Radiation Report

TL1431-SP Neutron Displacement Damage (NDD) Report

ABSTRACT

This report presents the effect of neutron displacement damage (NDD) on the TL1431-SP device. The results show that all devices were fully functional and within production test limits after having been irradiated up to 1×10^{12} n/cm^2. A sample size of nine units were exposed per MIL-STD-883, Method 1017 for Neutron Irradiation, and three additional devices were used as control units. Electrical testing was performed before and after neutron irradiation using the production test program for the TL1431-SP.

Table of Contents

List of Figures

List of Tables

Trademarks

1 Overview

The TL1431-SP is a precision programmable reference with specified thermal stability over automotive, commercial, and military temperature ranges. The output voltage can be set to any value between VI(ref) (approximately 2.5 V) and 36 V with two external resistors. This device has a typical output impedance of 0.2 Ω. Active output circuitry provides a very sharp turnon characteristic, making the device an excellent replacement for Zener diodes and other types of references in applications such as onboard regulation, adjustable power supplies, and switching power supplies.

Table 1-1. Overview Information

NDD Details	
TI Part Number	TL1431-SP
Device Name	5962R9962001VHA
Device Function	Programmable reference
Technology	JI SLM
Assembly Lot Number	2006815MTT
Unbiased Quantity Tested	9
Exposure Facility	VPT Rad
Neutron Fluence (1-MeV equivalent)	1.0×10^{12}, 5.0×10^{12}, 1.0×10^{13} n/cm^2
Irradiation Temperature	Room temperature
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2 Test Procedures

The TL1431-SP was electrically pre- and post-tested using the production automated test equipment program.

General test procedures adhered to MIL-STD-883, Method 1017 for Neutron Irradiation of TL1431-SP. Neutron irradiation conditions are listed in Table 2-1.

Table 2-1. Neutron Irradiation Conditions

Group	Sample Qty	Neutron Fluence (n/cm^2)	Bias
A	3	1.0×10^{12}	Unbiased
B	3	5.0×10^{12}	Unbiased
C	3	1.0×10^{13}	Unbiased

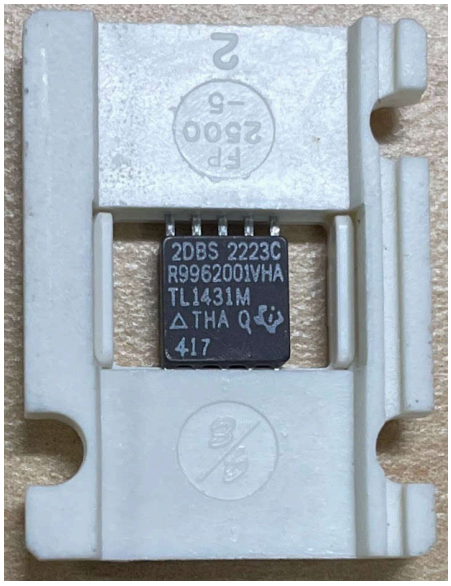


Figure 2-1. TL1431-SP Device (Front)

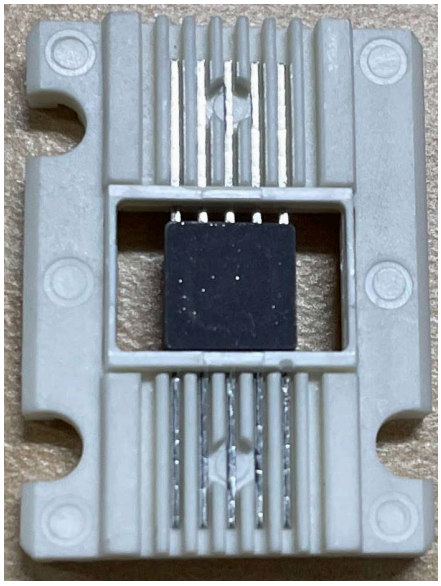


Figure 2-2. TL1431-SP Device (Back)

3 Facility

VPT Rad performs all neutron displacement damage irradiation in a Low-Enriched, open-pool, water moderated, thermal neutron reactor. It utilizes flat-plate type fuel, and having a maximum thermal energy output of up to 1 MW. The Fast Neutron Irradiator (FNI) faces one side of the reactor core. The design produces a geometrical planar beam of fast neutrons that is approximately uniform over an area of 12 in × 20 in. Lead and thermal neutron absorbing compounds are combined to filter out both fission gammas and thermal neutrons. The ratio of fast-to-thermal neutrons is approximately 400:1, with a gamma exposure of less than 150 rad (Si) for a 1E12 n/cm2 (1 MeV Si equivalent) exposure. The FNI can accommodate a sample or samples with size up to 30 cm in diameter and 15-cm thick including packaging materials. The minimum neutron fluence rate is 1E6 n/cm2-s. The maximum neutron fluence rate is approximately 1.0 E11 n/cm^2-s. (both values are 1 MeV Si equivalent).

The neutron fluence rate is determined using the previously-measured neutron radiation field for the FNI, performed in accordance with ASTM standards (ASTM F1190), and correlated to the measured reactor power level. The neutron dose is timed to meet the customer-specified fluence for the irradiation. Neutron dosimetry meets ASTM standards (ASTM E265). The facility retains source-suitability with the Defense Logistics Agency (DLA) Laboratory Suitability Program for ASTM Test Method 1017. The devices under test are typically irradiated in an unbiased condition as per TM1017.

4 Results

There were no functional failures up to 1 × 10^{12} n/cm^2. The devices exposed to 5 × 10^{12} n/cm^2 and 1 × 10^{13} n/cm^2 were no longer functional. Section 5 lists the parameters. Appendix A shows the related data.

5 Data Sheet Electrical Parameters and Associated Tests

at specified free-air temperature, IKA = 10 mA (unless otherwise noted)

Parameter		Test Conditions	T_A [2]	Min	Typ	Max	Unit	Test Numbers
$V_{I(ref)}$	Reference input voltage	VKA = VI(ref)	25°C	2475	2500	2540	mV	
			Full range	2460		2550		7.0
$V_{I(dev)}$	Deviation of reference input voltage over full temperature range[3]	VKA = VI(ref)	Full range		17	55[1]	mV	
$\Delta V_{I(ref)}/\Delta V_{KA}$	Ratio of change in reference input voltage to the change in cathode voltage	ΔVKA = 3 V to 36 V	Full range		-1.1	-2	mV/V	16.0
$I_{I(REF)}$	Reference input current	R1 = 10 kΩ, R2 = ∞	25°C		1.5	2.5	μA	
			Full range			5		15.2
$I_{I(dev)}$	Deviation of reference input current over full temperature range [3]	R1 = 10 kΩ, R2 = ∞	Full range		0.5	3[1]	μA	
I_{min}	Minimum cathode current for regulation	VKA = VI(ref)	25°C		0.45	1	mA	11.0
I_{off}	Off-state cathode current	VKA = 36 V, VI(ref) = 0	25°C		0.18	0.5	μA	
			Full range			2		2.0
$\|z_{KA}\|$	Output impedance[4]	VKA = VI(ref), f ≤ 1 kHz, IKA = 1 mA to 100 mA	Full range		0.2	0.4	Ω	14.1

1. On products compliant to MIL-PRF-38535, this parameter is not production tested.
2. Full range is –55°C to +125°C.
3. The deviation parameters VI(dev) and II(dev) are defined as the differences between the maximum and minimum values obtained over the rated temperature range. For more details, see the device data sheet.
4. Please see device data sheet for details on output impedance.

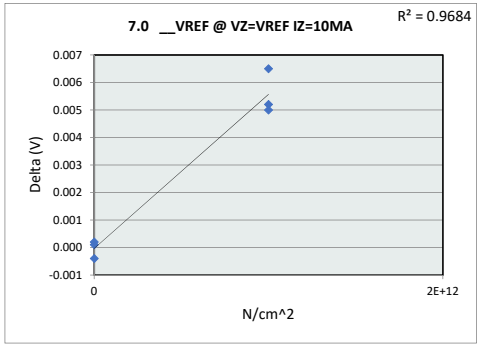
A Appendix: Test Results

This appendix contains the detailed NDD test results.

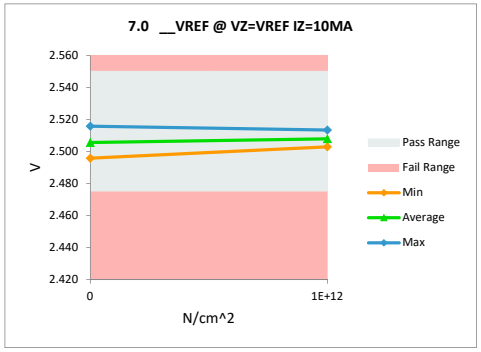
NDD Report
TL1431-SP

	7.0 __VREF @ VZ=VREF IZ=10MA	
Test Site	MTT	MTT
Tester	LTX	LTX
Test Number	XPM16108	XPM16108
Unit	V	V
Max Limit	2.55	2.55
Min Limit	2.475	2.475

N/cm^2	Serial #	Pre	Post	Delta
0	105	2.505	2.505	0.000
0	106	2.496	2.496	0.000
0	107	2.516	2.516	0.000
1E+12	415	2.502	2.507	0.005
1E+12	416	2.498	2.503	0.005
1E+12	417	2.507	2.513	0.007
	Max	2.516	2.516	0.007
	Average	2.504	2.507	0.003
	Min	2.496	2.496	0.000
	Std Dev	0.007	0.007	0.003



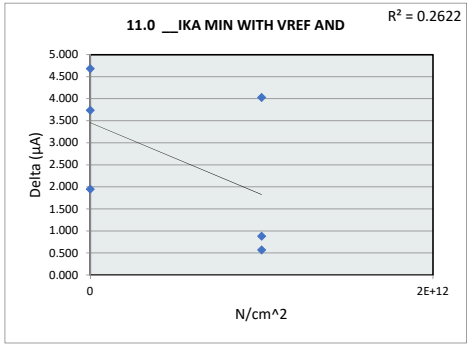
	7.0 __VREF @ VZ=VREF IZ=10MA		
Test Site	MTT		
Tester	LTX		
Test Number	XPM16108		
Max Limit	2.55	V	
Min Limit	2.475	V	
N/cm^2	0	1E+12	
LL	2.475	2.475	
Min	2.496	2.503	
Average	2.506	2.508	
Max	2.516	2.513	
UL	2.550	2.550	



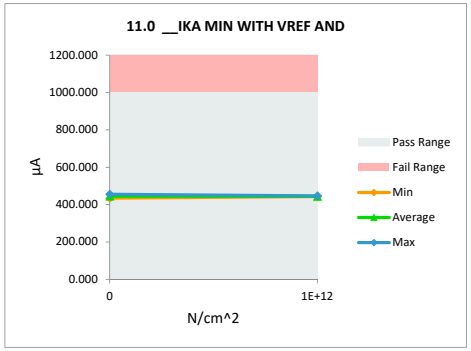
NDD Report
TL1431-SP

	11.0 __IKA MIN WITH VREF AND	
Test Site	MTT	MTT
Tester	LTX	LTX
Test Number	XPM16108	XPM16108
Unit	µA	µA
Max Limit	1000	1000
Min Limit	0.01	0.01

N/cm^2	Serial #	Pre	Post	Delta
0	105	443.338	445.284	1.947
0	106	451.456	455.194	3.737
0	107	430.426	435.108	4.682
1E+12	415	442.310	443.191	0.881
1E+12	416	445.932	446.502	0.569
1E+12	417	439.419	443.450	4.030
	Max	451.456	455.194	4.682
	Average	442.147	444.788	2.641
	Min	430.426	435.108	0.569
	Std Dev	7.032	6.473	1.742

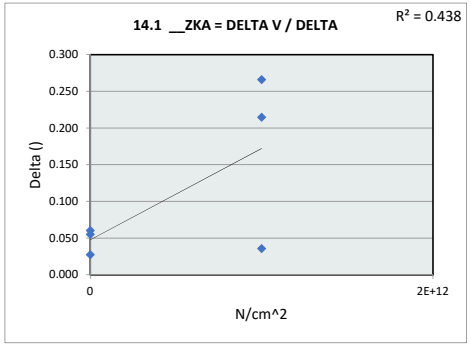


	11.0 __IKA MIN WITH VREF AND	
Test Site	MTT	
Tester	LTX	
Test Number	XPM16108	
Max Limit	1000	µA
Min Limit	0.01	µA
N/cm^2	0	1E+12
LL	0.010	0.010
Min	435.108	443.191
Average	445.195	444.381
Max	455.194	446.502
UL	1000.000	1000.000

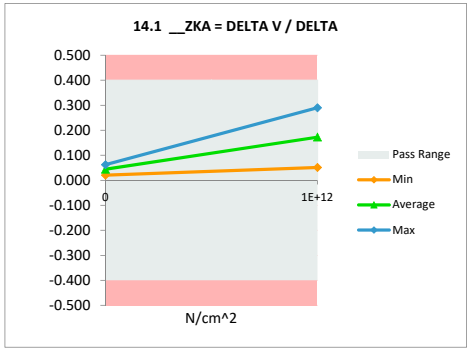


NDD Report
TL1431-SP

14.1 __ZKA = DELTA V / DELTA			
Test Site	MTT	MTT	
Tester	LTX	LTX	
Test Number	XPM16108	XPM16108	
Unit			
Max Limit	0.4	0.4	
Min Limit	-0.4	-0.4	
N/cm^2	Serial #	Pre	Post	Delta
0	105	-0.006	0.049	0.055
0	106	-0.007	0.021	0.027
0	107	0.002	0.062	0.060
1E+12	415	0.024	0.290	0.266
1E+12	416	0.015	0.051	0.036
1E+12	417	-0.038	0.176	0.215
	Max	0.024	0.290	0.266
	Average	-0.001	0.108	0.110
	Min	-0.038	0.021	0.027
	Std Dev	0.022	0.104	0.103



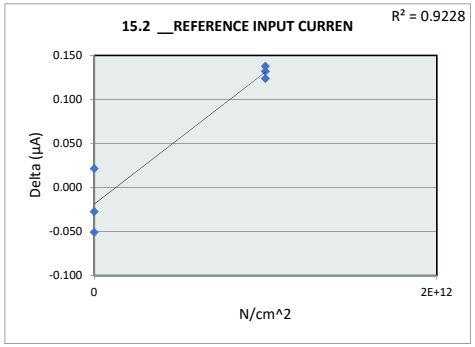
14.1 __ZKA = DELTA V / DELTA		
Test Site	MTT	
Tester	LTX	
Test Number	XPM16108	
Max Limit	0.4	
Min Limit	-0.4	
N/cm^2	0	1E+12
LL	-0.400	-0.400
Min	0.021	0.051
Average	0.044	0.173
Max	0.062	0.290
UL	0.400	0.400



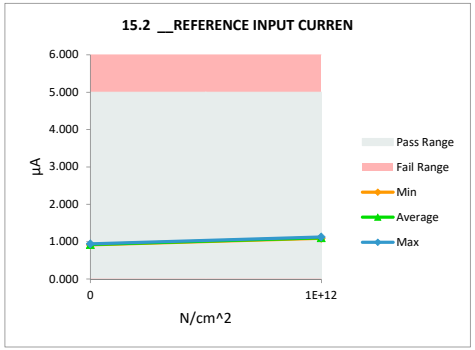
NDD Report
TL1431-SP

	15.2 __REFERENCE INPUT CURREN	
Test Site	MTT	MTT
Tester	LTX	LTX
Test Number	XPM16108	XPM16108
Unit	µA	µA
Max Limit	5	5
Min Limit	0.01	0.01

N/cm^2	Serial #	Pre	Post	Delta
0	105	0.892	0.914	0.022
0	106	0.969	0.942	-0.027
0	107	0.968	0.917	-0.051
1E+12	415	0.951	1.089	0.138
1E+12	416	1.001	1.125	0.124
1E+12	417	0.959	1.091	0.132
	Max	1.001	1.125	0.138
	Average	0.957	1.013	0.056
	Min	0.892	0.914	-0.051
	Std Dev	0.036	0.099	0.086



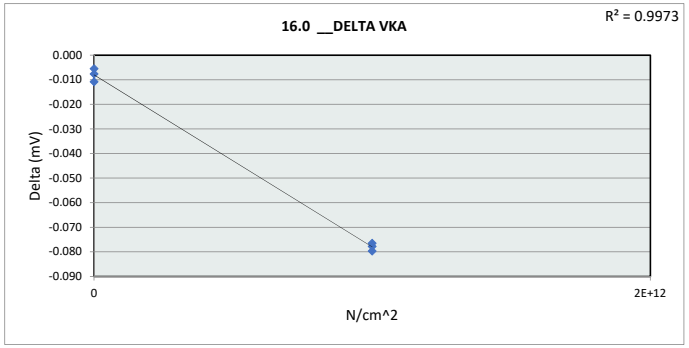
	15.2 __REFERENCE INPUT CURREN	
Test Site	MTT	
Tester	LTX	
Test Number	XPM16108	
Max Limit	5	µA
Min Limit	0.01	µA
N/cm^2	0	1E+12
LL	0.010	0.010
Min	0.914	1.089
Average	0.924	1.102
Max	0.942	1.125
UL	5.000	5.000



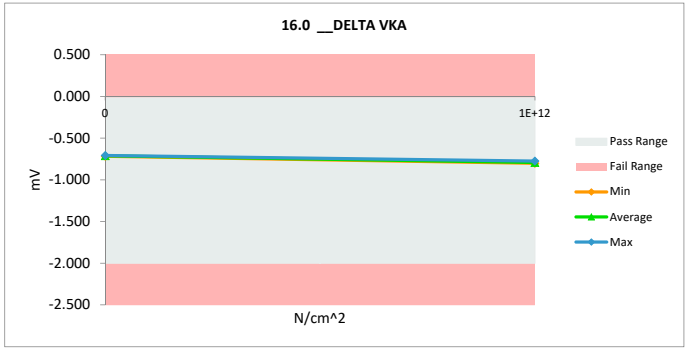
NDD Report
TL1431-SP

	16.0 __DELTA VKA	
Test Site	MTT	MTT
Tester	LTX	LTX
Test Number	XPM16108	XPM16108
Unit	mV	mV
Max Limit	-0.01	-0.01
Min Limit	-2	-2

N/cm^2	Serial #	Pre	Post	Delta
0	105	-0.707	-0.712	-0.006
0	106	-0.697	-0.708	-0.011
0	107	-0.709	-0.717	-0.008
1E+12	415	-0.721	-0.799	-0.078
1E+12	416	-0.725	-0.802	-0.076
1E+12	417	-0.695	-0.775	-0.080
	Max	-0.695	-0.708	-0.006
	Average	-0.709	-0.752	-0.043
	Min	-0.725	-0.802	-0.080
	Std Dev	0.012	0.045	0.038



	16.0 __DELTA VKA	
Test Site	MTT	
Tester	LTX	
Test Number	XPM16108	
Max Limit	-0.01	mV
Min Limit	-2	mV
N/cm^2	0	1E+12
LL	-2.000	-2.000
Min	-0.717	-0.802
Average	-0.712	-0.792
Max	-0.708	-0.775
UL	-0.010	-0.010



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