Test Report for Elevated Temperature Laser Testing of the Texas Instrument TPS79133 Voltage Regulator

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I. Introduction

This purpose of this test is to examine the laser-induced single event effects (SEE) performance at elevated temperatures of the TPS79133 voltage regulator from Texas Instrument.

II. Device Description

The TPS79133-EP is a low-dropout low-power linear voltage regulator with fixed output. The device achieves very fast start-up times, while consuming very low quiescent current (typically 170 µA) and yielding extremely low dropout voltages (38 mV at 100 mA). The device features, including the wide range of operation temperatures, makes it a candidate for defense and aerospace applications. Table I displays the part and test information. Figure 1 shows a microphotograph of the device. Table II shows the device specifications.

Table I. Test and part information.

Generic Part Number	TPS79133
Full Part Number	TPS79133MDBVTEP V62/03644-05XE
Package Marking	PESI
Manufacturer	Texas Instrument
Lot Date Code (LDC)	0710
Quantity tested	4
Part Function	Voltage regulator
Part Technology	BiCMOS
Package Style	5-pin SOT-23
Test Equipment	Power supply, Oscilloscope, Multimeter, laptop computer

Table II. Device specifications.

Parameter	Test Conditions	MIN	TYP	MAX	UNIT
T_J		-40		125	^oC
Input voltage	(recommended)	2.7		5.5	V
Output current	(recommended)			100	mA
Output voltage	$T_J = 25^oC$		3.3		V
	0 µA < I_O < 100mA, 4.3 V < V_I < 5.5 V	3.234		3.366	

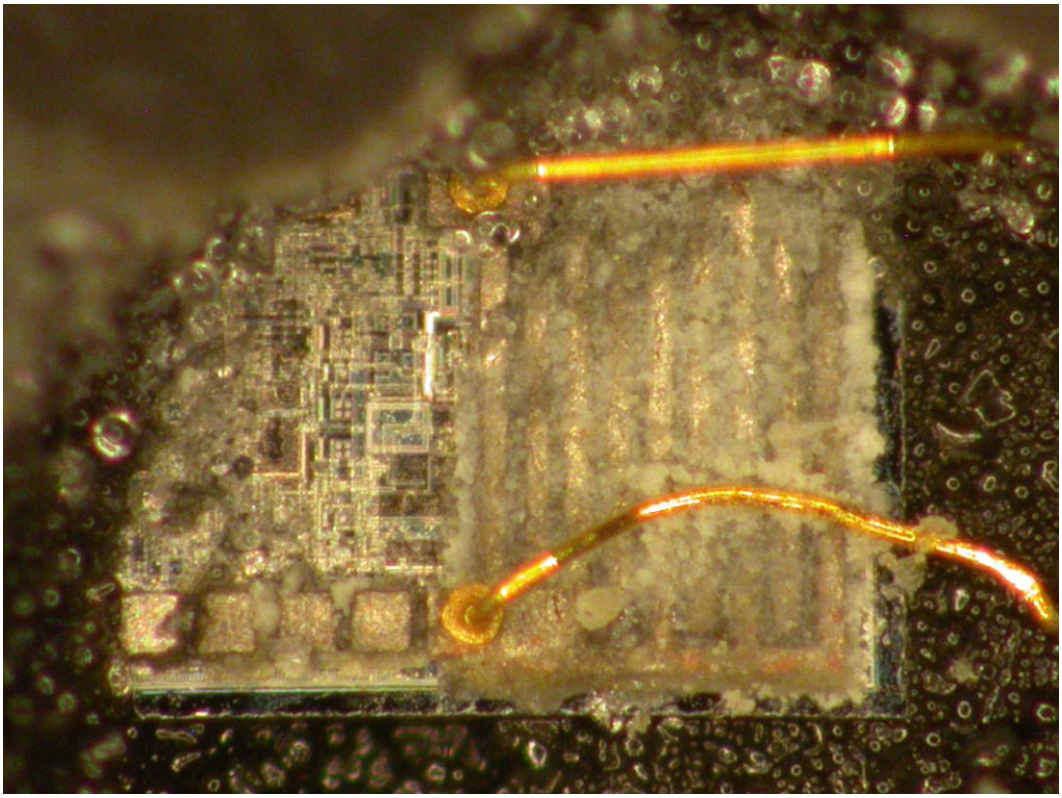

Figure 1. Microphotograph of a delidded TPS79133 voltage regulator.

III. Test Facility

The testing was conducted at the Naval Research Laboratory with a YLF laser. The laser beam characteristics are listed in Table 3 below.

Table 2. Laser characteristics.

Wave Length	590 nm
1/e penetration depth	2 µm
Beam diameter	1.7 µm

IV. Test Conditions

Test Temperature: Room temperature (~27°C) to 120°C
Operating Frequency: DC
Power Supply: V_{IN} = 5 V
Angle of Incidence: Normal
Parameters: Amplitude and width of SETs. The oscilloscope trigger level was adjusted appropriately according to the transient levels observed during the experiment.
Data Format: Data saved from oscilloscope onto floppy disk in ".dat" format.

V. Test Methods

The device was be biased with V_{IN} = 5 V and I_O = 50 mA during the laser irradiation. The bias circuit configuration is shown in Figure 2. An oscilloscope was connected to the output to capture the SEE waveforms. A thermal pad and thermistor were attached to the device for controlling the temperature. The thermal pad supplies the heat to the device. And the thermistor monitors the temperature by measuring the resistance through the current meter. The heating setup is controlled by a Labview program. Figure 3 shows the block diagram of the test setup.

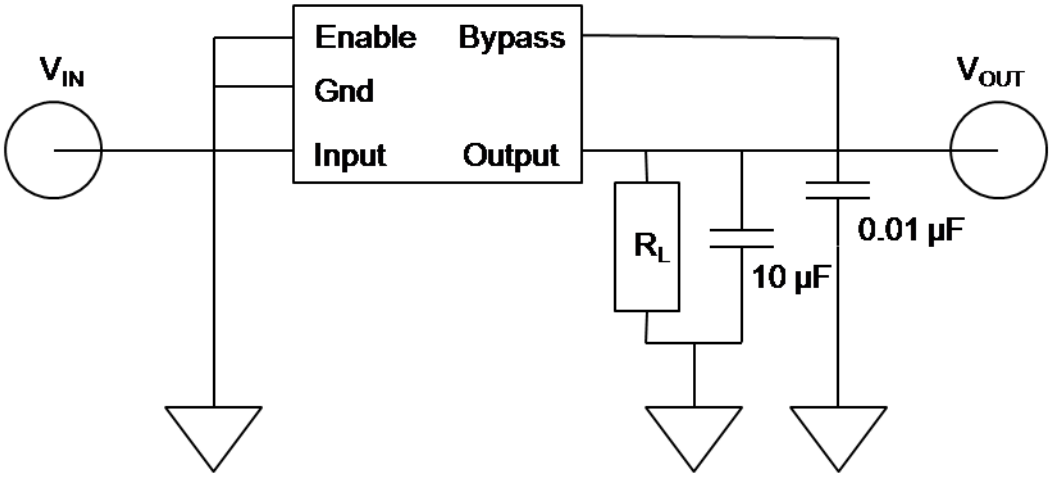

Figure 2. Bias configuration schematic diagram.

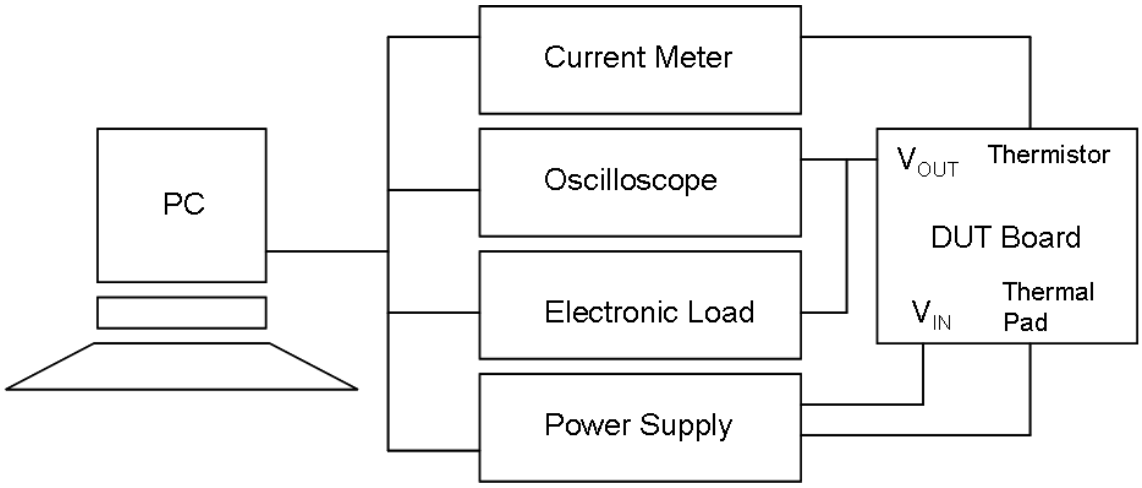

Figure 3. Block diagram of the testing setup.

VI. Results

The captured transients are shown in Figures 4−7. Figure 4 shows an SET that was consistently observed in all the DUTs. The transient has bipolar characteristics, with amplitudes of approximately 0.1 to 0.2 V in magnitude for the positive and negative peaks. The duration of the transient was approximately 40 µs. However the Full-Width-Half-Maximum (FWHM) pulse width of each of the two large peaks was approximately 10 µs. The transient amplitude and width were slightly enhanced at 373 K (100°C) relative to at 300 K (27°C).

There were also several transients that were not consistently observed for all parts. One possible explanation is the variability of the delidding process which produced inconsistencies in exposed areas for the different parts. These SETs are shown in Figures 5 – 7. In Figure 5 the SET appeared as a series of oscillations with peak amplitude ~ 1 V and duration ~ 1 µs. Another transient that was uniquely observed in one part is shown in Figure 6. The positive-going SET has amplitude ~ 0.2 V and FWHM width ~ 6 µs. Finally Figure 7 shows an SET with bipolar characteristics. The amplitude of the positive transient was ~ 0.015 V and the FWHM pulse width was ~ 0.3 µs, while the negative-going transient has an amplitude of ~ 0.025 and FWHM pulse width ~ 0.15 µs.

In several instances, the DUT showed increases to the input current as the sensitive area was continuously pulsed with laser, until eventually the device turns off. The TPS79133 is designed with internal current limiting and thermal protection circuitry. Therefore it is possible the device was shut off due to a high current state and/or overheating.

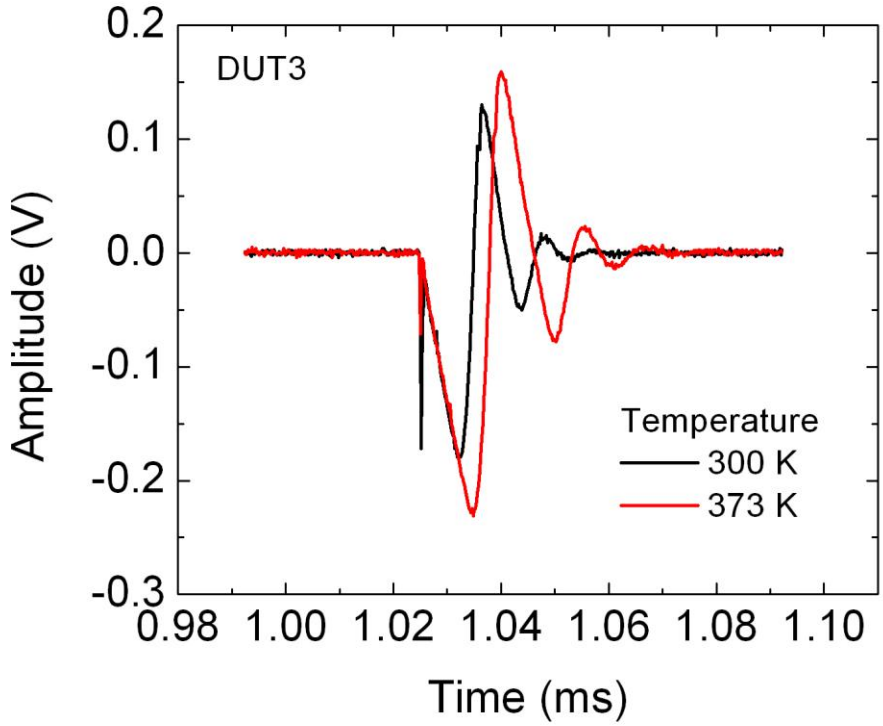

Figure 4. SETs at 300 K (27°C) and 373 K (100°C) observed in all devices.

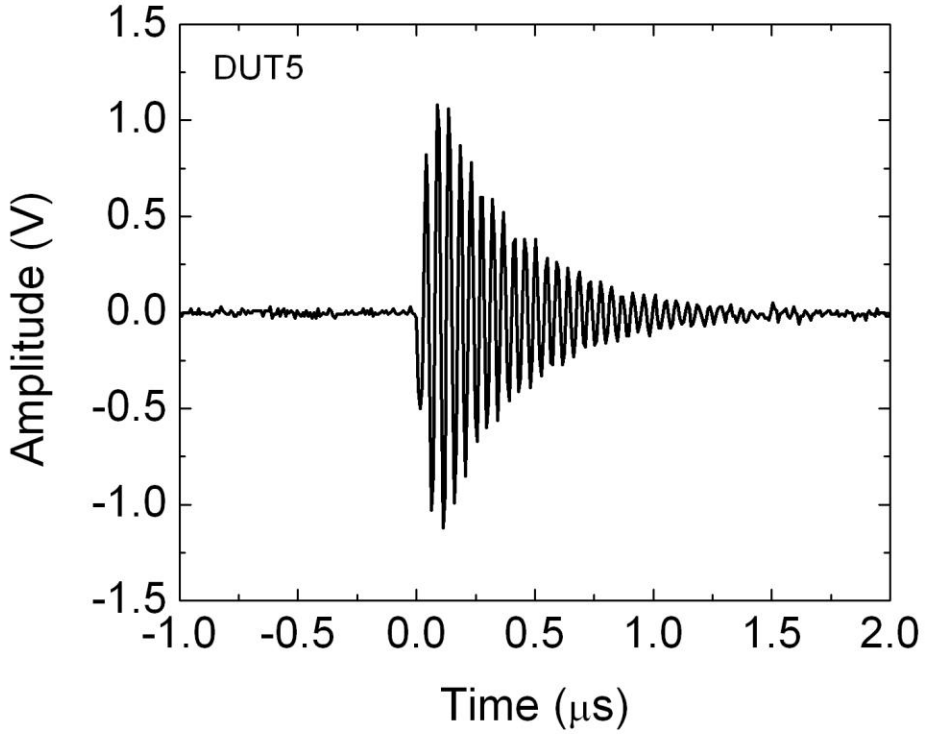

Figure 5. SETs at 300 K (27°C) observed in DUT5.

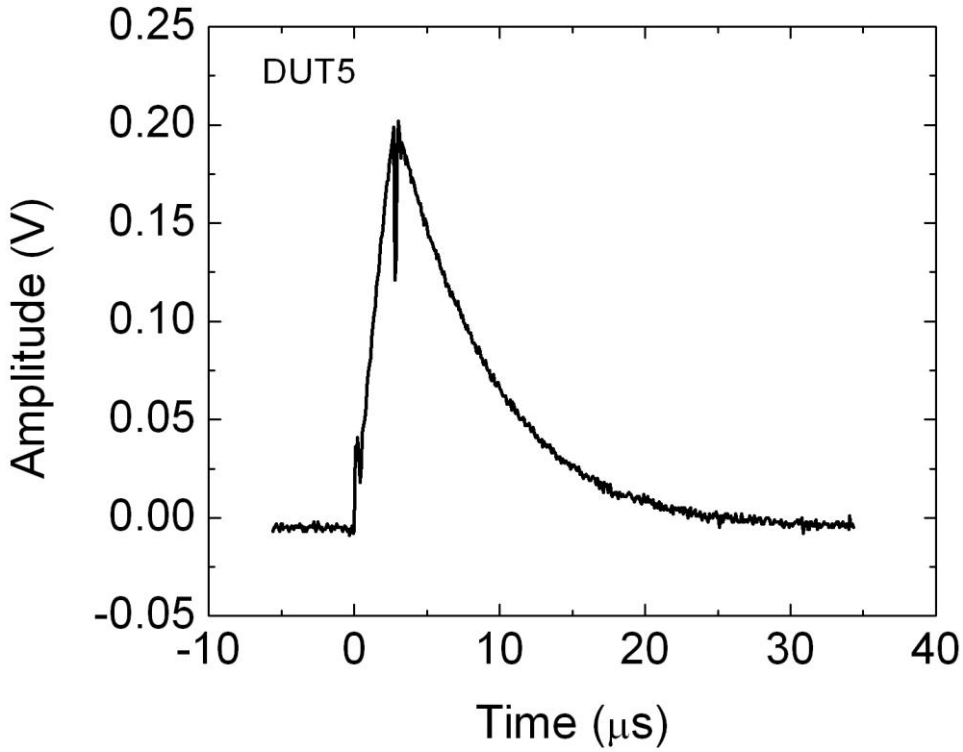

Figure 6. SETs at 300 K (27°C) observed in DUT5.

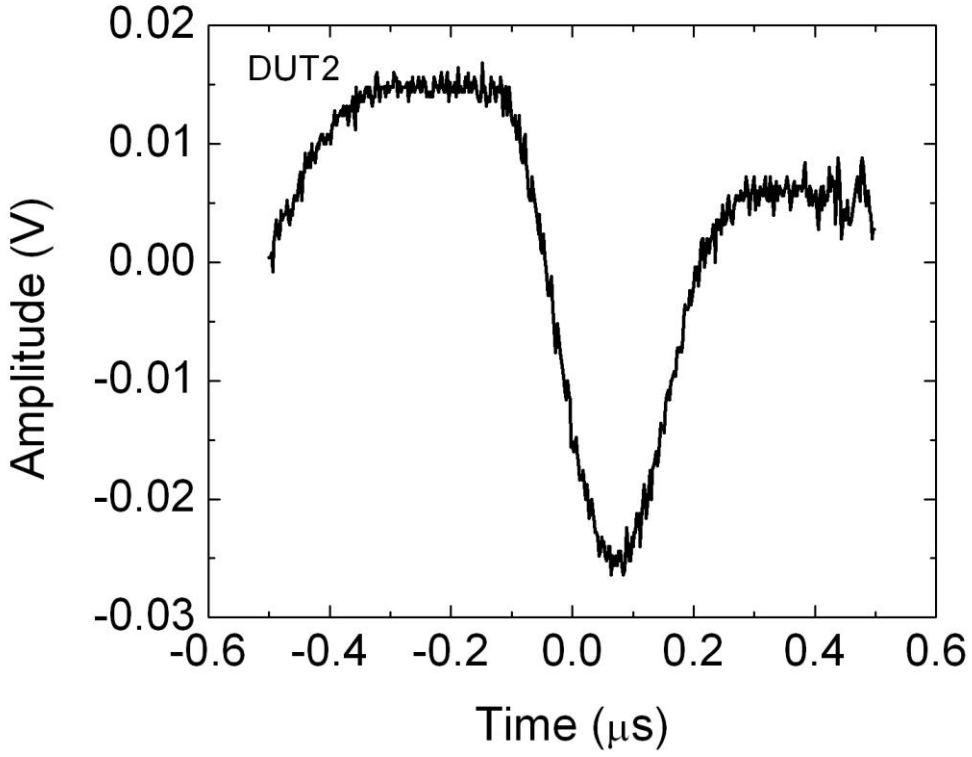

Figure 7. SETs at 300 K (27^{o}C) observed in DUT2.

VII. Conclusion

We have shown that the TPS79133 voltage regulator is susceptible to laser-induced SETs. The transients observed are relatively small in magnitude in general. The most common SET found in all devices, as shown in Figure 4, has amplitudes of -0.2 V and 0.15 V for the negative and positive peaks, respectively. The SET's duration is relatively long at 40 μs. The SET pulse amplitude and width increased slightly at elevated temperatures.

The instances where the device shuts off are possibly due to a high current state that was caused by the laser. But the internal current limiting circuitry may have prevented single event latchup by shutting off the device. We observed these events at room temperature and at elevated temperature. Elevated temperature may not have a significant impact in inducing the high current states.

While the magnitudes of the SETs may be acceptable in certain space applications, more experiments are necessary to examine the susceptibility of the TPS79133 to the high current events.