3.00E-07	5.00E+03	see above 1%K	10	9
Sine	1500	-10	3	4	4	3.96E-07	5.05E+03	see above 1%K	5	4
Sine	1500	-10	3	5	5	5.00E-07	5.00E+03	see above 1%K	4	1
Sine	1500	-10	3	9	9	9.00E-07	5.00E+03	see above 1%K	1	0