Application Report

CDCLVP111-SP Total Ionizing Dose (TID) Radiation Report

High Reliability, High Performance Analog

ABSTRACT

This report discusses the results of the Total Ionizing Dose (TID) testing of the QML Class V Texas Instrument's CDCLVP111-SP (5962-1620701VXC). The CDCLVP111-SP passes up to 75-krad(Si) Low Dose Rate (LDR) and 100-krad(Si) High Dose Rate (HDR) TID.

Table of Contents

1 Trademarks

All trademarks are the property of their respective owners.

2 Device Information

2.1 Product Description

The CDCLVP111-SP clock driver distributes one differential clock pair of LVPECL input, (CLK0, CLK1) to ten pairs of differential LVPECL clock (Q0, Q9) outputs with minimum skew for clock distribution. The CDCLVP111-SP can accept two clock sources into an input multiplexer. The CDCLVP111-SP is specifically designed for driving 50-Ω transmission lines. When an output pin is not used, leaving it open is recommended to reduce power consumption. If only one of the output pins from a differential pair is used, the other output pin must be identically terminated to 50 Ω. The VBB reference voltage output is used if single-ended input operation is required. In this case, the VBB pin should be connected to CLK0 and bypassed to GND via a 10-nF capacitor. For high-speed performance, the differential mode is strongly recommended. The CDCLVP111-SP is characterized for operation from –55°C to 125°C. It has been tested to 75 krad(Si) under both LDR and HDR (after 540 hours of anneal).

2.2 Device Details

Table 2-1 lists the device information used in the initial TID characterization and qualification of HDR tests.

Table 2-1. Device and Exposure Details

TID HDR/LDR Details: 50 krad(Si)	
TI Device Number	CDCLVP111-SP (5962-1620701VXC)
Package	36-Pin Ceramic Flatpack (HKG)
Technology	RF-SIGE
Die Lot Number	5243712
A/T Lot Number / Date Code	5950799
Quantity Tested	51 units including 2 control units
HDR Radiation Facility	Texas Instruments SVA Group in Santa Clara, California
LDR Radiation Facility	RAD/Aeroflex in Colorado Springs, Colorado
HDR Dose Level	3 krad(Si), 10 krad(Si), 30 krad(Si), 50 krad(Si), 75 krad(Si)
HDR Dose Rate	65 rad(Si)/s
LDR Dose Level	20 krad(Si), 30 krad(Si), 50 krad(Si) and 75 krad(Si)
LDR Dose Rate	0.01 rad(Si)/s
HDR Radiation Source	Gammacell 220 Excel (GC-220E) Co-60
LDR Radiation Source	Gammacell JLSA 81-24 Co-60
Irradiation Temperature	Ambient, room temperature

Figure 2-1. CDCLVP111-SP Device Used in Exposure

3 Total Dose Test Setup

3.1 Test Overview

The CDCLVP111-SP was tested according to MIL-STD-883, Test Method 1019.9. For this testing, Condition A and Condition D was used. For Condition A and Condition D the product was irradiated up to 75 krad(Si) the rated radiation level and then put through parametric testing on the ATE. The device was functional and passed all electrical parametric tests with the readings within (guard bands) of the Standard Microcircuit Drawing (SMD) electrical specification limits and is ELDRS free.

The CDCLVP111-SP RF-SIGE process technology contains Bipolar and CMOS components. Both HDR and LDR tests were performed.

3.2 Test Description and Facilities

The CDCLVP111-SP LDR exposure was performed on biased and unbiased devices in a Co60 gamma cell under a 10 mrad(Si)/s exposure rate. The dose rate of the irradiator used in the exposure ranges from < 10 mrad(Si)/s to a maximum of approximately 65 rad(Si)/s, determined by the distance from the source. For the LDR (10 mrad(Si)/s) exposure, the test box was positioned approximately 2 m from the source. The exposure boards are housed in a lead-aluminum box (as specified in MIL-STD-883 TM 1019.9) to harden the gamma spectrum and minimize dose enhancement effects. The irradiator calibration is maintained by Logmire Laboratories using Thermoluminescence Dosimeters (TLDs) traceable to the National Institute of Standards and Technology (NIST) and the dosimetry was verified using TLDs prior to the radiation exposures. After exposure, the devices were packed in dry ice (per MIL-STD-883 Method 1019.9 section 3.10) and returned to TI Dallas for a full post radiation electrical evaluation using Texas Instruments production Automated Test Equipment (ATE). ATE guard band test limits are set within SMD electrical limits to ensure a minimum Cpk and test error margin based on initial qualification and characterization data. Post radiation measurements were taken within 30 minutes of removal of the devices form the dry ice container. The devices were allowed to reach room temperature prior to electrical post radiation measurements.

The CDCLVP111-SP HDR exposure was performed on biased and unbiased devices in a Co60 gamma cell at TI SVA facility in Santa Clara, California. The un-attenuated dose rate of this cell is 65 rad(Si)/s. After exposure, the devices were packed in dry ice (per MIL-STD-883 Method 1019.9 section 3.10) and returned to TI Dallas for a full post radiation electrical evaluation using Texas Instruments Automated Test Equipment (ATE). ATE guard band test limits are set within SMD electrical limits to ensure a minimum Cpk and test error margin based on initial qualification and characterization data. Post radiation measurements were taken within 30 minutes of removal of the devices form the dry ice container. The devices were allowed to reach room temperature prior to electrical post radiation measurements.

3.3 Test Setup Details

The devices under HDR and LDR exposure were tested in both biased and unbiased conditions as described below.

1. **Unbiased** - - *For the unbiased LDR conditions, the exposure was performed with all pins grounded.*
2. **Biased** - - *Figure 3-1 is used for HDR and LDR exposure with biased condition.*

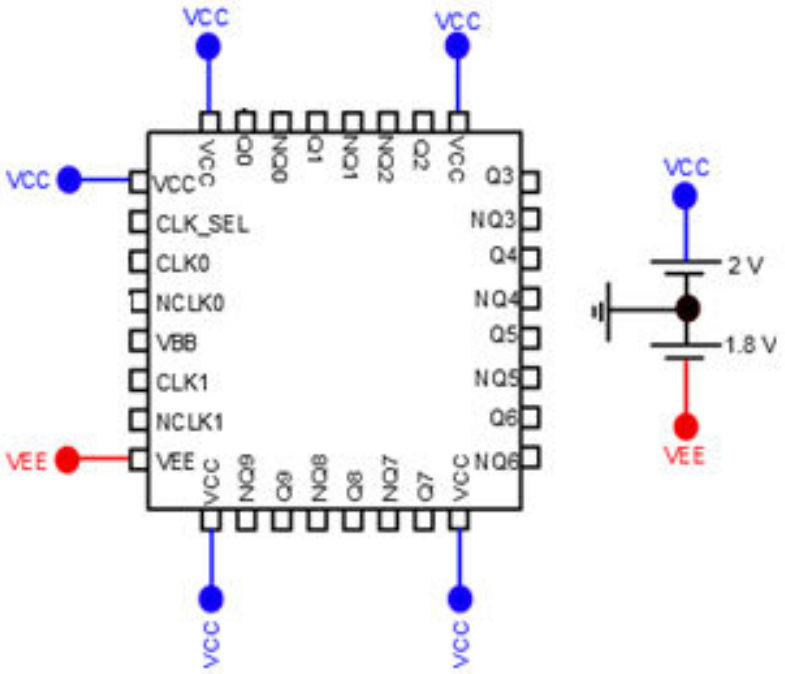

Figure 3-1. Bias Diagram Used in TID Exposure

3.4 Test Configuration and Condition

A step-stress (3k, 10k, 30k, 50k, 75k) test method was used to determine the TID hardness level. That is, after a predetermined TID level was reached, an electrical test was performed on a given sample of parts to verify that the units are within SMD electrical test limits. MIL-STD-883, Test Method 1019.9, Condition A, Condition D.

Table 3-1. HDR Biased Device and Exposure Information

HDR = 65 rad(Si)/s			
Total Samples: 5 Biased/TID level			
Exposure Level:			
3k	10k	30k	75k
36, 37, 38	39, 40, 41	42, 43, 44	45, 46, 47

Control Unit: 33

Table 3-2. LDR Biased Device and Exposure Information

LDR = 10 mrad(Si)/s			
Total Samples: 5 Biased/TID level			
Exposure Level:			
20k	30k	50k	75k
1, 2, 3	7, 8, 9	13, 14, 15	19, 20, 21

Table 3-3. LDR Unbiased Device and Exposure Information

LDR = 10 mrad(Si)/s			
Total Samples: 5 Unbiased/TID level			
Exposure Level:			
20k	30k	50k	75k
4, 5, 6	10, 11, 12	16, 17, 18	22, 23, 24

Control Unit: 42, 44

4 Total Ionizing Dose Characterization Test Results

4.1 Total Ionizing Dose Characterization Summary Results

The parametric data for the CDCLVP111-SP passes up to 75-krad(Si) LDR and HDR.

The drift of SMD electrical parameters including critical parameters through LDR is within experimental error to the drift at HDR. The device is tested to maximum total dose of 75 krad(Si) per MIL-STD-883, TM1090 Condition A, Condition D.

Samples were assembled from one wafer level variability regarding TID drift through post electrical test on ATE after LDR and HDR exposure.

- HDR (65 rad(Si)/s) biased: Post 3 krad(Si), 10 krad(Si), 30 krad(Si), 50 krad(Si), 75 krad(Si)
- LDR (0.01 rad(Si)/s) unbiased: Post 20 krad(Si), 30 krad(Si), 50 krad(Si), 75 krad(Si)
- LDR (0.01 rad(Si)/s) biased: Post 20 krad(Si), 30 krad(Si), 50 krad(Si), 75 krad(Si)

Overall radiation performance was very solid. There were no functional or parametric failures at any read point. All datasheet parameters passed at all exposure levels with margin and ELDRS free. There were 2 parameters that showed a consistent trend during exposure and these were the worst case shift seen of all parameters tested. These are listed below.

1. **Clk0Tpd_1000MHz:clk0Tpdlh_1000MHz@Q4**

   Propagation delay of the signal – exhibits a decrease from 0 krad(Si) to 20 krad(Si), but then an increase in time from 20 krad(Si) to 100 krad(Si). This amounts to a shift of ~20 ps which is < 20% of the guardbanded limit range. No failures.

2. **Clk1Tskp_1000MHz:clk1Tskp@Q0**

   Channel to channel skew – exhibits an increase of channel skew through increased exposure.

These timing measurements can be partially attributed to slight voltage shifts seen on the output pins. The test method uses a strobe set a particular voltage to determine the output timing. If the voltage levels shift, this strobe is kept constant, this will result in a shift of the timing reading.

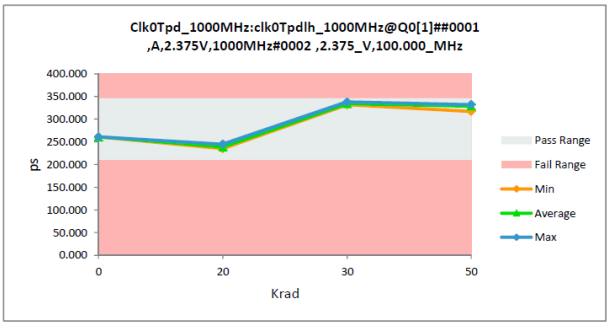

Figure 4-1. Radiation Exposure Effect on Propagation Delay

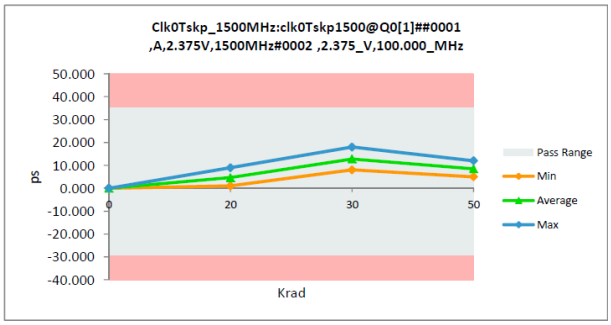

Figure 4-2. Radiation Exposure Effect on Output to Output Skew

5 Applicable and Reference Documents

5.1 Applicable Documents

CDCLVP111-SP 1:10 High Speed Clock Buffer with Selectable Input Clock Driver (SCAS946)

CDCLVP111-SP Evaluation Module

CDCLVP111-SP Evaluation Module User Guide (SCAU055)

5.2 Reference Documents

Texas Instruments total ionizing dose radiation (total dose) test procedure follows the standards put forth in MIL-STD-883 TM 1019. The document can be found at the DLA website.

6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (August 2017) to Revision A (January 2020)	Page
• Updated the numbering format for tables, figures, and cross-references throughout the document	1
• Changed 5962R1620701VXC to 5962-1620701VXC in the document	1
• Removed note from the Abstract	1

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265