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SEE Test Report for Texas Instruments LMV7219 7 ns, 2.7 V to 5 V Comparator with Rail-to-Rail Output

Raymond Ladbury

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1. Reference Documents

- LMV7219 Datasheet, http://www.TI.com/lit/ds/symlink/LMV7219.pdf ,9/15/2014
- Johnston, A.H.; , "The influence of VLSI technology evolution on radiation-induced latchup in space systems," *IEEE Trans. Nucl. Sci.*, vol.43, no.2, pp. 505-521, Apr 1996.
- "IEEE Recommended Practice for Latchup Test Methods for CMOS and BiCMOS Integrated-Circuit Process Characterization," *IEEE Std 1181-1991*. (Deprecated)
- JEDEC JESD57

2. Purpose

The primary purpose of this testing is to characterize the Texas Instruments LMV7219 comparator for single-event latchup (SEL) susceptibility. These data will be used to assess the Single-Event Latchup (SEL) risk for the OSIRIS-REx Laser Altimeter (OLA). A secondary goal is to assess the susceptibility of the comparator to single-event transients (SET) and other nondestructive Single-Event Effects (SEE).

3. Test Samples

Six (6) parts were provided to Code 561 for de-encapsulation and SEL testing. Two devices survived the de-encapsulation process and were exposed to heavy ion irradiation. More information about the devices can be found in Table I.

The parts were prepared for testing by removing the plastic encapsulation from the target die. However, once this was done, we realized that the die were mounted face down in the package—as was the case for the ADP3330 from Analog Devices. The same approach was used—namely carefully drilling holes through the motherboard and daughter card on which the parts were mounted and then etching the plastic over the die on the bottom side. Two parts survived this process and were tested. Unfortunately, the small holes through which the beam had to pass in the mother board and daughter card precluded irradiating the parts at angles other than normal. The parts were fabricated in bulk BiCMOS technology. Since we do not know the number of overlayers used in these processes, linear energy transfer calculations were recorded based on the top-surface incident ion species and kinetic energy, and we ensured that the particles had a range in Si of more than 100 microns from the top of the die.

Table I: Part Identification Information

Qty	Part Number	LDC	Source	Package
2 functional after processing	LMV7219M5	N/A	Texas Instruments	SOT-23 (5 pin)

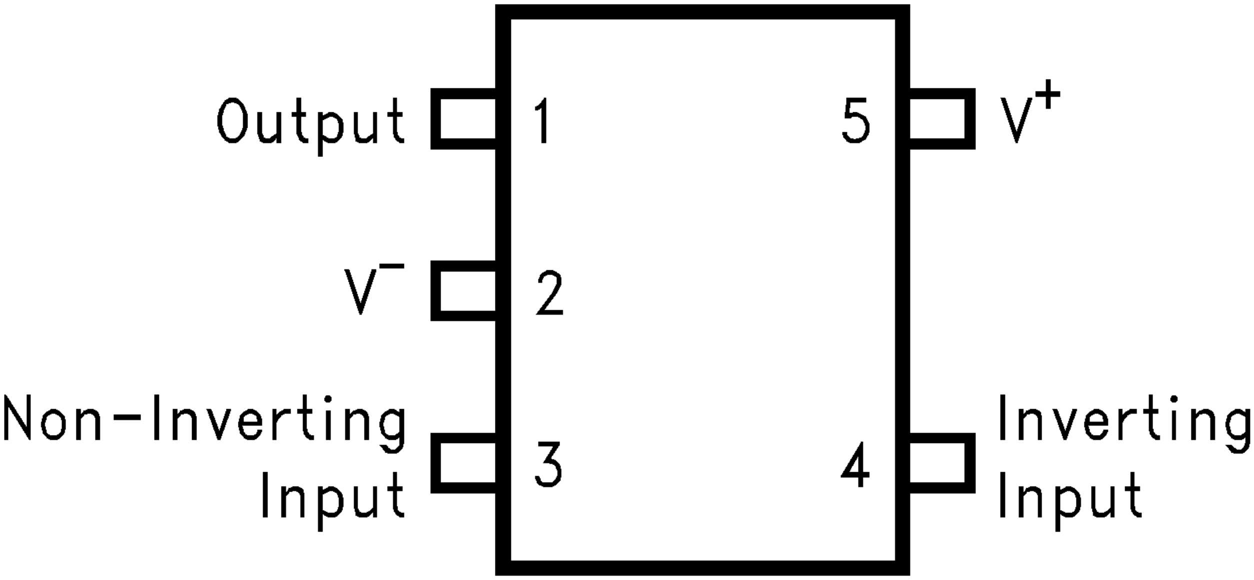

Figure 1: Pin diagram for LMV7219 comparator

4. Test Facility

Facility: Texas A&M University Radiation Effects Facility. Tune: 15 MeV/amu
Flux: 5×10^3 to 5×10^5 ions cm^{-2} s^{-1}
Fluence: All tests will be run to a fluence of 5×10^6 cm^{-2} or until a latchup event is observed

Table II: Possible Ions. Ranges and Linear Energy Transfer (LET) Used for Device Irradiation

Ion	Energy (MeV)	Range in Silicon	Silicon LET (MeV cm^2/mg)
^{197}Au	2954	155	80.2
^{129}Xe	1934	156	47.3
^{109}Ag	1634	156	38.5
^{84}Kr	1259	170	25.4
^{40}Ar	599	229	7.7
^{20}Ne	300	316	2.5

Note that energy, range, and LET are those characteristic of ions before traversing the aramica window and 50 mm of air prior to the silicon target.

5. Test Conditions and Error Modes

Table III: Test Information for LMV7219

Test Temperature	Ambient and 75-80° C
Inputs	Steady State, Square Wave
Power Supply Voltage	5 Vdc
Parameters of Interest	LET$_{th}$, temperature, supply voltage
SEE Conditions	Prolonged and self-sustained high-current state, SETs

Current limit was set to 110% of absolute maximum rating. In the event of observing SEL, a destructive test limiting current to 1 A could be run.

6. Test Methods

The test circuits for these devices were built to approximate the intended application. The test setup requires only power supplies and data logging equipment. The power supplies were in the irradiation cave, while the data logging equipment was in the control room. Each test had a single device under test, with new samples switched by hand.

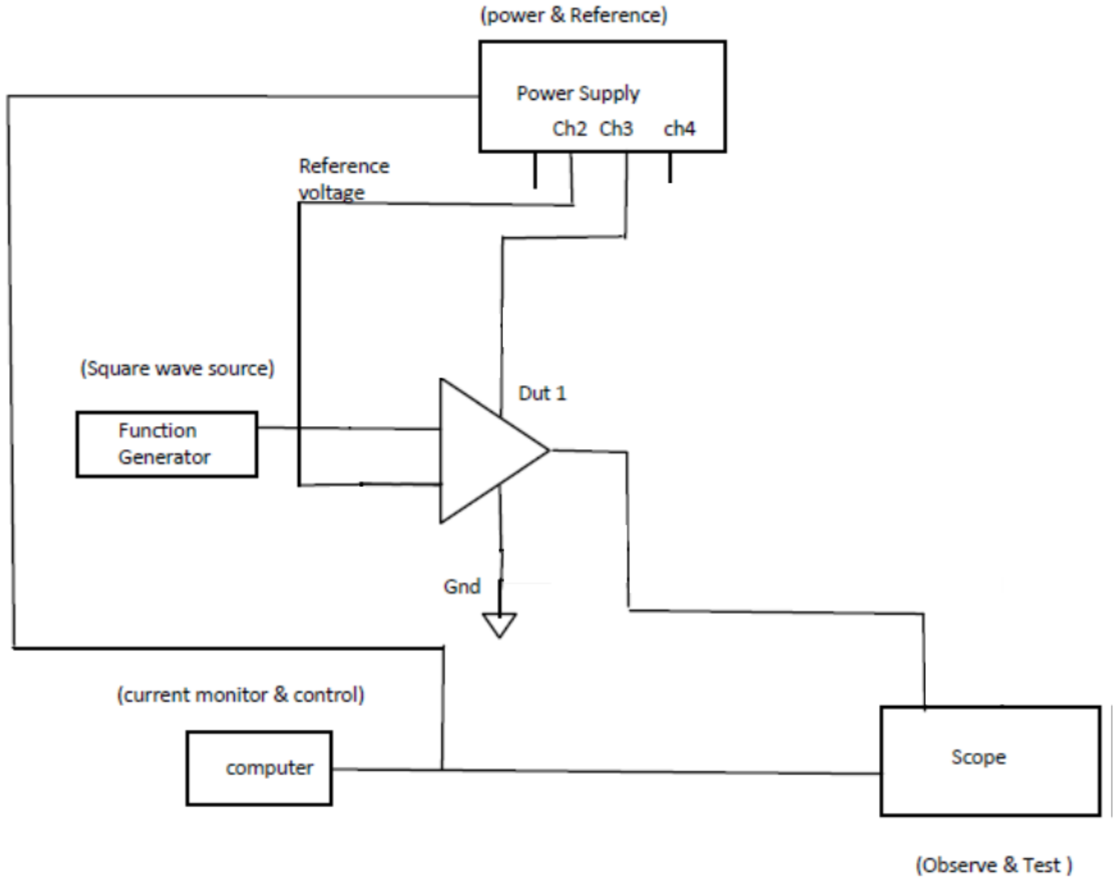

Figure 2: Block diagram of LMV7219 test set up

7. Test Performance

Test personnel included the principal investigator, the test engineer and an observer from the Canadian Space Agency (CSA). Eight hours were allotted for the test. A test was stopped if an SEL occurred or if the effective fluence reached 5×10^6 ions/cm^2. The following table is a rough outline of the tests planned during the test slot. Initial testing looked for transients on a square wave input, but none were seen. We then switched to a static input, which yielded transients for all LET values tested.

Table IV: Test Condition Plan

Condition	Temp (°C)	Tilt (°)	Roll (°)	Ion	Notes
1	80	0	0	Kr, Xe, Au,	Worst-case
4	25	0	0	Ne, Ar, Kr, Xe, Au	SET susceptibility

8. Results and Test Report

No destructive SEEs were seen up to the highest test LET (53.1 MeVcm^2/mg with Xe at normal incidence, since the mounting of the die precluded testing at other angles to the normal) and at the highest temperature tested (80 °C). We also tested with Au ions, but the results seem unphysical (substantially lower SET cross section than for the nominally lower LET Xe ions), so these are deemed untrustworthy. SETs were seen for all test ions/LETs, and the susceptibility depended strongly on the voltage difference, ΔV, between the inputs of the comparator. Also, the comparator was more susceptible for negative ΔV than for positive ΔV. Figure 3 shows the transient cross section vs. LET for ΔV= -0.1, -0.05, 0.05 and 0.1 V. We also made measurements at +/- 0.5 V, and these indicate that the strongest SET cross section dependence was at low-magnitude negative ΔV.

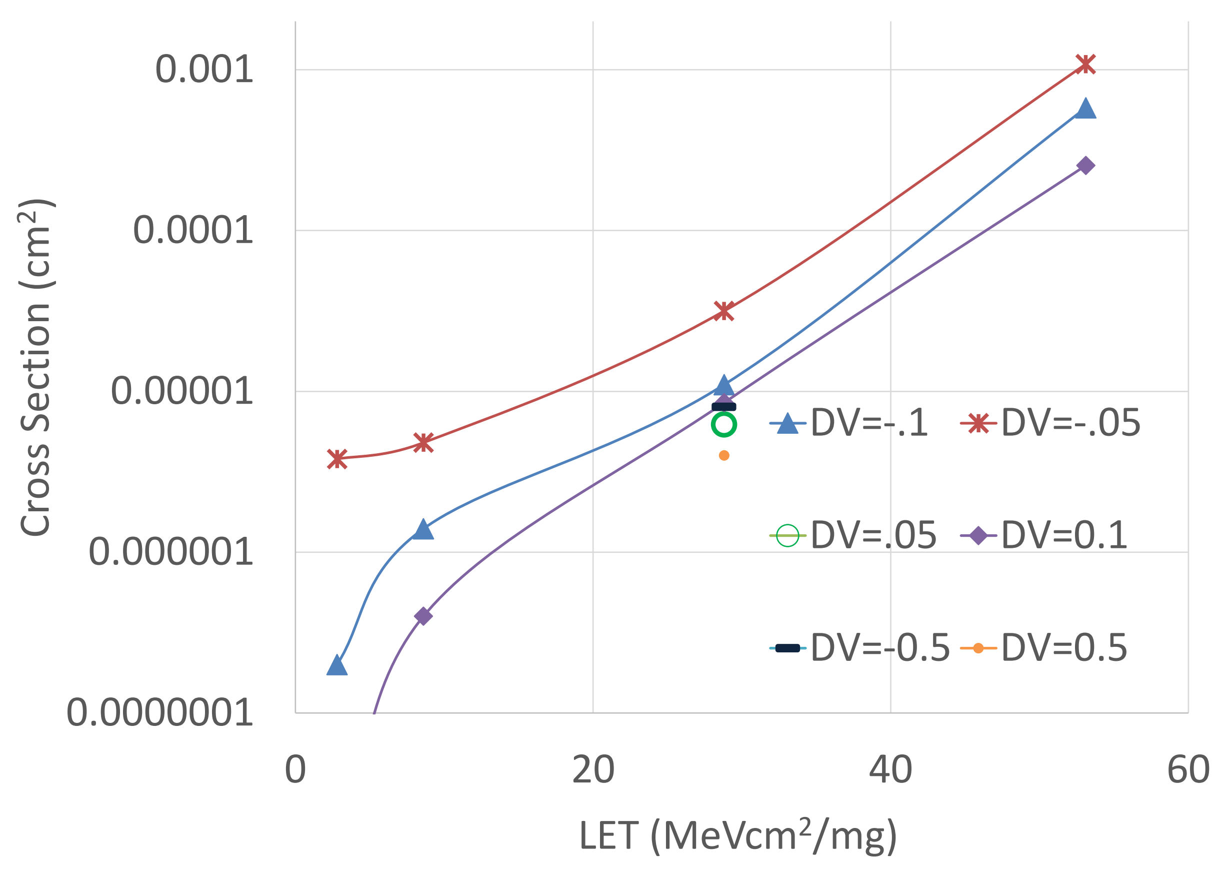

Figure 3: SET cross section vs. LET for several different input voltage differences represented as DV in the legend. DV is equivalent to ΔV in the report text.

From this figure, several trends are evident. First, it is clear that the SET susceptibility has not saturated by the highest test LET=53.1 MeVcm^2/mg. This complicates rate estimation. However, we can bound the saturation cross section by the area of the die, which was less than 1 mm^2. A second trend is that the ΔV dependence is stronger when ΔV is negative, and the differences appear to become insignificant once the magnitude of ΔV increases above 0.1 V. This also explains why no transients were seen with a 2-V square-wave input, as the transient susceptibility is very low when ΔV is larger than 0.1 V positive or negative.

Another feature of the test was that the two parts tested yielded slightly different results. Because of limited beam time, DUT 3 was tested only with Xe at normal incidence, where the cross section was about 10x lower than the SET cross sections for DUT 2. However, DUT3 showed longer transients, lasting up to several microseconds. This may have been because one or both devices did not have all the overburden removed over the entire face of the die. As such, and because there was not a third tie-breaker device functional for the test, it is prudent to assume both the worst-case cross section (DUT 2) and the worst-case transient duration (DUT 3). During quiescent solar periods, we would expect only a few transients per year per device. Some of these transients could last up to 5 microseconds and have rail-to-rail amplitudes. During a solar particle event, the rates could be up to 100x higher—perhaps a transient a day during a large solar particle event. These are worst-case numbers that would be appropriate for a small input voltage difference ($|\Delta V|<0.1$ V). If the project supplies the characteristics of the actual signal for the application, we can use this to better bound (and likely reduce) the SET rate if needed.

9. Implications of Results

The lack of SEL susceptibility and the relatively low SET susceptibility (due to the very small die size) suggest that the LMV7219 would be suitable in most applications.