Radiation Report

TL7700-SEP NDD (Neutron Displacement Damage) Characterization

ABSTRACT

This report presents the effect of neutron displacement damage (NDD) on the TL7700-SEP 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 three units were exposed to radiation testing per (MIL-STD-883, Method 1017 for Neutron Irradiation). Electrical testing was performed at Texas Instruments before and after neutron irradiation using the production test program for TL7700CMPWTPSEP.

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Trademarks

1 Overview

The TL7700-SEP is a bipolar integrated circuit designed for use as a reset controller in microcomputer and microprocessor systems. The SENSE voltage can be set to any value greater than 0.5 V using two external resistors.

General device information and testing conditions are listed in Table 1-1.

Table 1-1. Overview Information

TI Part Number	TL7700-SEP
Device Function	Supply-voltage supervisor
Die Name	STLN7700CPS
Technology	JI1
A/T Lot Number / Date Code	0440460 / 2024A
Biased Quantity Tested	0
Unbiased Quantity Tested	3
Exposure Facility	VPT Rad
Neutron Fluence (1 MeV equivalent)	1.0×10^{12} n/cm^2
Irradiation Temperature	25°C
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2 Test Procedures

The TL7700-SEP was electrically pre-tested using the production automated test equipment program. General test procedures were IAW MIL-STD-883, Method 1017 for Neutron Irradiation of TL7700-SEP as modified 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} n/cm^2	Unbiased

Figure 2-1. TL7700-SEP Device

3 Facility

VPT Rad performs all neutron displacement damage irradiations 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, its 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/cm^2 (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/cm^2-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 meeting ASTM standards (ASTM E265) is utilized to track and ensure irradiations meet the required minimum. The facility retains *source-suitability* with the Defense Logistics Agency (DLA) Laboratory Suitability Program for ASTM Test Method 1017. The DUTS are typically irradiation in an unbiased condition as per TM1017. If bias conditions are required, they can be maintained via dry thimbles connected to the irradiation volume.

4 Results

The device passed all parametric measurements well within all data sheet limits for the exposure level 1.0×10^{12} n/cm^2. All parametric measurements remained well within the production test limits which are guard banded from the data sheet limits. An overview of the largest drifts seen post-test is discussed later in this section. The data sheet parameters that were tested pre- and post-neutron radiation and their corresponding test names are included in Appendix A. Appendix B has the graphs showing the drift between pre- and post-neutron radiation for these parameters.

The SENSE input current parameter was reduced after neutron exposure. This parameter is measured with test number 015. This parameter drifted downward from an average value of 2.421 µA to an average value of 2.264 µA.

A Test Results

Table A-1 provides the list of tested parameters.

Table A-1. Test List

V_{CC} = 3 V (unless otherwise noted)

Parameters		Test Conditions	TL7700-SEP Data Sheet SLVSF13 –MARCH 2019				Test# or Name
Symbol	Description		MIN	TYP	MAX	Unit	
V_S	SENSE input voltage		490		520	mV	056
I_S	SENSE input current	V_s = 0.4 V	2	2.5	3	µA	015
I_{CC}	Supply current	V_{CC} = 40 V, V_s = 0.6 V, no load		0.6	1	mA	002, 003, 004, 005
V_{OL}	Low-level output voltage	I_{OL} = 1.5 mA			0.4	V	011
		I_{OL} = 3 mA			0.8		012
I_{OH}	High-level output current	V_{OH} = 40 V, V_s = 0.6 V			1	µA	008
I_{CT}	Timing-capacitor charge current	V_s = 0.6 V	11	15	19	µA	014

B Test Results

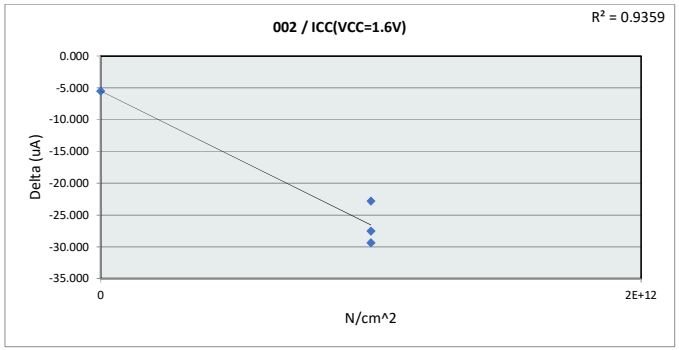
Appendix B shows the detailed test results.

NDD Report - Parametric Drift Graphs

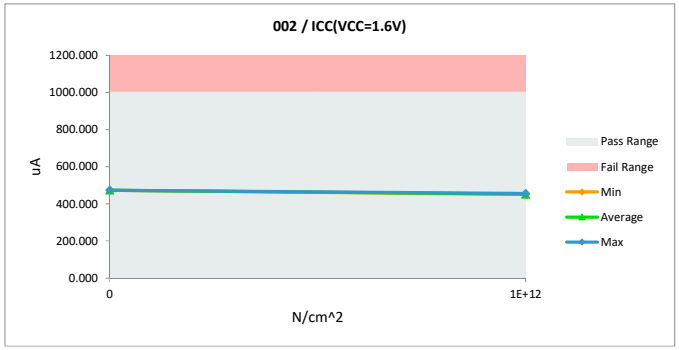
TL7700-SEP

NDD Report - Parametric Drift Graphs
TL7700-SEP

	002 / ICC(VCC=1.6V)		
Test Site	TIM	TIM	
Tester	HSM 149.0	HSM 149.0	
Test Number	227423	227423	
Unit	uA	uA	
Max Limit	1000	1000	
Min Limit	0	0	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	478.923	456.110	-22.813
1E+12	2	479.966	450.611	-29.355
1E+12	3	478.134	450.611	-27.523
0	10	478.923	473.410	-5.513
	Max	479.966	473.410	-5.513
	Average	478.987	457.685	-21.301
	Min	478.134	450.611	-29.355
	Std Dev	0.751	10.799	10.880

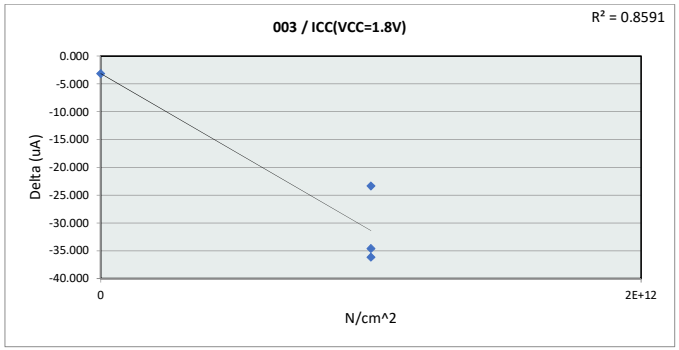


	002 / ICC(VCC=1.6V)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	1000	uA
Min Limit	0	uA
N/cm^2	0	1E+12
LL	0.000	0.000
Min	473.410	450.611
Average	473.410	452.444
Max	473.410	456.110
UL	1000.000	1000.000

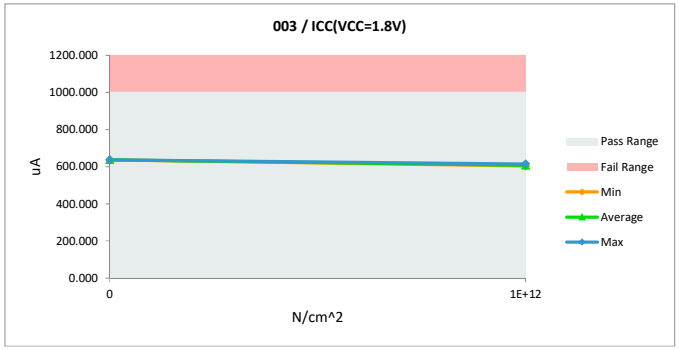


NDD Report - Parametric Drift Graphs
TL7700-SEP

		003 / ICC(VCC=1.8V)		
	Test Site	TIM	TIM	
	Tester	HSM 149.0	HSM 149.0	
	Test Number	227423	227423	
	Unit	uA	uA	
	Max Limit	1000	1000	
	Min Limit	0	0	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	638.545	615.209	-23.336
1E+12	2	639.588	603.437	-36.151
1E+12	3	639.856	605.255	-34.601
0	10	640.392	637.233	-3.159
	Max	640.392	637.233	-3.159
	Average	639.595	615.283	-24.312
	Min	638.545	603.437	-36.151
	Std Dev	0.776	15.521	15.214

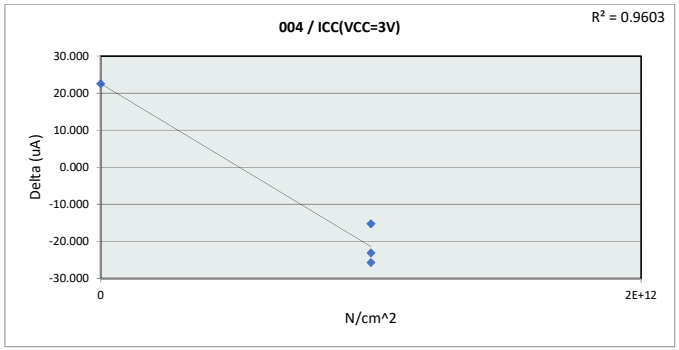


	003 / ICC(VCC=1.8V)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	1000	uA
Min Limit	0	uA
N/cm^2	0	1E+12
LL	0.000	0.000
Min	637.233	603.437
Average	637.233	607.967
Max	637.233	615.209
UL	1000.000	1000.000

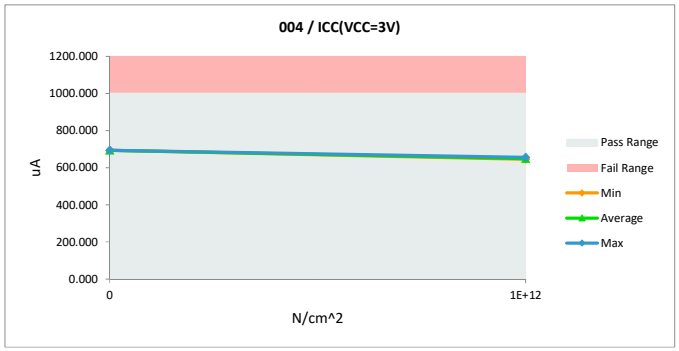


NDD Report - Parametric Drift Graphs
TL7700-SEP

	004 / ICC(VCC=3V)		
Test Site	TIM	TIM	
Tester	HSM 149.0	HSM 149.0	
Test Number	227423	227423	
Unit	uA	uA	
Max Limit	1000	1000	
Min Limit	0	0	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	671.059	655.860	-15.199
1E+12	2	671.059	647.992	-23.067
1E+12	3	671.059	645.369	-25.690
0	10	671.059	693.589	22.530
	Max	671.059	693.589	22.530
	Average	671.059	660.702	-10.357
	Min	671.059	645.369	-25.690
	Std Dev	0.000	22.373	22.373

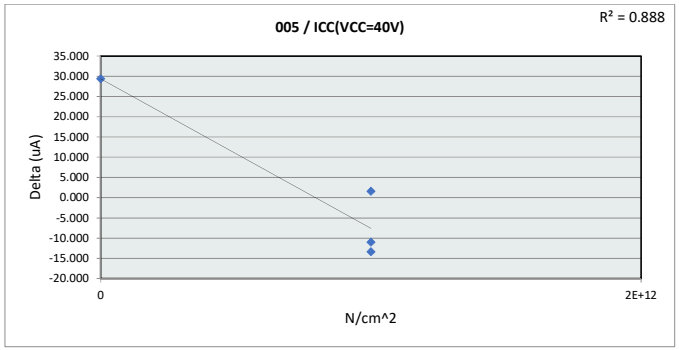


	004 / ICC(VCC=3V)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	1000	uA
Min Limit	0	uA
N/cm^2	0	1E+12
LL	0.000	0.000
Min	693.589	645.369
Average	693.589	649.740
Max	693.589	655.860
UL	1000.000	1000.000

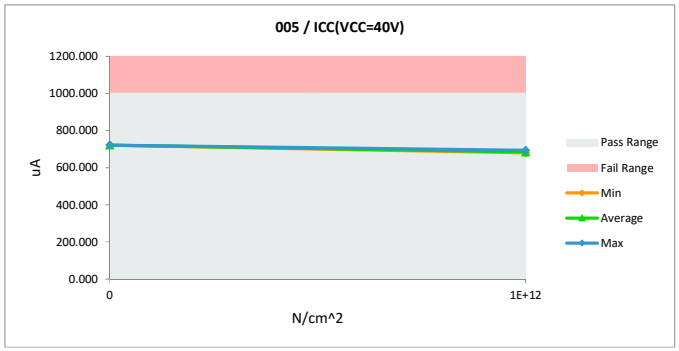


NDD Report - Parametric Drift Graphs
TL7700-SEP

		005 / ICC(VCC=40V)		
	Test Site	TIM	TIM	
	Tester	HSM 149.0	HSM 149.0	
	Test Number	227423	227423	
	Unit	uA	uA	
	Max Limit	1000	1000	
	Min Limit	0	0	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	692.278	693.858	1.580
1E+12	2	692.815	679.433	-13.382
1E+12	3	692.815	681.818	-10.997
0	10	692.815	722.170	29.355
	Max	692.815	722.170	29.355
	Average	692.681	694.320	1.639
	Min	692.278	679.433	-13.382
	Std Dev	0.268	19.611	19.608

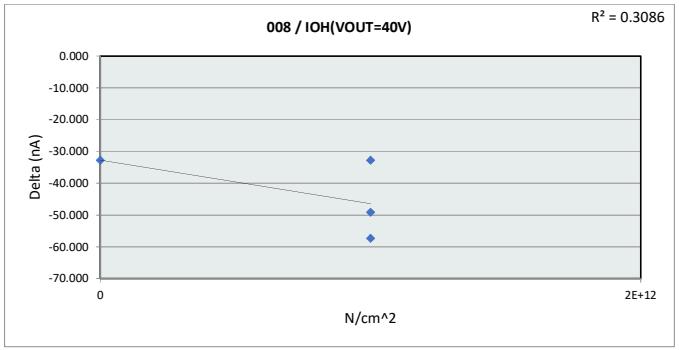


	005 / ICC(VCC=40V)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	1000	uA
Min Limit	0	uA
N/cm^2	0	1E+12
LL	0.000	0.000
Min	722.170	679.433
Average	722.170	685.036
Max	722.170	693.858
UL	1000.000	1000.000

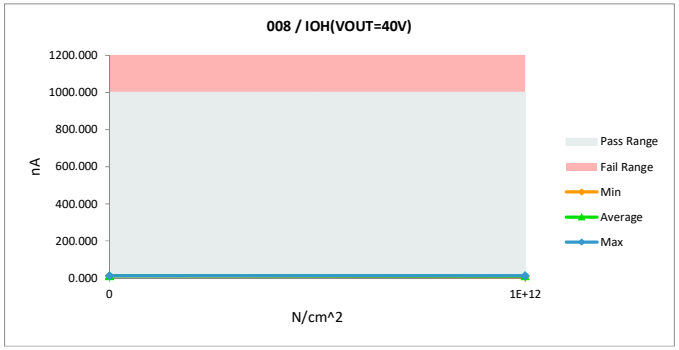


NDD Report - Parametric Drift Graphs
TL7700-SEP

	008 / IOH(VOUT=40V)		
Test Site	TIM	TIM	
Tester	HSM 149.0	HSM 149.0	
Test Number	227423	227423	
Unit	nA	nA	
Max Limit	1000	1000	
Min Limit	0	0	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	61.438	12.288	-49.150
1E+12	2	65.535	8.192	-57.343
1E+12	3	45.055	12.288	-32.767
0	10	45.055	12.288	-32.767
	Max	65.535	12.288	-32.767
	Average	54.271	11.264	-43.007
	Min	45.055	8.192	-57.343
	Std Dev	10.772	2.048	12.288

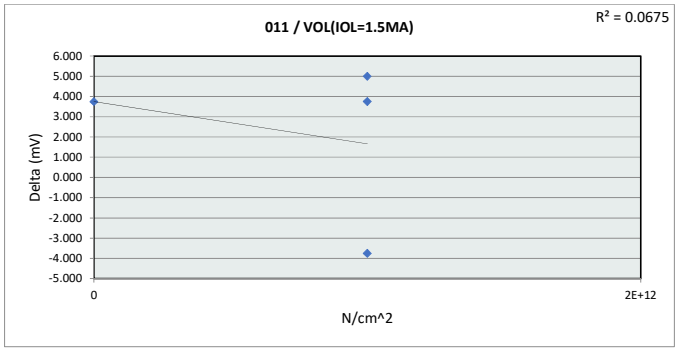


	008 / IOH(VOUT=40V)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	1000	nA
Min Limit	0	nA
N/cm^2	0	1E+12
LL	0.000	0.000
Min	12.288	8.192
Average	12.288	10.923
Max	12.288	12.288
UL	1000.000	1000.000

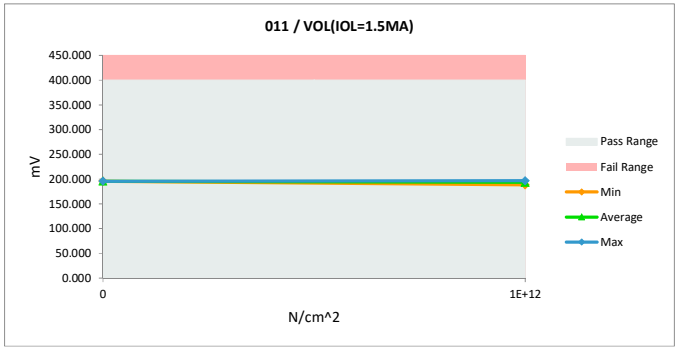


NDD Report - Parametric Drift Graphs
TL7700-SEP

		011 / VOL(IOL=1.5MA)		
	Test Site	TIM	TIM	
	Tester	HSM 149.0	HSM 149.0	
	Test Number	227423	227423	
	Unit	mV	mV	
	Max Limit	400	400	
	Min Limit	0	0	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	191.986	188.232	-3.754
1E+12	2	191.734	196.732	4.998
1E+12	3	191.231	194.984	3.753
0	10	191.986	195.732	3.746
	Max	191.986	196.732	4.998
	Average	191.734	193.920	2.186
	Min	191.231	188.232	-3.754
	Std Dev	0.356	3.859	4.003

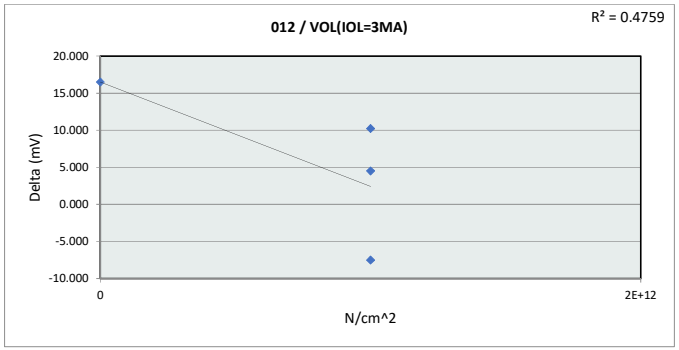


	011 / VOL(IOL=1.5MA)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	400	mV
Min Limit	0	mV
N/cm^2	0	1E+12
LL	0.000	0.000
Min	195.732	188.232
Average	195.732	193.316
Max	195.732	196.732
UL	400.000	400.000

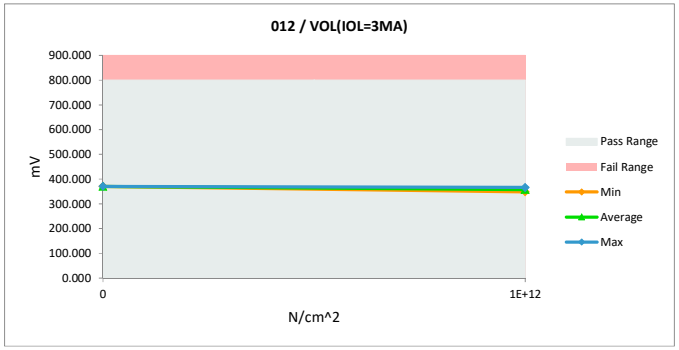


NDD Report - Parametric Drift Graphs
TL7700-SEP

	012 / VOL(IOL=3MA)		
Test Site	TIM	TIM	
Tester	HSM 149.0	HSM 149.0	
Test Number	227423	227423	
Unit	mV	mV	
Max Limit	800	800	
Min Limit	0	0	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	355.713	348.221	-7.492
1E+12	2	355.972	366.211	10.239
1E+12	3	354.721	359.222	4.501
0	10	354.218	370.712	16.494
	Max	355.972	370.712	16.494
	Average	355.156	361.091	5.936
	Min	354.218	348.221	-7.492
	Std Dev	0.826	9.796	10.204

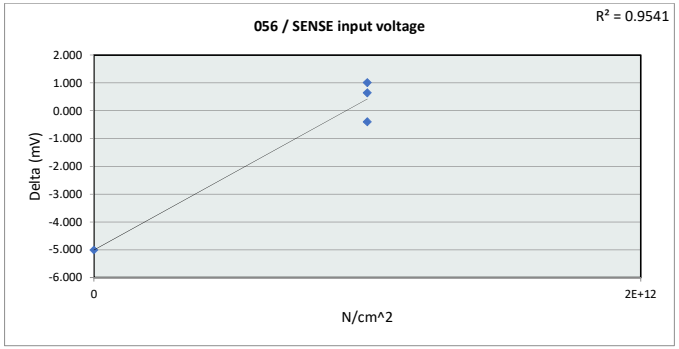


	012 / VOL(IOL=3MA)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	800	mV
Min Limit	0	mV
N/cm^2	0	1E+12
LL	0.000	0.000
Min	370.712	348.221
Average	370.712	357.885
Max	370.712	366.211
UL	800.000	800.000

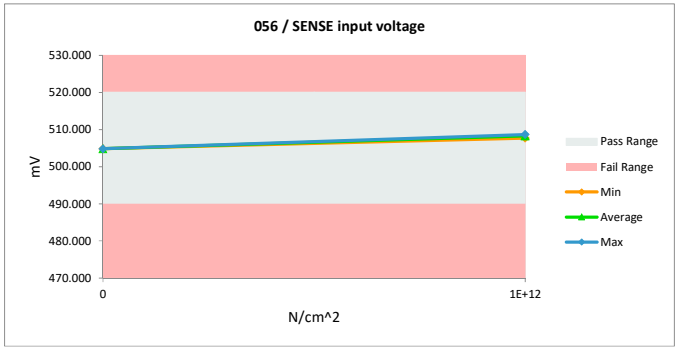


NDD Report - Parametric Drift Graphs
TL7700-SEP

		056 / SENSE input voltage		
	Test Site	TIM	TIM	
	Tester	HSM 149.0	HSM 149.0	
	Test Number	227423	227423	
	Unit	mV	mV	
	Max Limit	520	520	
	Min Limit	490	490	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	507.812	508.453	0.641
1E+12	2	507.690	508.698	1.008
1E+12	3	508.087	507.690	-0.397
0	10	509.827	504.822	-5.005
	Max	509.827	508.698	1.008
	Average	508.354	507.416	-0.938
	Min	507.690	504.822	-5.005
	Std Dev	0.996	1.782	2.776

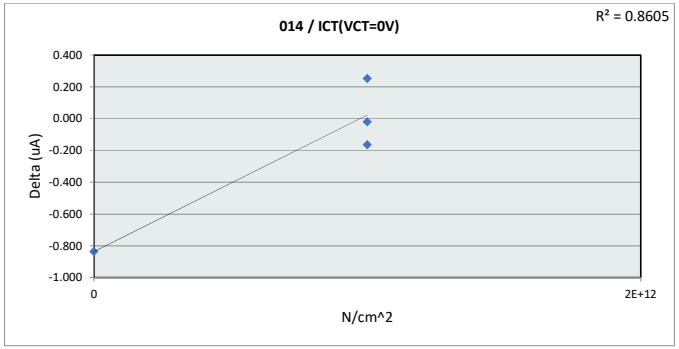


	056 / SENSE input voltage	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	520	mV
Min Limit	490	mV
N/cm^2	0	1E+12
LL	490.000	490.000
Min	504.822	507.690
Average	504.822	508.280
Max	504.822	508.698
UL	520.000	520.000

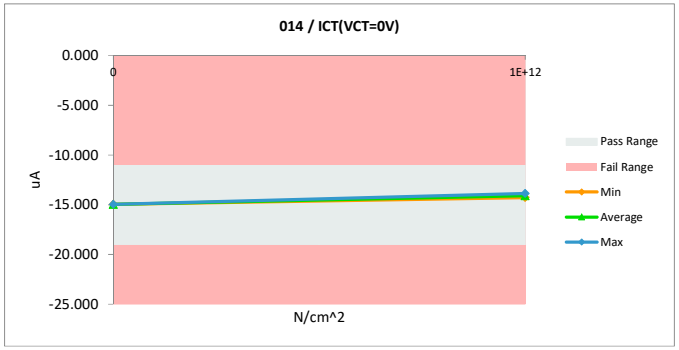


NDD Report - Parametric Drift Graphs
TL7700-SEP

	014 / ICT(VCT=0V)		
Test Site	TIM	TIM	
Tester	HSM 149.0	HSM 149.0	
Test Number	227423	227423	
Unit	uA	uA	
Max Limit	-11	-11	
Min Limit	-19	-19	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	-14.110	-14.274	-0.164
1E+12	2	-14.107	-14.127	-0.020
1E+12	3	-14.110	-13.857	0.253
0	10	-14.127	-14.963	-0.836
	Max	-14.107	-13.857	0.253
	Average	-14.113	-14.305	-0.192
	Min	-14.127	-14.963	-0.836
	Std Dev	0.009	0.471	0.463

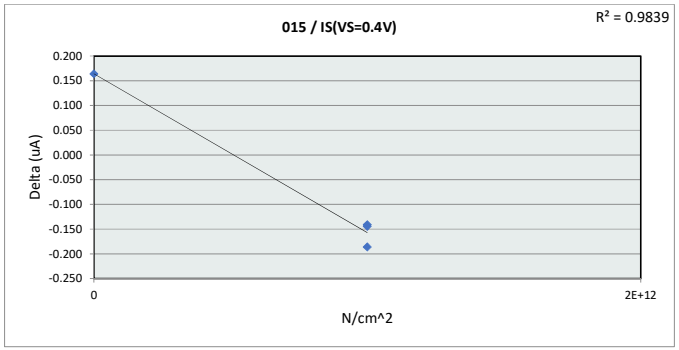


	014 / ICT(VCT=0V)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	-11	uA
Min Limit	-19	uA
N/cm^2	0	1E+12
LL	-19.000	-19.000
Min	-14.963	-14.274
Average	-14.963	-14.086
Max	-14.963	-13.857
UL	-11.000	-11.000

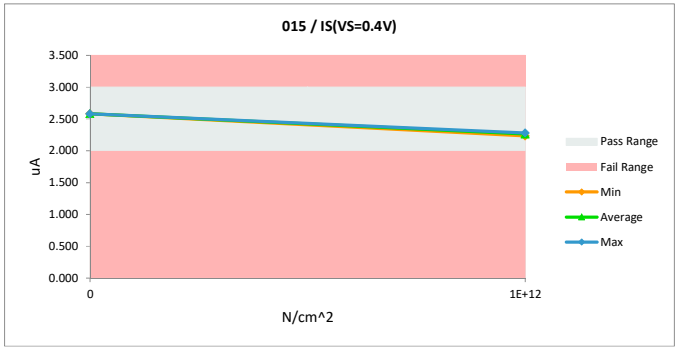


NDD Report - Parametric Drift Graphs
TL7700-SEP

	015 / IS(VS=0.4V)		
Test Site	TIM	TIM	
Tester	HSM 149.0	HSM 149.0	
Test Number	227423	227423	
Unit	uA	uA	
Max Limit	3	3	
Min Limit	2	2	
N/cm^2	Serial #	Pre	Post	Delta
1E+12	1	2.422	2.278	-0.144
1E+12	2	2.419	2.233	-0.186
1E+12	3	2.421	2.280	-0.141
0	10	2.418	2.582	0.164
	Max	2.422	2.582	0.164
	Average	2.420	2.343	-0.077
	Min	2.418	2.233	-0.186
	Std Dev	0.002	0.161	0.162



	015 / IS(VS=0.4V)	
Test Site	TIM	
Tester	HSM 149.0	
Test Number	227423	
Max Limit	3	uA
Min Limit	2	uA
N/cm^2	0	1E+12
LL	2.000	2.000
Min	2.582	2.233
Average	2.582	2.264
Max	2.582	2.280
UL	3.000	3.000



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