Single-Event Latch-Up Test Report of the SN55HVD233-SEP CAN Bus Transceiver

ABSTRACT

This study characterized the effect of heavy-ion irradiation on the single-event latch-up (SEL) performance of the SN55HVD233-SEP CAN Transceiver. Heavy-ions with LET of 43 MeV-cm^2/mg were used to irradiate up to a fluence of 1.0 × 10^7 ions/cm^2. The results demonstrate that the SN55HVD233-SEP is SEL-free up to LET = 43 MeV-cm^2/mg at 125°C.

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1 Overview

The SN55HVD233-SEP is a radiation-hardened CAN Bus Transceiver for use in accordance with the ISO 11898 standard. The SNHVD233-SEP can be used to transmit and receive data between a CAN controller and a CAN bus up to 1 Mbps. The device features cross-wire protection, overvoltage protection up to ±16 V, loss-of-ground protection, overtemperature (thermal shutdown) protection. The SN55HVD233-SEP can operate over a wide –7-V to 12-V common-mode range.

For more information on the SN55HVD233-SEP device, see http://www.ti.com/product/SN55HVD233-SEP.

Table 1. Overview Information[1]

TI Part Number	SN55HVD233MDPSEP/ SN55HVD233MDTPSEP
VID Number	V62/18617
Device Function	CAN Bus Transceiver
Exposure Facility	Radiation Effects Facility, Cyclotron Institute, Texas A&M University
Heavy Ion Fluence per Run	1.0×10^7 ions/cm^2
Irradiation Temperature	125°C

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2 SEE Mechanisms

The primary single-event effect (SEE) events of interest in the SN55HVD233-SEP are single-event latch-up (SEL). From a risk or impact point-of-view, the occurrence of an SEL is potentially the most destructive SEE event and the biggest concern for space applications. In mixed technologies such as the LBC3S process used for the SN55HVD233-SEP, the BICMOS circuitry introduces a potential for SEL susceptibility. SEL can occur if excess current injection caused by the passage of an energetic ion is high enough to trigger the formation of a parasitic cross-coupled PNP and NPN bipolar structure (formed between the p-sub and n-well and n+ and p+ contacts).[1][2] The parasitic bipolar structure initiated by a single-event creates a high-conductance path (inducing a steady-state current that is typically orders-of-magnitude higher than the normal operating current) between power and ground that persists (is *latched*) until power is removed or until the device is destroyed by the high-current state. The SN55HVD233-SEP exhibited no SEL with heavy-ions up to an LET of 43 MeV-cm^2/mg at a fluence of 1.0×10^7 ions/cm^2 and a chip temperature of 125°C.

3 Test Device and Test Board Information

The SN55HVD233-SEP is packaged in an 8-pin Small Outline Integrated Circuit Plastic package (D) shown with the pinout in Figure 1. The TCAN10xx Controller Area Network (CAN) Evaluation Module used for the SEE characterization is shown in Figure 2.

The package is decapp'ed to reveal the die face for all heavy ion testing.

Figure 1. SN55HVD233-SEP Photograph (Left) and a Pinout Diagram (Right)

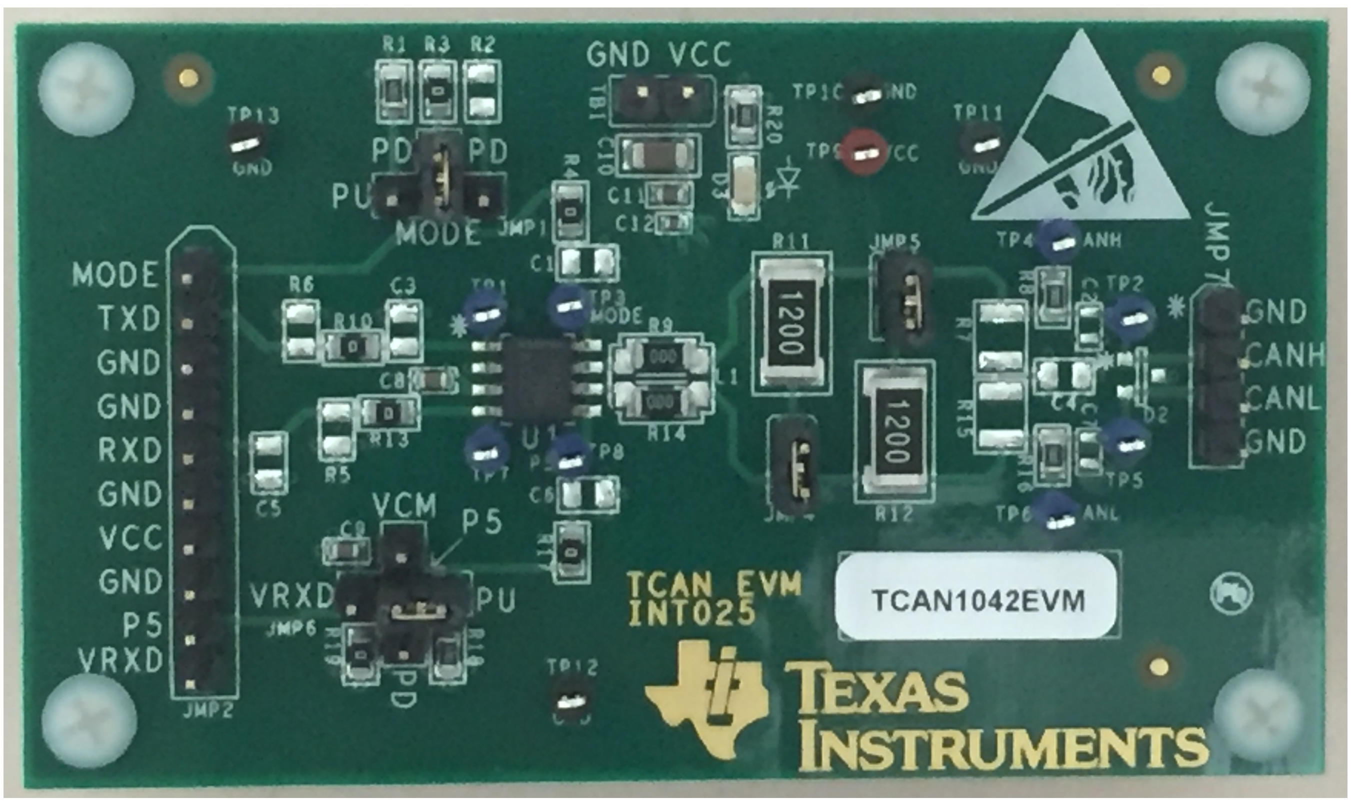

Figure 2. SN55HVD233-SEP Mounted on TCAN1042DEVM

A schematic of the TCAN1042DEVM is illustrated in Figure 3.

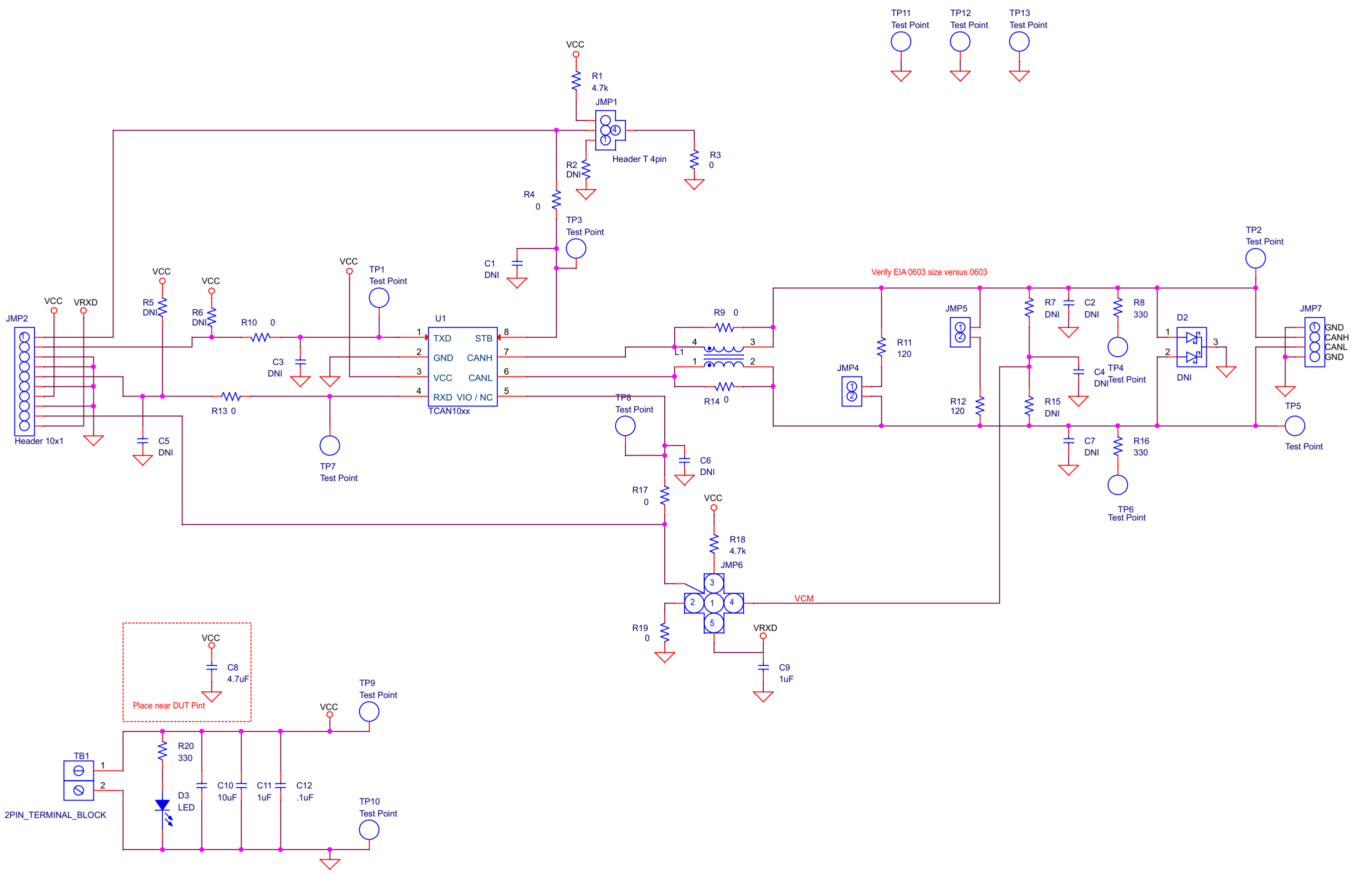

Figure 3. TCAN1042DEVM Schematic Evaluation Board Used to Perform the SEL

4 Irradiation Facility and Setup

The heavy ion species used for the SEE studies on this product were provided and delivered by the *TAMU Cyclotron Radiation Effects Facility*[3] using a superconducting cyclotron and advanced electron cyclotron resonance (ECR) ion source. Ion beams are delivered with high uniformity over a 1-in diameter circular cross-sectional area for the in-air station. Uniformity is achieved by means of magnetic defocusing. The intensity of the beam is regulated over a broad range spanning several orders of magnitude. For the bulk of these studies, ion fluxes of 1.0 × 10^5 ions/s-cm^2 were used to provide heavy ion fluences between 1.0 × 10^7 ions/cm^2. For these experiments, Silver (Ag) ions were used. Ion beam uniformity for all tests was in the range of 91% to 98%. The air space between the device and the ion beam port window was maintained at 40 mm for all runs.

5 Results

5.1 Single-Event Latch-Up (SEL)

During SEL characterization, the device was heated using forced hot air, maintaining the die temperature at 125°C. The temperature was monitored by means of a K-type thermocouple attached as close as possible to the die. The species used for the SEL testing was a Silver (^{47}Ag) ion with an angle-of-incidence of 0° degrees for an LET = 43 MeV-cm^2/mg. The kinetic energy in the vacuum for this ion is 1.634 GeV (15-MeV/amu line). A flux of approximately 1.0 × 10^5 ions/cm^2-s and a fluence of approximately 1.0 × 10^7 ions were used for all seven runs. The VCC voltage was set to the recommended maximum at 3.6 V. Run duration to achieve this fluence was approximately 2 minutes. No SEL events were observed during all seven runs. The SEL tests were conducted in Dynamic Mode with the part clocked at 10 kHz, and static on a recessive mode as described in Table 2.

Figure 4 shows the plot of the current versus time and Figure 5 shows the temperature versus time for run # 1 (active at 10 kHz).

Table 2. SN55HVD233-SEP SEL Conditions Using ^{47}Ag at an Incidence of 0°

Run #	Dev #	Average Flux (MeV-cm^2/mg)	Conditions				
			LBK	D	Bus Load	Rs	Bus Common Mode Voltage (V)
1	1	1.05 × 10^5	High	10 kHz	60 Ω	Low	N/A
2	1	9.86 × 10^4	High	10 kHz	60 Ω	Low	N/A
3	1	9.66 × 10^4	High	H	60 Ω	Low	6
4	1	9.40 × 10^4	High	H	60 Ω	Low	6
5	1	1.05 × 10^5	High	H	60 Ω	Low	12
6	1	1.05 × 10^5	High	H	60 Ω	Low	14
7	1	9.96 × 10^4	High	H	60 Ω	Low	18

No SEL events were observed, indicating that the SN55HVD233-SEP is SEL-immune at LET = 43 MeV-cm²/mg and T = 125°C. Using the MFTF method and combining (or summing) the fluences of the seven runs (7.0 × 10^7), the upper-bound cross section (using a 95% confidence level) is calculated as:

$$\sigma_{SEL} \leq 5.27 \times 10^{-8}\ cm^2 \text{ for LET} = 43\ MeV\text{-}cm^2/mg \text{ and } T = 125°C \quad (1)$$

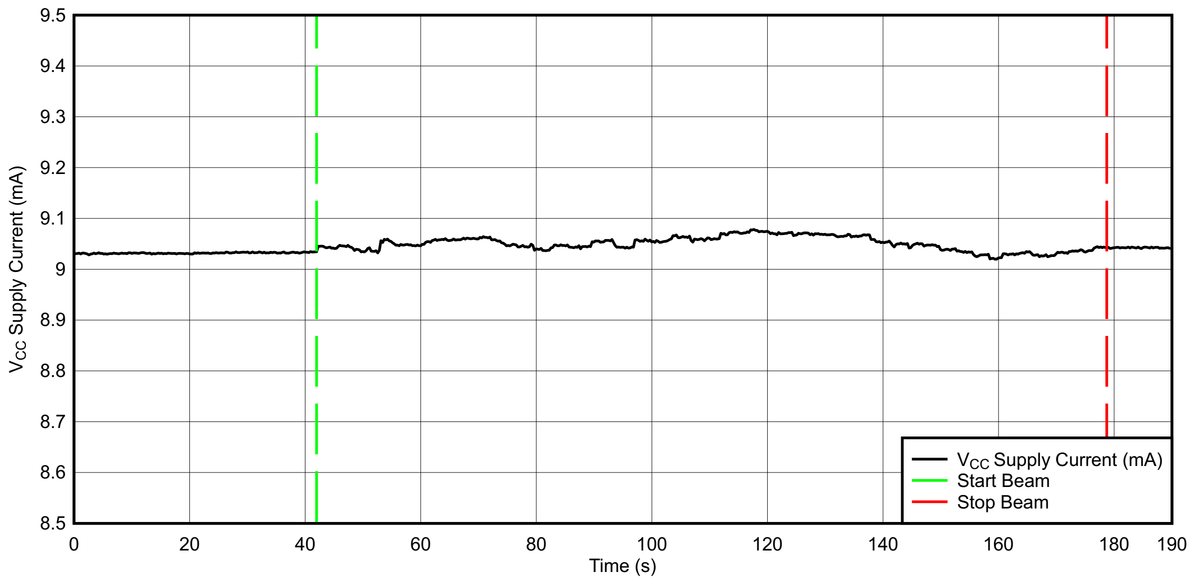

Figure 4. Current vs Time (I vs t) Data for VCC Supply Current During SEL Run # 1

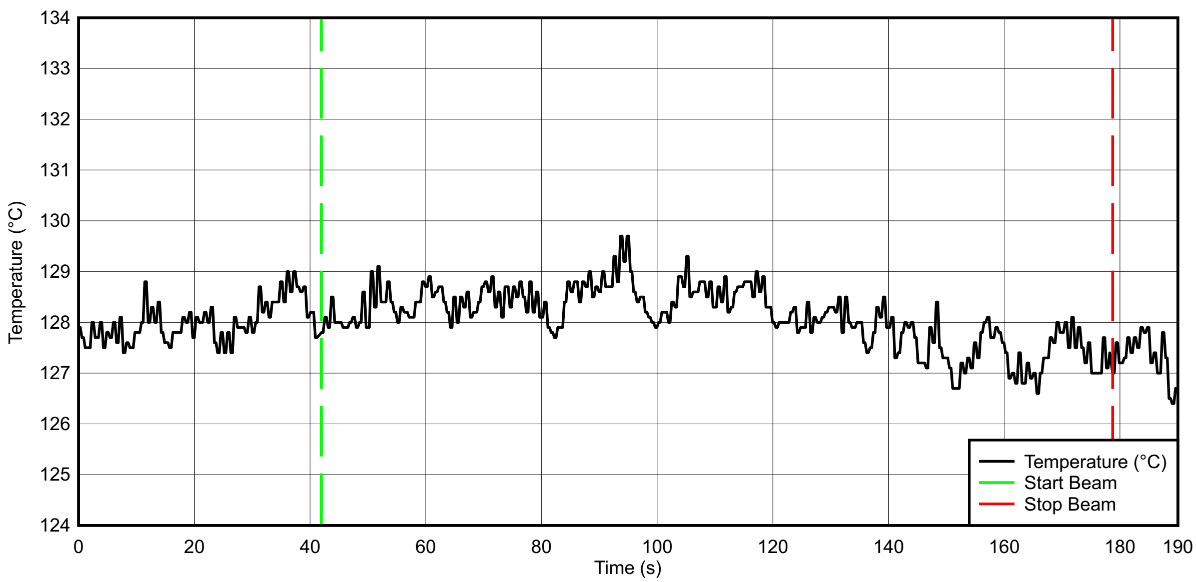

Figure 5. Temperature vs Time Data for SEL Run # 1

6 Summary

The purpose of this study was to characterize the effect of heavy-ion irradiation on the single-event latch-up (SEL) performance of the SN55HVD233-SEP CAN Transceiver. The SEL results show the device is latch-up free up to 43 MeV-cm^2/mg.

7 References

(1) M. Shoga and D. Binder, “Theory of Single Event Latchup in Complementary Metal-Oxide Semiconductor Integrated Circuits”, IEEE Trans. Nucl. Sci, Vol. 33(6), Dec. 1986, pp. 1714-1717.

(2) G. Bruguier and J.M. Palau, “Single particle-induced latchup”, IEEE Trans. Nucl. Sci, Vol. 43(2), Mar. 1996, pp. 522-532.

(3) TAMU Radiation Effects Facility website. http://cyclotron.tamu.edu/ref/

(4) “The Stopping and Range of Ions in Matter” (SRIM) software simulation tools website. http://www.srim.org/index.htm#SRIMMENU

(5) D. Kececioglu, “Reliability and Life Testing Handbook”, Vol. 1, PTR Prentice Hall, New Jersey,1993, pp. 186-193.

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(7) A. J. Tylka, et al., "CREME96: A Revision of the Cosmic Ray Effects on Micro-Electronics Code", IEEE Trans. Nucl. Sci., 44(6), 1997, pp. 2150-2160.

(8) A. J. Tylka, W. F. Dietrich, and P. R. Bobery, “Probability distributions of high-energy solar-heavy-ion fluxes from IMP-8: 1973-1996”, IEEE Trans. on Nucl. Sci., 44(6), Dec. 1997, pp. 2140 – 2149.

(9) A. J. Tylka, J. H. Adams, P. R. Boberg, et al.,“CREME96: A Revision of the Cosmic Ray Effects on Micro-Electronics Code”, Trans. on Nucl. Sci, 44(6), Dec. 1997, pp. 2150 – 2160.

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