Laser SEE Test Report for the LTC6400-20 Differential Output Amplifier/ADC Driver

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I. Introduction

The purpose of this study is to examine laser-induced single-event-effects (SEEs) of the LTC6400-20 differential amplifier manufactured by Linear Technology. We compare a part with total-ionizing-dose with a fresh part.

II. Device Description

The LTC6400-20 is a high-speed differential amplifier designed to drive 12-, 14-, and 16-bit ADCs. The device features a fixed gain of 10 V/V (20dB), and a -3dB bandwidth up to 1.8 GHz. The test/part information is listed in Table 1. The device specifications are listed in Table 2.

Table 1. Test and part information

Generic Part Number	LTC6400-20
Full Part Number	746 LCCS N112 705 LCCS N016
Manufacturer	Linear Technology
Lot Date Code (LDC)	746 and 705
Quantity tested	2
Part Function	Differential amplifier
Part Technology	Silicon-Germanium
Package Style	16-lead QFN
Test Equipment	Power supply, RF generator, high-speed oscilloscope
Test Engineer	Anthony Phan

Table 2. Device specifications

Parameter	Test Conditions	Min	Typ	Max	Unit
Gain*	V_{IN} = ±100 mV Differential	19.4	20	20.6	dB
Supply Voltage (V_S)		2.85	3	3.5	V
Supply Current (I_S)	$\overline{\text{ENABLE}}$ = 0.8V	75	90	105	mA
Shutdown Supply Current (I_{SHDN})	$\overline{\text{ENABLE}}$ = 2.4V		1	3	mA

* The actual gain measured at the output of the demo board will be ~14 dB.

III. Test Facility

The testing will be conducted at the Naval Research Laboratory with a YLF laser. The laser beam characteristics are listed in Table 2 below.

Table 2. Laser characteristics.

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

IV. Test Method

Figure 1 shows the test circuit designed for single-ended input operation. The application circuit uses input and output transformers for single-ended-to-differential conversion and impedance transformation. The -3dB bandwidth is reduced from 1.8 GHz to 1.3 GHz as a result of the transformers. A block diagram schematic of the test setup is shown in Figure 2. A LabVIEW program will capture and store the SETs.

Demo Circuit 987B Schematic (Test Circuit A)

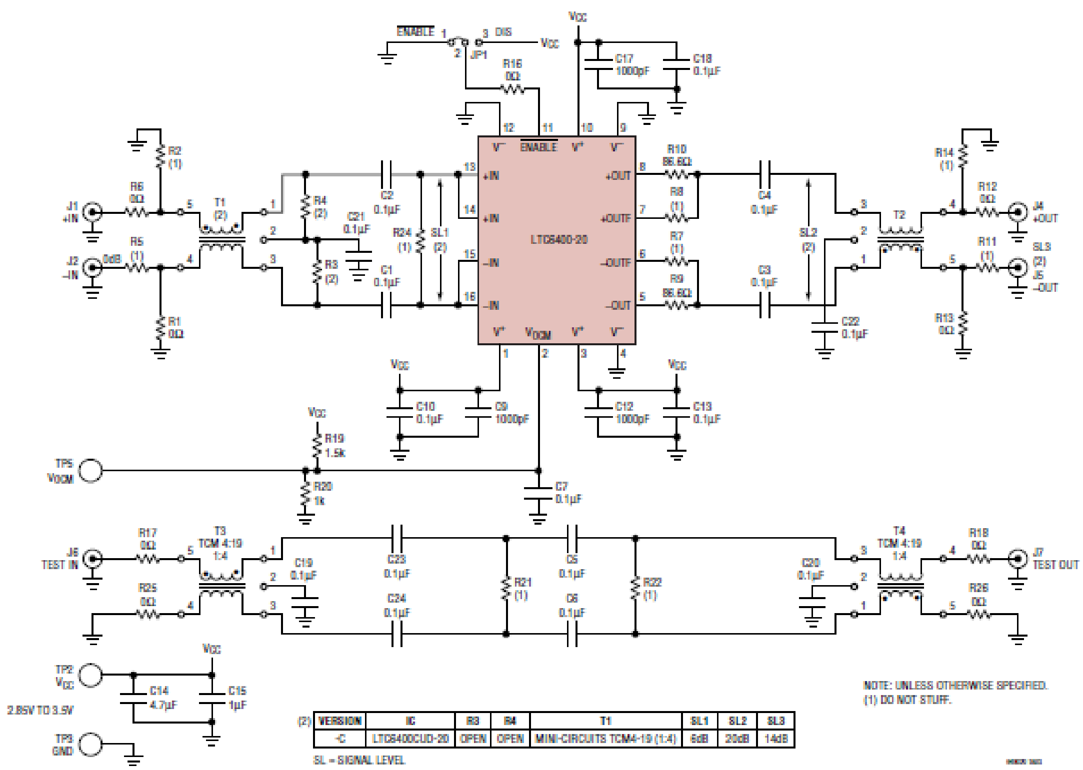

Figure 1. Application circuit configuration.

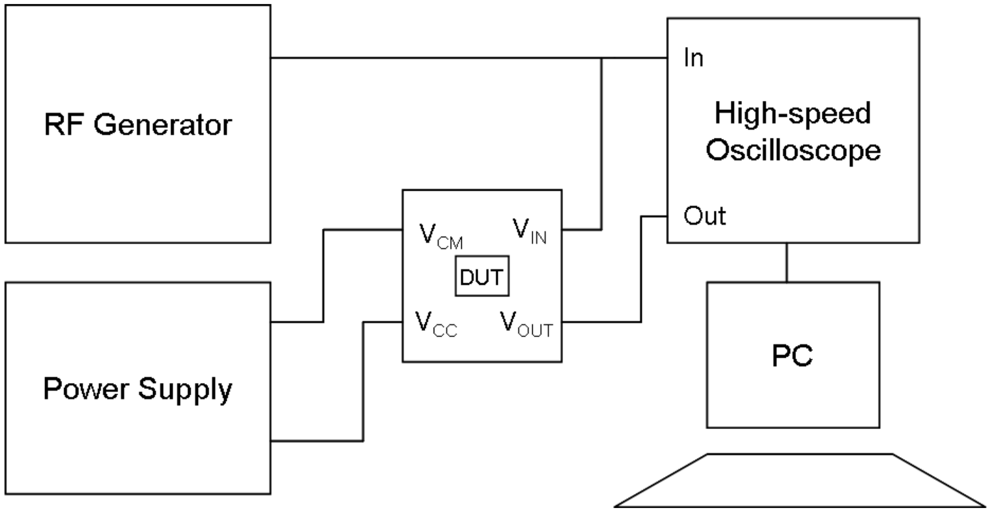

Figure 2. Test setup block diagram.

A fresh part and a part previously irradiated with ^{60}Co will be examined for the SET sensitivity and characteristics.

Test Conditions

Test temperature:	Ambient temperature (25^{o}C)
Operating frequency:	500 MHz
Input supply voltage:	3 V
Common mode voltage:	1.25 V
Input Voltage:	V_{IN+} = 100 mV_{pp} sine wave
Parameter:	(1) The trigger will be set to record deviations in the pulse width of the sine wave signal (2) The input, common mode, and supply currents will be monitored
Data format:	LabVIEW .dat reduced to .txt

V. Results

We identified several areas sensitive to laser probing. Figure 3 shows these sensitive regions. We do not have knowledge of the detailed circuit layout at this time. So we cannot identify the nature of the sensitive regions (i.e. transistor components). Also there may be additional sensitive regions not yet identified by this experiment.

The device operated at a frequency of 500 MHz throughout the experiment. When a sensitive region is identified, we altered the laser energy and observed/captured the transients. The laser energy varied from approximately 25 to 125 pJ.

We irradiated 1 device with a ^{60}Co source prior to laser probing. The time between TID irradiation to the laser experiment was approximately 1.5 hrs. We compare a virgin device with a device that has been irradiated to a total dose of 250 krad(Si). In figures 4 – 11 we show the SETs at a given location for the fresh part and the TID irradiated part.

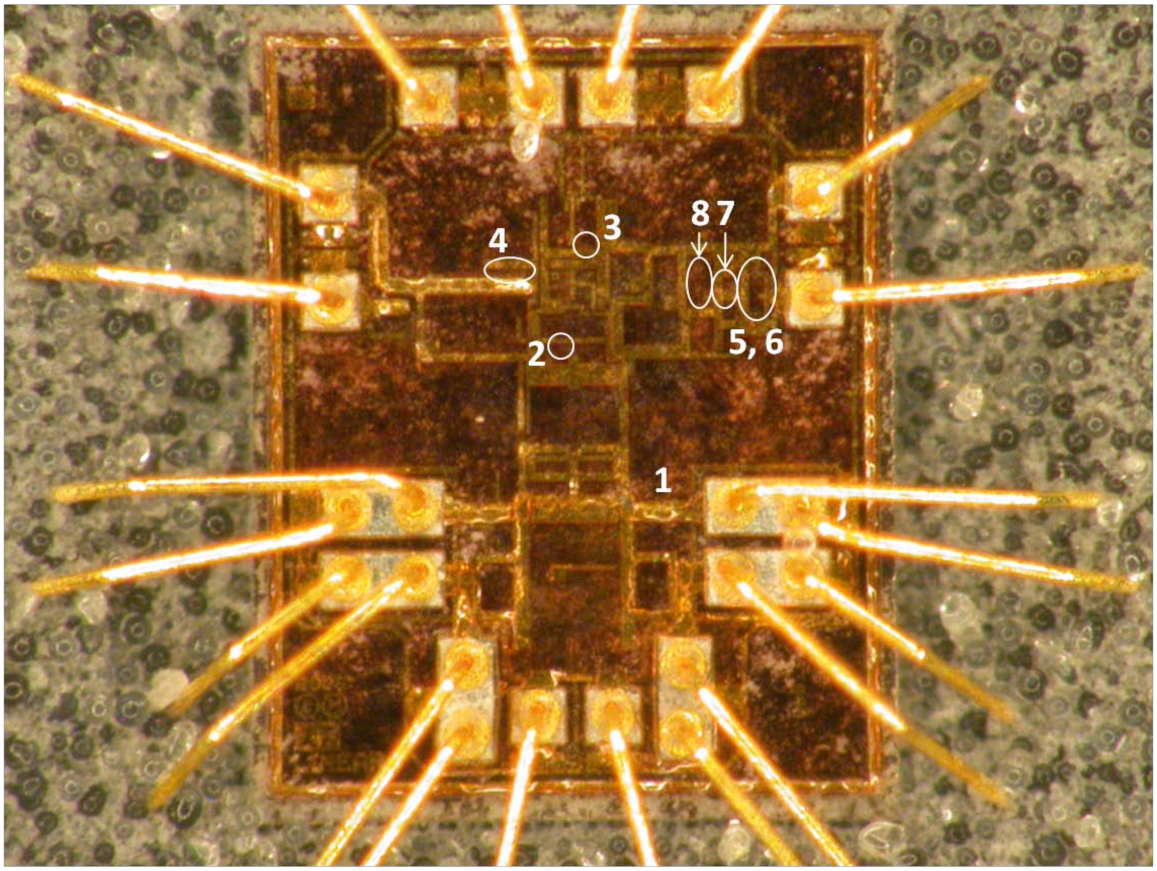

Figure 3. Microphotograph of a delidded LTC6400-20 differential output amplifier/ADC driver showing areas sensitive to laser-induced SETs.

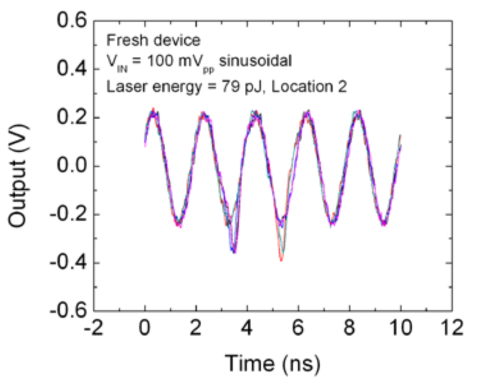

Figure 4. SETs at location 2 of an unirradiated device, operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

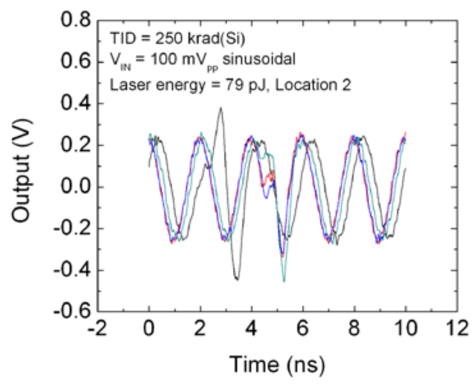

Figure 5. SETs at location 2 of a device irradiated to 250 krad(Si),, operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

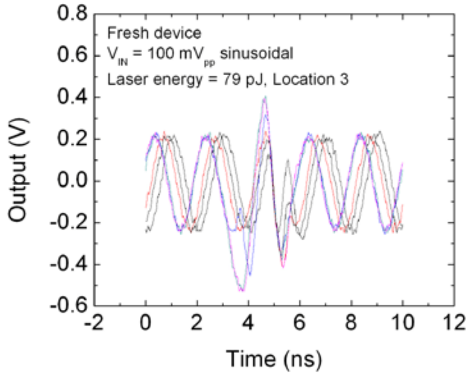

Figure 6. SETs at location 3 of an unirradiated device, operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

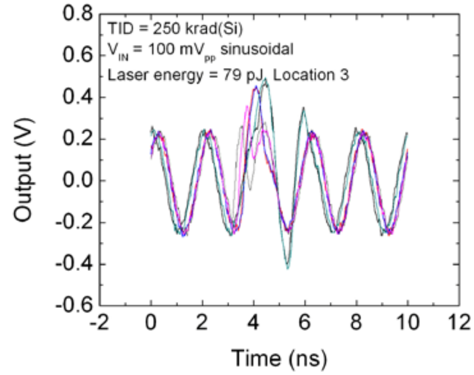

Figure 7. SETs at location 3 of a device irradiated to 250 krad(Si), operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

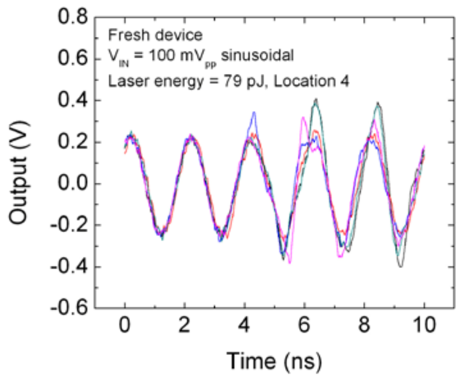

Figure 8. SETs at location 4 of an unirradiated device, operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

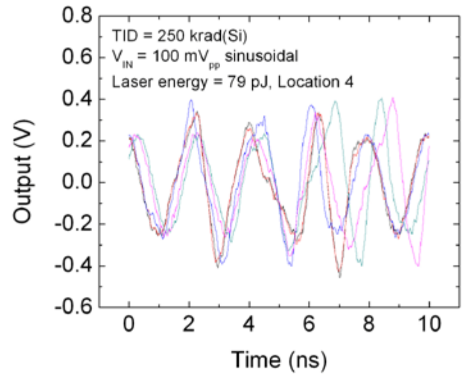

Figure 9. SETs at location 4 of a device irradiated to 250 krad(Si), operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

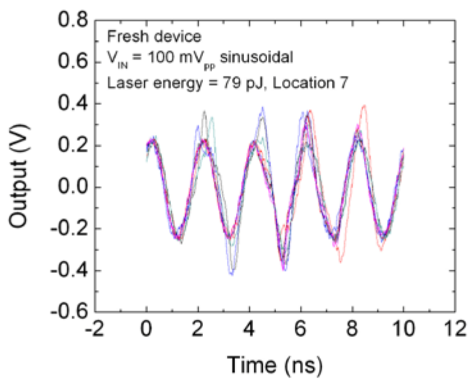

Figure 10. SETs at location 7 of an unirradiated device, operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

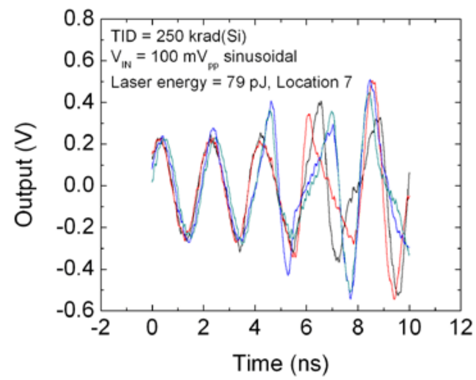

Figure 11. SETs at location 7 of a device irradiated to 250 krad(Si), operating at 500 MHz, V_{IN} = 100 mV_{PP} sine wave, and a laser energy of 79 pJ.

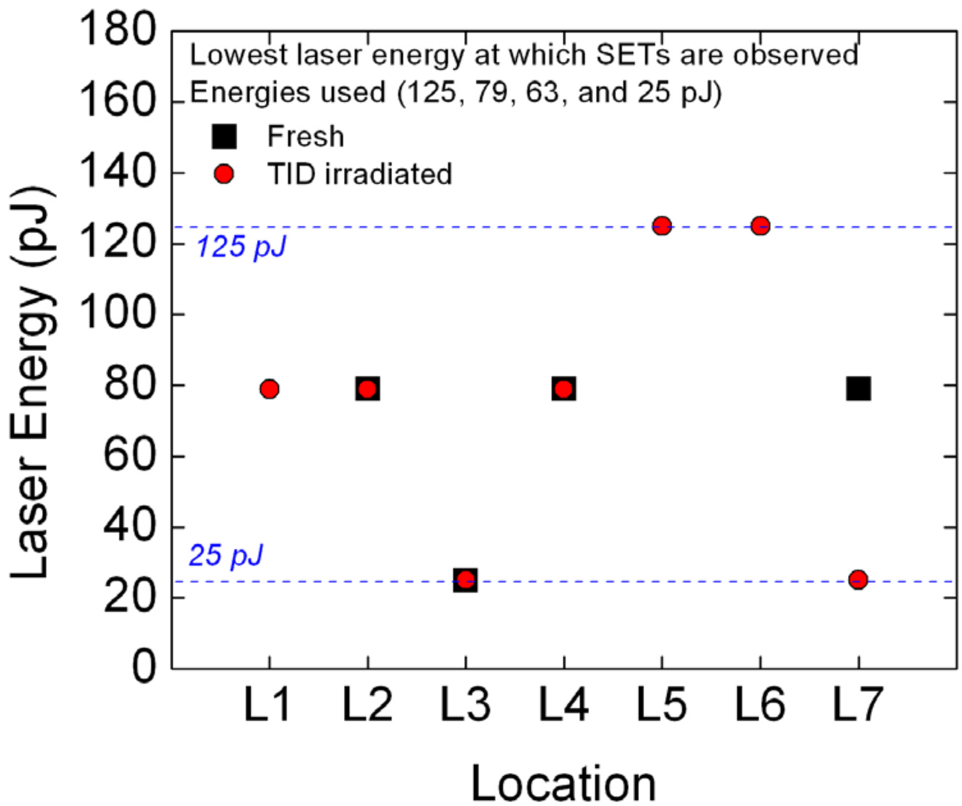

Figure 12. The lowest laser energy used at which SETs were observed at different locations, for a fresh device and a device irradiated to 250 krad(Si).

In most cases an SET distorts the sinusoidal wave for up to several periods, depending on the laser energy. The SET's magnitude varied slightly for different locations, for a given energy.

The differences in SET sensitivities for different locations are more pronounced. Figure 12 shows the lowest laser energy for which SETs were observed at each location. Locations 3 and 7 are the most sensitive, while 5 and 6 are the least sensitive.

In figure 12 we also see distinct differences in the SET sensitivities between the TID irradiated device and the fresh device. For example in location 7, as described on the microphotograph in Figure 3, we observed SETs down to 25 pJ on the TID irradiated device, while we observed SETs only at 79 pJ or higher for the fresh device. Furthermore we did not observe any SETs in locations 5 and 6 on the fresh device, while on the TID irradiated device, we observed SETs only at relatively high laser energy of 125 pJ.

The differences in sensitivities are not as pronounced in the other locations. However figures 4 – 11 show that the SETs from the TID irradiated device are generally slightly more disruptive than those from the fresh device for a given energy. It is difficult to select and compare a single wave from the two parts. So a collection of SETs are more representative of each part's response.

We may be able to determine more precise SET energy thresholds, given finer energy steps. Nevertheless, the results here show evidence of lower sensitivity to laser-induced SETs for a TID irradiated device relative to a fresh one.

VI. Conclusion

We identified several areas on the LTC6400 that are sensitive to laser-induced SETs. The sensitivities varied depending on the location. The TID irradiated device showed higher sensitivities relative to the fresh device. In two areas (L5 and L6) no SETs were observed from the fresh device, while SETs were observed on the TID irradiated device only at relatively high energies. The results from this experiment and previous proton irradiation results suggest that total ionizing dose may enhance the part’s sensitivity to SETs. Additional tests (heavy-ion and/or proton) may be needed to verify this assertion.