NASA/TM—20230001865

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February 2023

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Test Date: November 9, 2022
Report Date: February 6, 2023

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

February 2023

Acknowledgments (optional)

This work was sponsored by the NASA GSFC Radiation Effects and Analysis Group and supported by NASA Headquarters Office of Safety and Mission Assurance (OSMA).

Level of Review: This material has been technically reviewed by technical management.

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1. Introduction

The purpose of this testing was to characterize the single event effects (SEE) susceptibility of the TLE4309 adjustable linear low dropout light emitting diode (LED) driver. The device was monitored for single event effects on during exposure to a heavy ion beam at Lawrence Berkeley National Laboratory (LBNL) 88-inch Cyclotron. Testing was performed on November 9, 2022.

2. Test Result Summary

The TLE4309 did not experience any destructive single-event effects during heavy ion irradiation with Xe at normal incidence with a linear energy transfer (LET) of 51.7 MeV-cm^2/mg to a fluence of 1.00x10^7 cm^{-2} with the enable pin not grounded. However, the TLE4309 did experience transients under the stated conditions.

The TLE4309 did not experience any destructive single-event effects during heavy ion irradiation with Xe at an angle of 40° with a LET of 76.6 MeV-cm2/mg to a fluence of 1.00x10^7 cm^{-2} with the enable pin grounded. However, the TLE4309 did experience transients under the stated conditions.

The TLE4309 was operated under room temperature for both cases (enable pin grounded/enable pin not grounded)

3. Devices Tested

3.1. Part Background

The TLE4309 is an integrated adjustable constant current source [1]. The output current level can be controlled with an external shunt resistor. The TLE4309 yields constant brightness independent from the supply voltage or LED forward voltage.

3.2. Device Under Test (DUT) Information

Ten (10) parts of TLE4309s were provided for heavy ion testing. Eight devices were decapsulated, and two devices were used as controls. All specifications and descriptions are according to the TLE4309 datasheet. More information can be found in Table 1.

Table 1. Part Identification Information

Part Number	TLE4309
REAG ID#	22-013
Manufacturer	Infineon
Lot Date Code	n/a
Quantity Tested	10
Part Function	Current Source
Part Technology	Bipolar
Package	7 pin TO263

An image of the TLE4309 die can be seen in Figure 1.

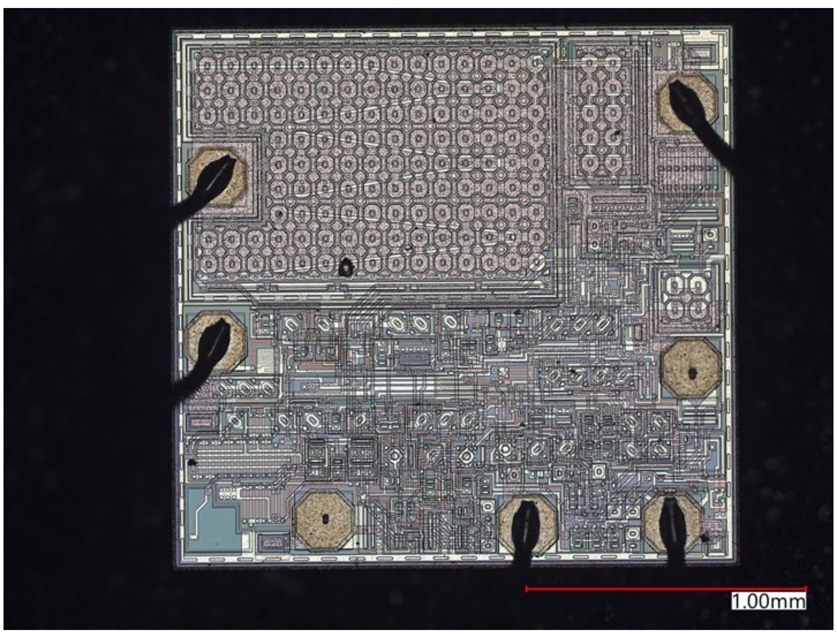

Figure 1: TLE4309 die

4. Test Setup

The test circuit for the TLE4309 were built to model/approximate the intended application. Figure 2 shows the circuit diagram implemented on the PCB with the electrical components listed in table 2.

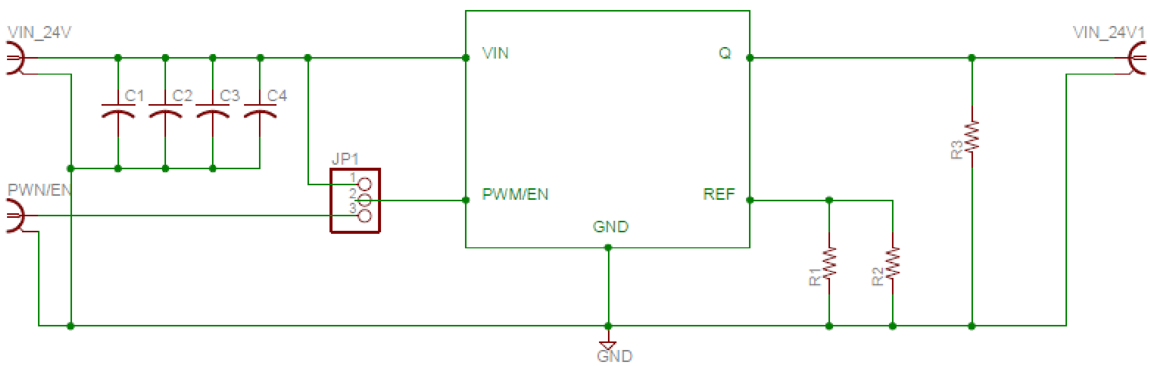

Figure 2: Schematic of the TLE4309 test circuit.

Table 2: List of Electronic Components

Component	Value
C1, C2, C3, C4	0.47 μF
R1, R2	10 Ω
R3	100 Ω

Two different configurations of the TLE4309 were tested.

Case 1: Enable not grounded

Case 2: Enable grounded

Case 1 represents the configuration that will used during flight. Multiple ions were tested to understand the behavior of the TLE4309 during heavy ion irradiation. Case 2 represents a worst-case configuration and was only tested at the largest possible LET for this test set up (Xe at 40°).

The test setup required a DC power supply, an oscilloscope for capturing the current and voltage, and a laptop equipped with LabVIEW for saving the data. Parts were serialized randomly. Figure 3 shows a block diagram of the experiment setup and Figure 4 shows a device under test (DUT) in the beamline.

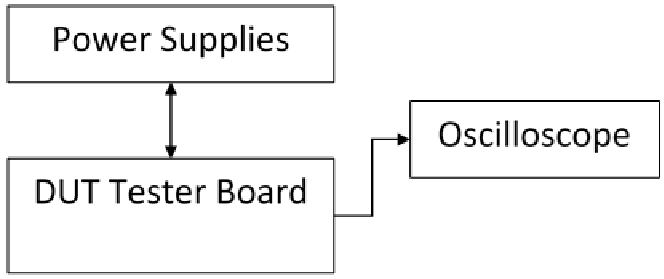

Figure 3: Block Diagram

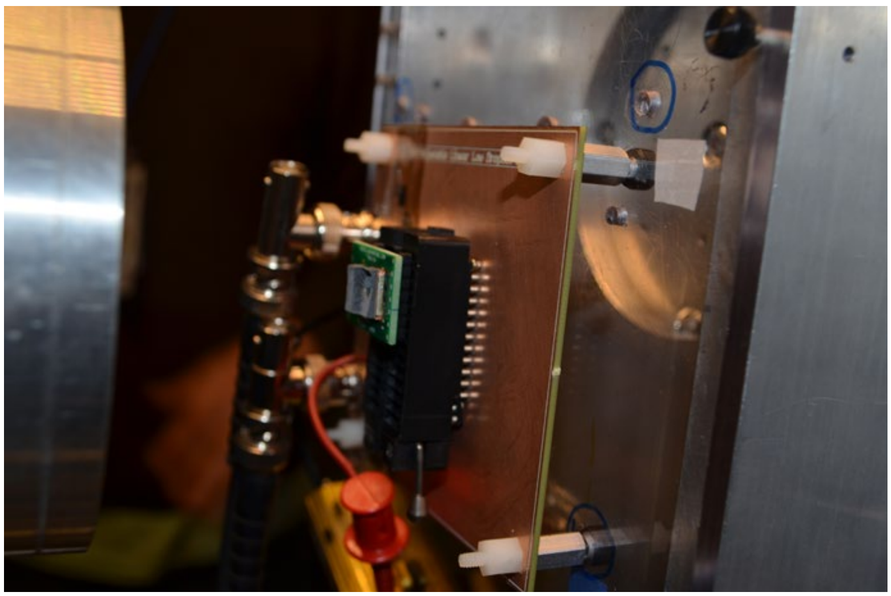

Figure 4: Experiment Test Set-up

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
Tektronix	DSA 72004	2173383	Oscilloscope
Agilent Technologies	N6702A	M161871	Power supply
Mounting board	N/A	N/A	Mounting board
Cables	N/A	N/A	Cables to make connections

5. Test Facility

SEE testing is done by exposing a decapsulated die to heavy ions to see the radiation response over varied LET. This is done by utilizing different species of ions, one at a time to capture the cross section of that device at each LET to characterize the device.

Facility: Lawrence Berkeley National Laboratory 88" Cyclotron Facility
Type of Radiation: Heavy ions
Facility Configuration: 16MeV/amu tune
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 a destructive event occurs
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)
^{36}Kr	0*	1024	130.7	28.6
^{54}Xe	0*	1523	120.4	51.7
^{54}Xe	40**	1191	53	76.6

*Air gap 2.54 cm
**Air gap 6.985 cm

6. Test Conditions

Test Temperature: Room temperature
Vacuum: No
Input Voltage: 24V
Error Modes: The primary purpose of this test to identify destructive single event effects. All events will be captured by the oscilloscope

7. Test Methods and Procedures

The conditions tested during irradiation are shown in table 4. The DUT was powered with 24V at room temperature. The supply was monitored for transients. Two different configurations were tested. The first configuration had the enabled pin for the TLE4309 not grounded, and the second configuration grounded the enabled pin. Initially the DUT was irradiated with Kr ions at normal incidence. After the DUT was irradiated with Xe ions at normal incidence. Finally, the DUT was rotated to 40° relative to the beam line and irradiated with Xe ions for the maximum possible LET. For all conditions tested, transients with positive and negative amplitudes were captured.

8. Test Personnel

Tom Carstens (NASA), Michael Campola (NASA), and Anthony Phan (SSAI)

9. Test Results

The TLE4309 with the enabled pin "not grounded" was irradiated with Xe ions at normal incidence (LET of 51.7 MeV-cm^2/mg). During heavy ion irradiation the DUT did not experience any destructive single event effects. However, transients were observed during irradiation. An example of a transient is shown in Figure 5. All transients were like Figure 5.

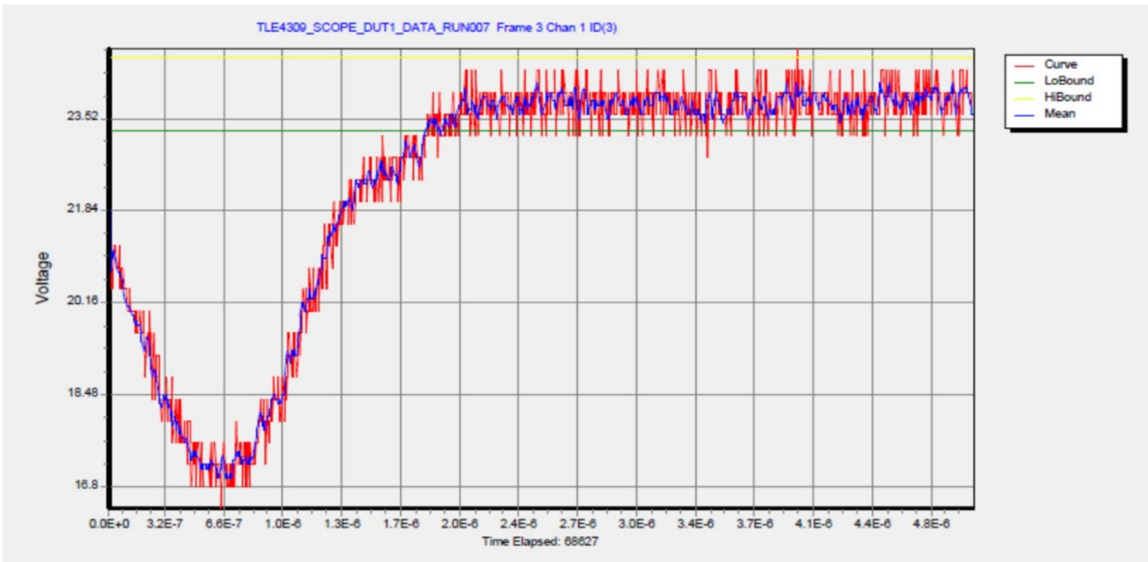

Figure 5: TLE4309 During Xe Irradiation with Enabled Pin Not Grounded

Figure 6 shows the amplitudes and pulse-widths generated when irradiated with Xe with enabled pin not grounded. The maximum pulse width was 4.90E-07 seconds for this configuration. The maximum voltage drop for this configuration was 7.6V (referenced from 24V).

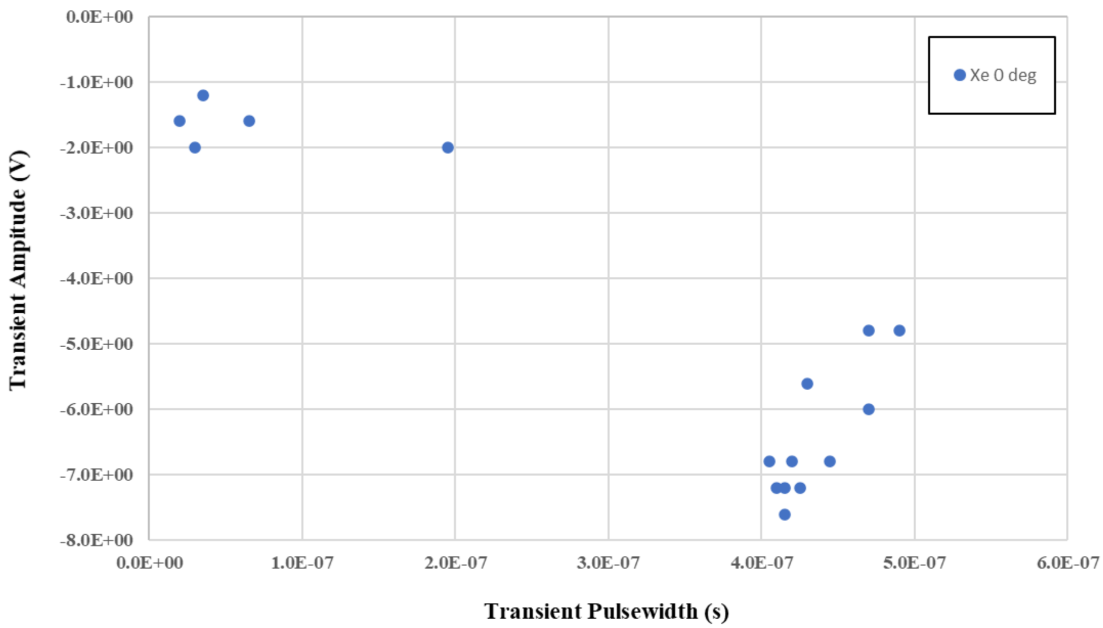

Figure 6: Amplitude and Pulse width Scatterplot for Transients Generated with the Enabled Pin Not Grounded. Amplitude Measured relative to 24V input voltage

After this the TLE4309 enable pin was grounded. For this the case the DUT was irradiated with Xe ions at an 40° angle (LET of 71.2 MeV-cm^2/mg). Transients also occurred in this configuration. Examples of these transients can be seen in this configuration are shown Figure 7 and Figure 8.

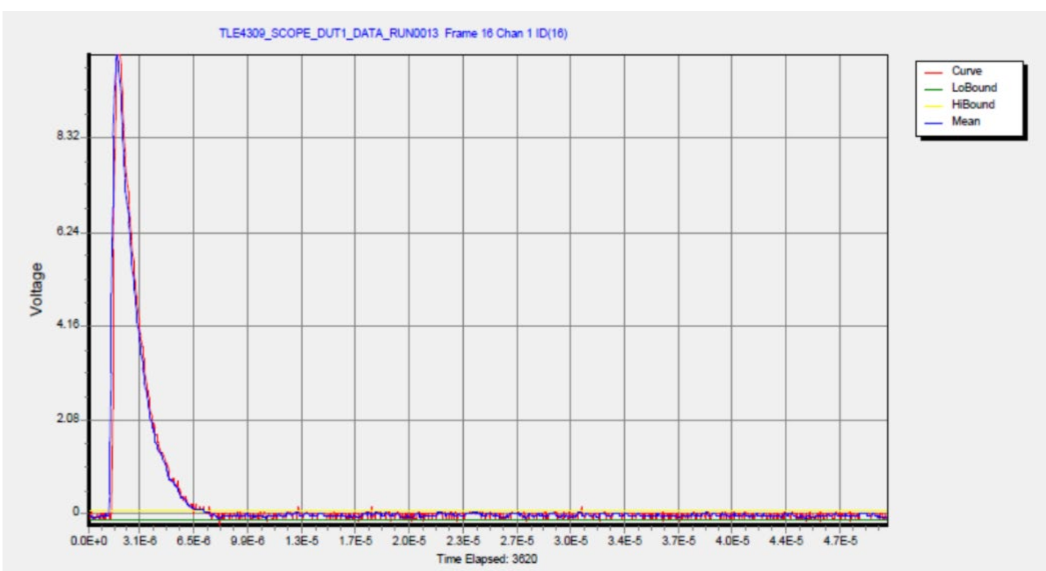

Figure 7: TLE4309 During Xe Irradiation with Enabled Pin Grounded Example 1

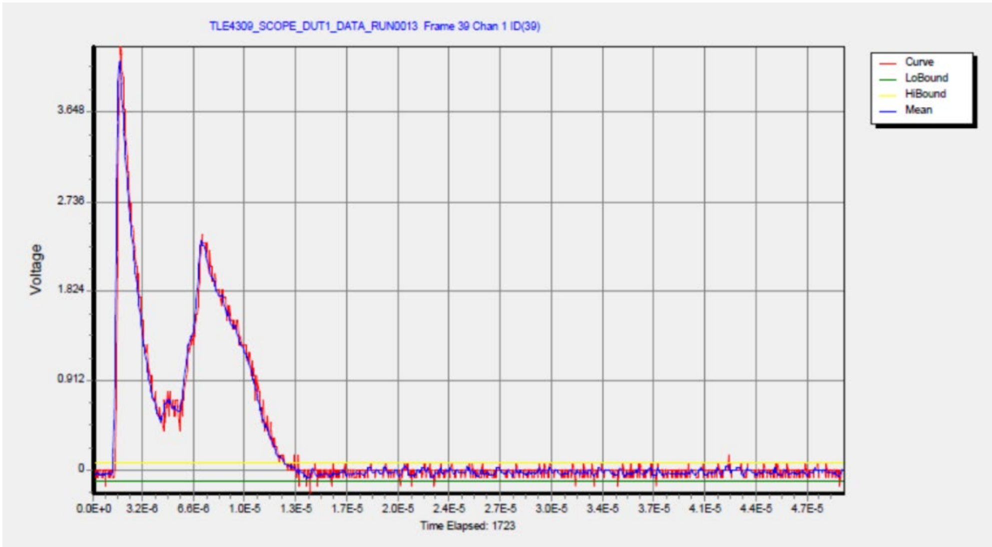

Figure 8: TLE4309 During Xe Irradiation with Enabled Pin Grounded Example 2

Figure 9 shows the amplitudes and pulse-widths generated when irradiated with Xe with enabled pin grounded. The maximum pulse width was 9.25E-06 seconds for this configuration. The maximum voltage transient for this configuration was 10.2V.

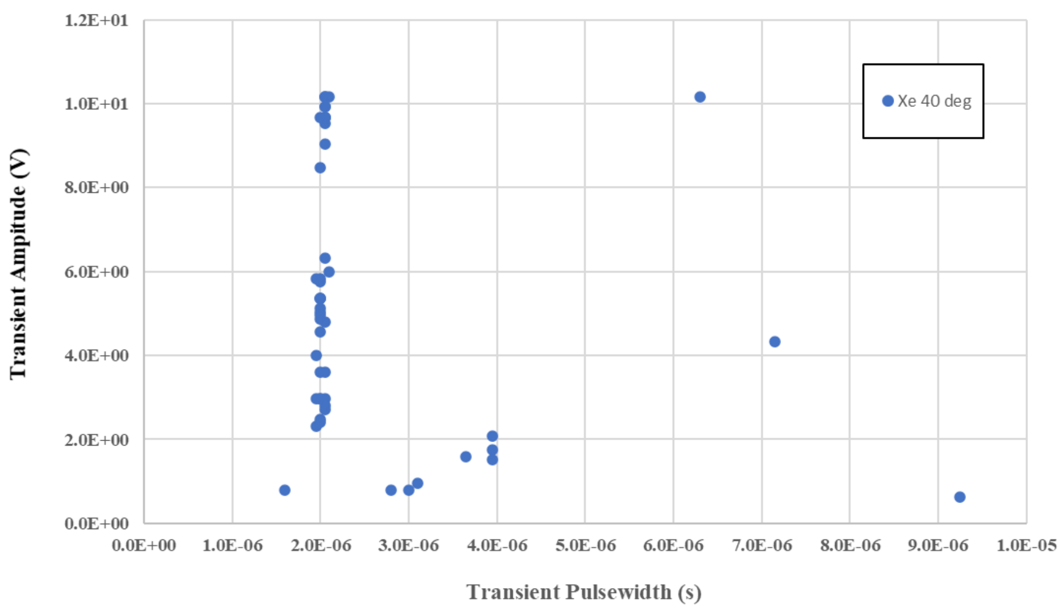

Figure 9: Amplitude and Pulse width Scatterplot for Transients Generated with the Enabled Pin Grounded

10. REFENCES

[1] Infineon, “Adjustable Linear Low Dropout LED Driver”, TLE4309 datasheet, March 2007.