ISL705AEH

Neutron Testing

TR035
Rev 0.00
August 29, 2016

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the ISL705AEH microprocessor supervisory circuit. The test was conducted in order to determine the sensitivity of the part to Displacement Damage (DD) caused by neutron or proton environments. Neutron fluences ranged from $2x10^{12}n/cm^2$ to $1x10^{14}n/cm^2$. The six parts of the ISL705xEH and ISL706xEH family are closely similar and the results for the ISL705AEH are applicable to all six parts. This project was carried out in collaboration with Boeing (El Segundo, CA), whose support is gratefully acknowledged.

Reference Documents

- MIL-STD-883 test method 1017
- ISL705AEH datasheet
- DSCC Standard Microcircuit Drawing (SMD) 5962-11213

Part Description

The ISL705xEH and ISL706xEH family of devices consists of the ISL705AEH, ISL705BEH, ISL705CEH, ISL706AEH, ISL706BEH and ISL706CEH and are radiation hardened 5.0V/3.3V microprocessor supervisory circuits that reduce the complexity required to monitor supply voltages in microprocessor systems. These devices significantly improve accuracy and reliability relative to discrete solutions. Each IC provides four key functions:

1. A reset output during power-up, power-down, and brownout conditions.
2. An independent watchdog output that goes low if the watchdog input has not been toggled within 1.6s.
3. A precision threshold detector for monitoring a power supply other than V_{DD}.
4. An active-low manual-reset input.

Specifications for radiation hardened QML devices are controlled by the Defense Logistics Agency Land and Maritime (DLA). Detailed electrical specifications are contained in SMD 5962-11213.

The ISL705xRH and ISL706xRH families of devices are acceptance tested to a total dose (TID) level of 300krad(Si) at high dose rate (50-300rad(Si)/s) only. The ISL705xEH and ISL706xEH families of devices are acceptance tested to a total dose (TID) level of 300krad(Si) at high dose rate (50-300rad(Si)/s) and to 50krad(Si) at low dose rate (<0.01rad(Si)/s). The parts are identical except for these acceptance testing flows.

TABLE 1. ISL705AEH PIN ASSIGNMENTS

TERMINAL NUMBER	TERMINAL SYMBOL	TERMINAL NUMBER	TERMINAL SYMBOL
1	MR_BAR	5	PFO_BAR

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TERMINAL NUMBER	TERMINAL SYMBOL	TERMINAL NUMBER	TERMINAL SYMBOL
2	VDD	6	WDI
3	GND	7	RST_BAR
4	PFI	8	WDO_BAR

Test Description

Irradiation Facilities

1MeV equivalent neutron irradiation was performed at the White Sands Missile Range Fast Burst Reactor (FBR). Dosimetry data can be furnished upon request. Parts were tested in an unbiased configuration with all leads shorted together in general accordance with TM 1017 of MIL-STD-883. As neutron irradiation activates many of the heavier elements found in a packaged integrated circuit, the parts exposed at the higher neutron levels required considerable ‘cooldown’ time before being shipped back to Intersil for electrical testing.

Test Fixturing

No formal irradiation test fixturing was involved. These DD tests are informally termed ‘bag tests’ indicating that the parts are irradiated in an inactive state with all leads shorted together.

Characterization Equipment and Procedures

Electrical testing was performed before and after irradiation using the Intersil Palm Bay, FL Automated Test Equipment (ATE). All electrical testing was performed at room temperature.

Experimental Matrix

The experimental matrix consisted of 5 samples irradiated at $2x10^{1}n/cm^2$, 5 irradiated at $1x10^{13}n/cm^2$, 5 irradiated at $3x10^{13}n/cm^2$ and 5 irradiated at $1x10^{14}n/cm^2$. Five control units were used. ISL705AEHF samples were drawn from fabrication lot WPD4HFEH and were packaged in the standard eight-lead ceramic production package code K8.A. Samples were screened to the SMD limits over temperature before the start of neutron testing.

Results

Neutron testing of the ISL705AEH is complete and the results are reported in the balance of this report. It should be carefully realized when interpreting the data that each neutron irradiation was performed on a different five-unit sample; this is *not* total dose testing, where the damage is cumulative over a number of downpoints.

Attributes Data

TABLE 2. ISL705AEH ATTRIBUTES DATA

PART	SERIAL	SAMPLE SIZE	FLUENCE, (n/cm^2)	PASS (Note 1)	FAIL	NOTES
ISL705AEH	1-5	5	2x10^{12}	5	0	All passed
ISL705AEH	6-10	5	1x10^{13}	5	0	All passed
ISL705AEH	11-15	5	3x10^{13}	5	0	All passed
ISL705AEH	16-20	5	1x10^{14}	4	1	S/N 921 failed, nonfunctional

NOTE:

1. 'Pass' indicates a sample that passes all SMD limits.

Variables data

The plots in Figures 1 through 13 show data plots for key parameters before and after irradiation to each level. The reported parameters and their data sheet limits are shown in "Appendices" on page 9. The plots show the population median, minimum and maximum of each parameter as a function of neutron irradiation. We chose to plot the median because of the small sample sizes (five per cell) involved. We also show the applicable post-total dose electrical limits as taken from the SMD; it should be carefully noted that these limits are provided for *guidance only* as the ISL705AEH is not specified or guaranteed for the neutron environment. Intersil does not design, qualify or guarantee its parts for the DD environment, but has performed limited collaborative neutron testing for customer guidance.

Variables Data Plots

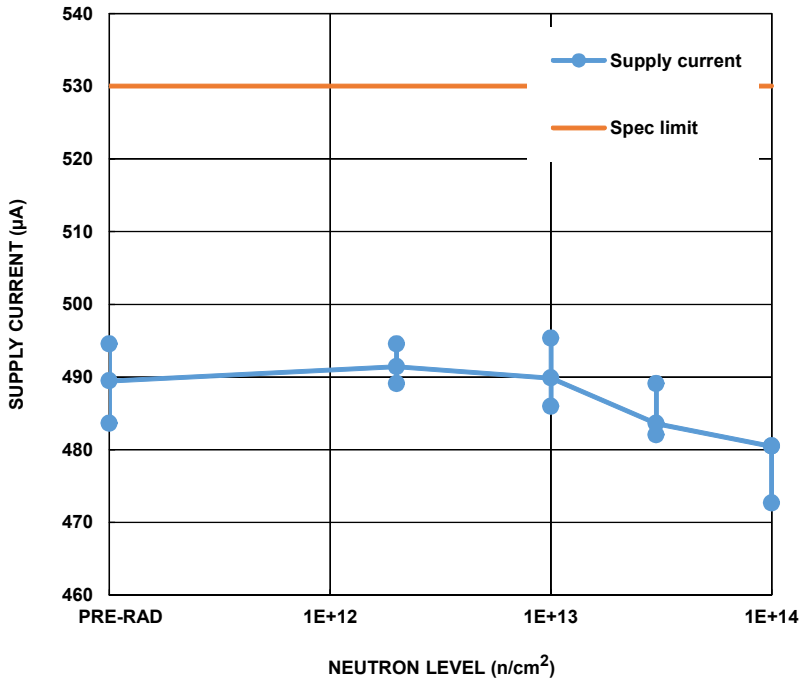

FIGURE 1. ISL705AEH supply current, V_{DD} = 5.5V, as a function of 1MeV equivalent neutron irradiation at 2x10^{12}n/cm^2, 1x10^{13}n/cm^2, 3x10^{13}n/cm^2 and 1x10^{14}n/cm^2. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is 530µA maximum.

Variables Data Plots (Continued)

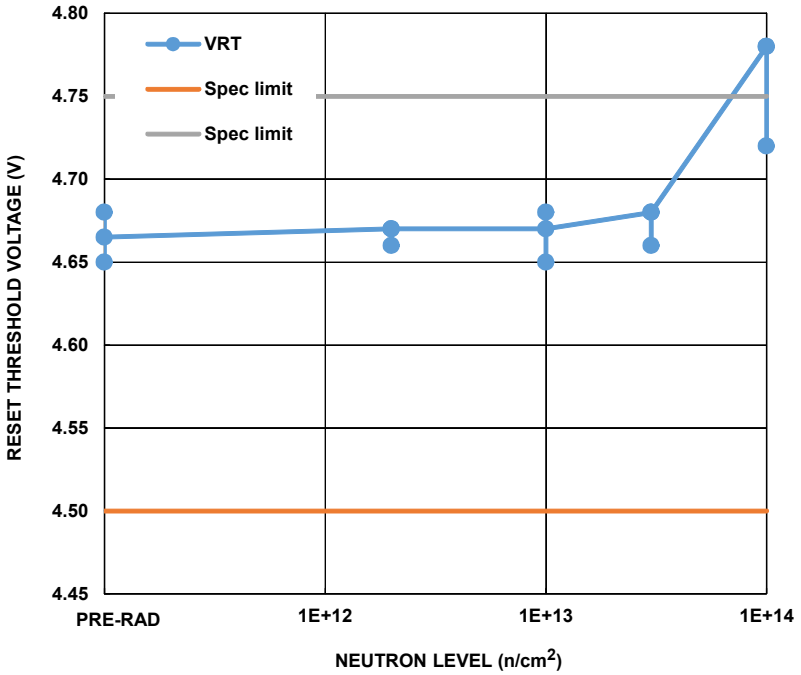

FIGURE 2. ISL705AEH reset threshold voltage as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 4.5V to 4.75V.

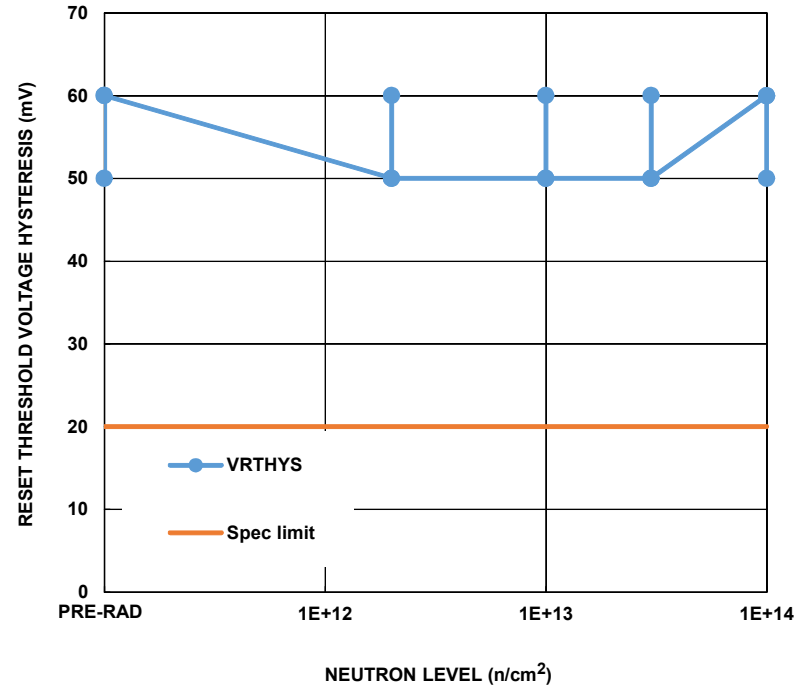

FIGURE 3. ISL705AEH reset threshold voltage hysteresis as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is 20mV minimum.

Variables Data Plots (Continued)

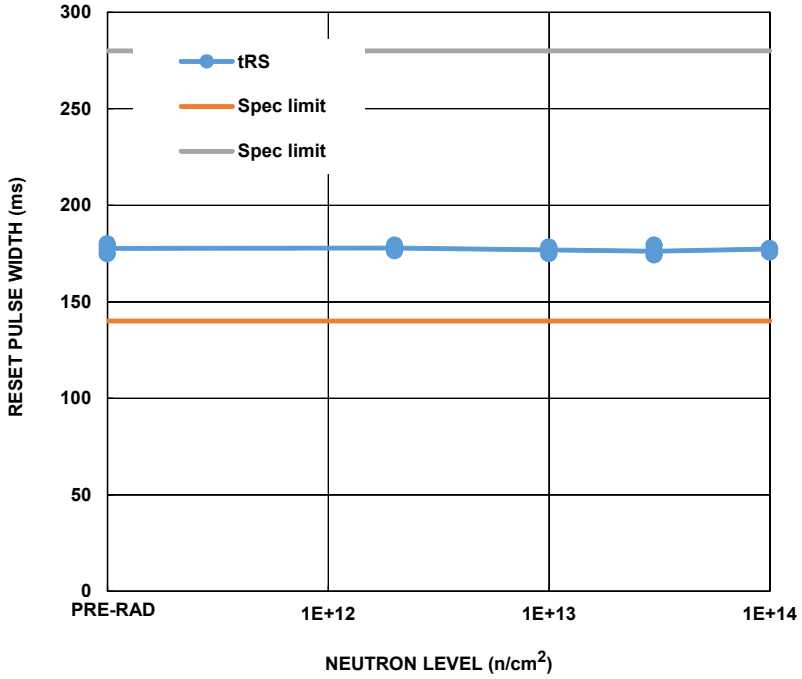

FIGURE 4. ISL705AEH reset pulse width as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 140ms to 280ms.

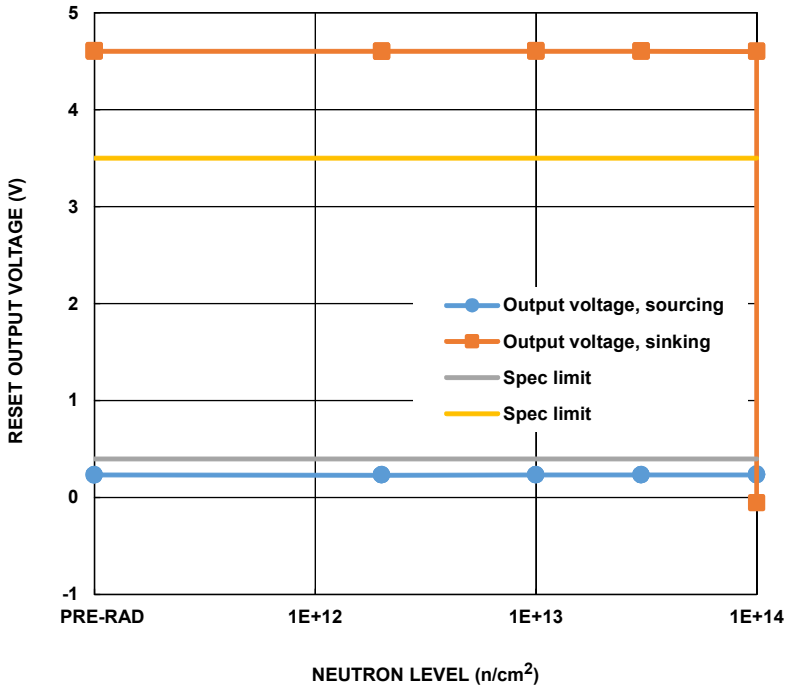

FIGURE 5. ISL705AEH reset output voltage, sourcing (800µA) and sinking (3.2mA), as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 3.5V minimum (sourcing) and 0.4V maximum (sinking).

Variables Data Plots (Continued)

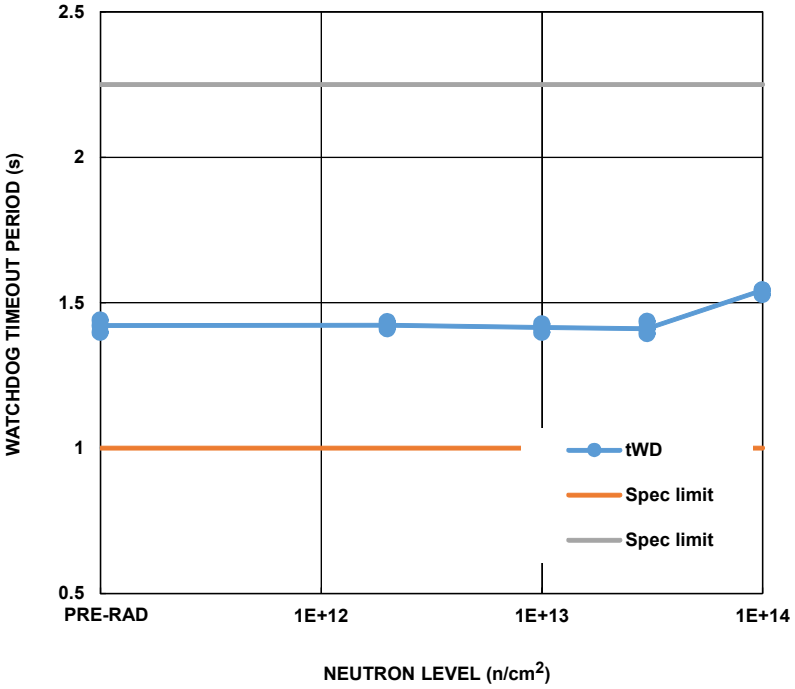

FIGURE 6. ISL705AEH watchdog timeout period as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 1s to 2.25s.

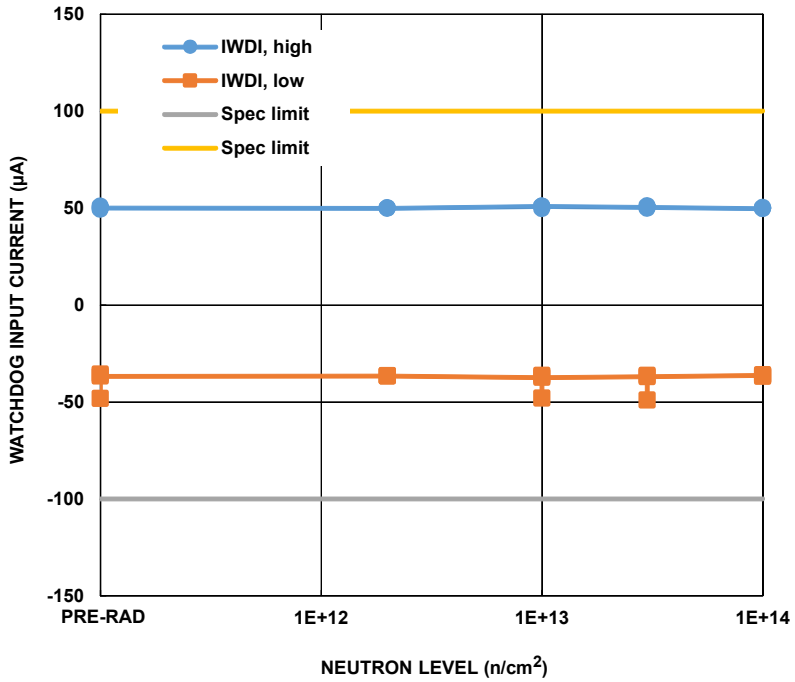

FIGURE 7. ISL705AEH watchdog input current, HIGH and LOW, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 100µA maximum (HIGH) and -100µA minimum (LOW).

Variables Data Plots (Continued)

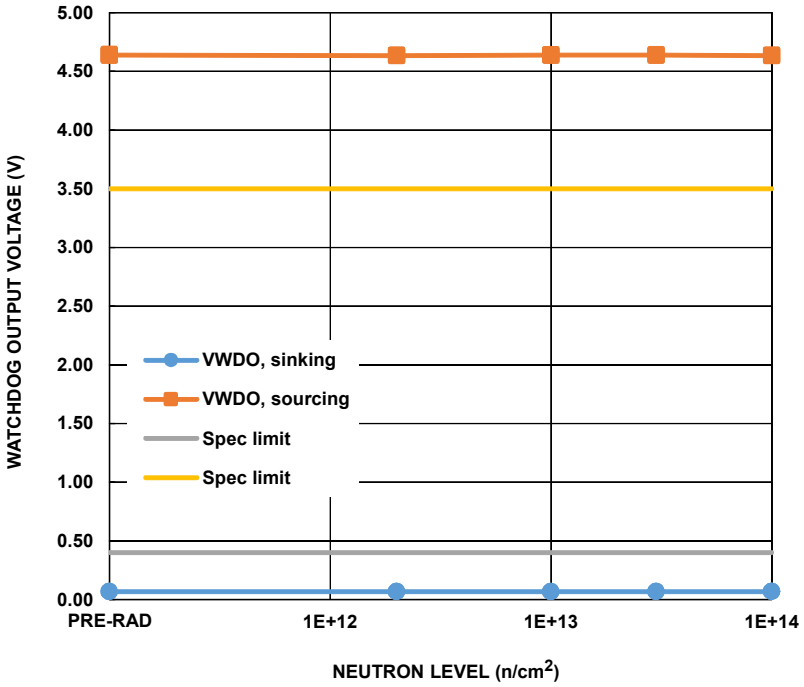

FIGURE 8. ISL705AEH watchdog output voltage, sourcing (800µA) and sinking (-800µA), as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 3.5V minimum (sourcing) and 0.4V maximum (sinking).

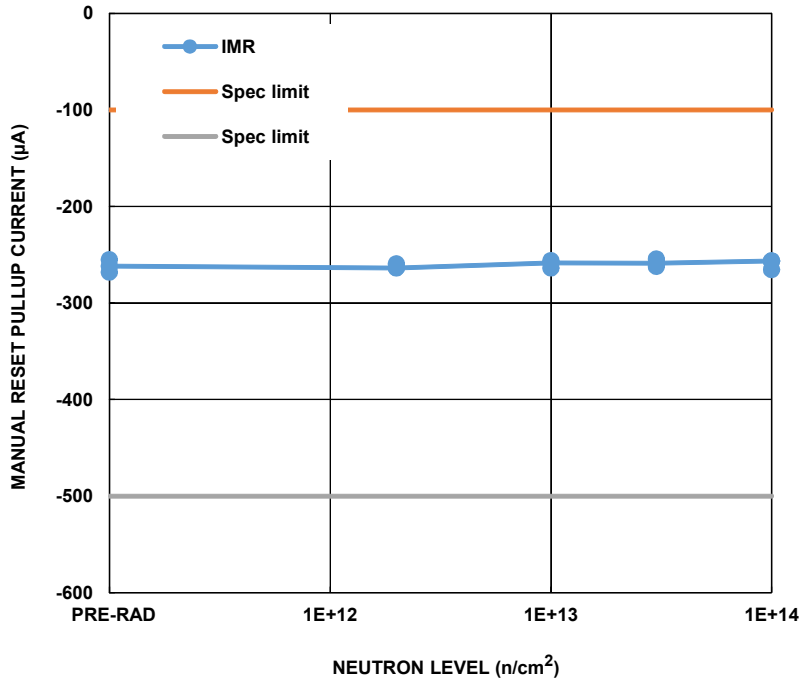

FIGURE 9. ISL705AEH manual reset pull-up current as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm2$ and $1x10^{14}n/cm2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -500µA to -100µA.

Variables Data Plots (Continued)

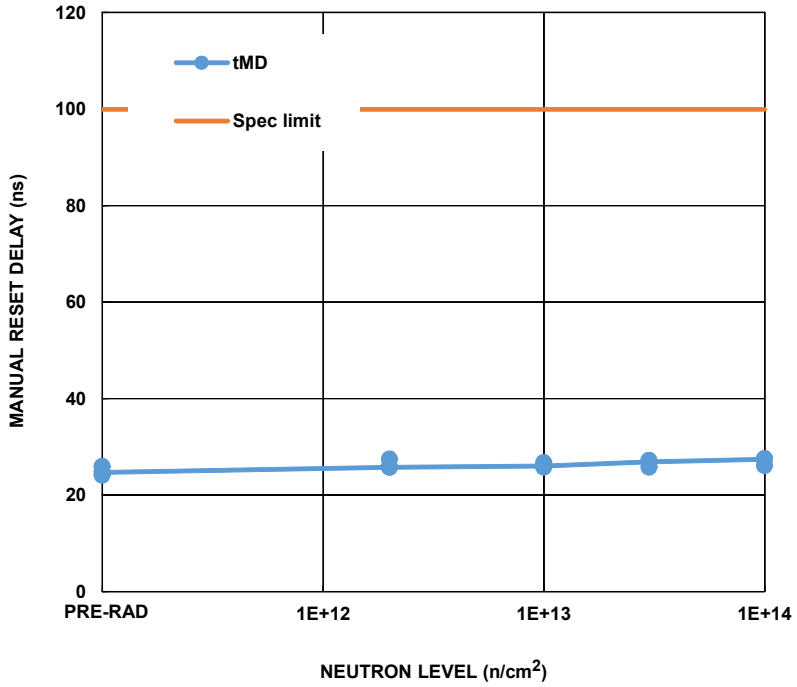

FIGURE 10. ISL705AEH manual reset delay as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is 100ns maximum.

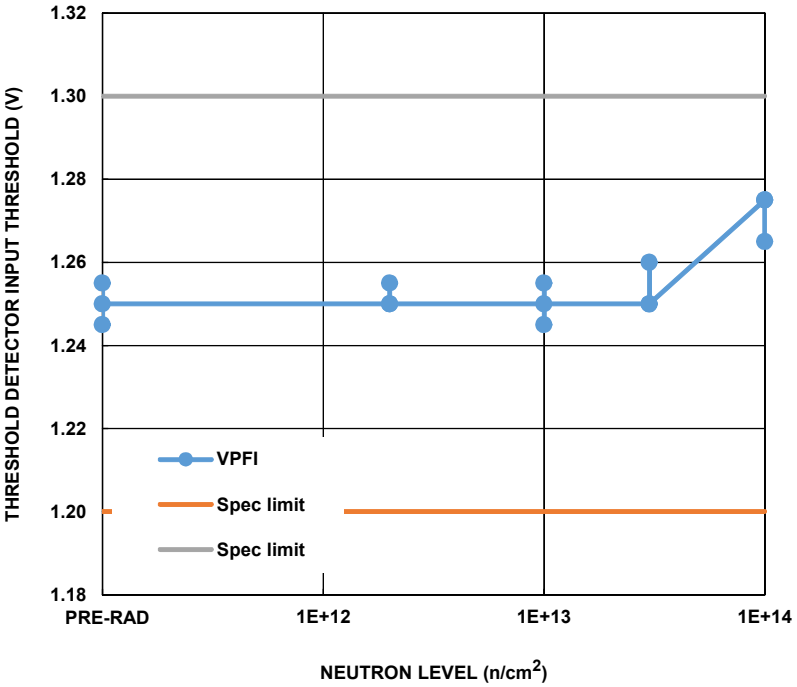

FIGURE 11. ISL705AEH threshold detector input threshold voltage as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 1.2V to 1.3V.

Variables Data Plots (Continued)

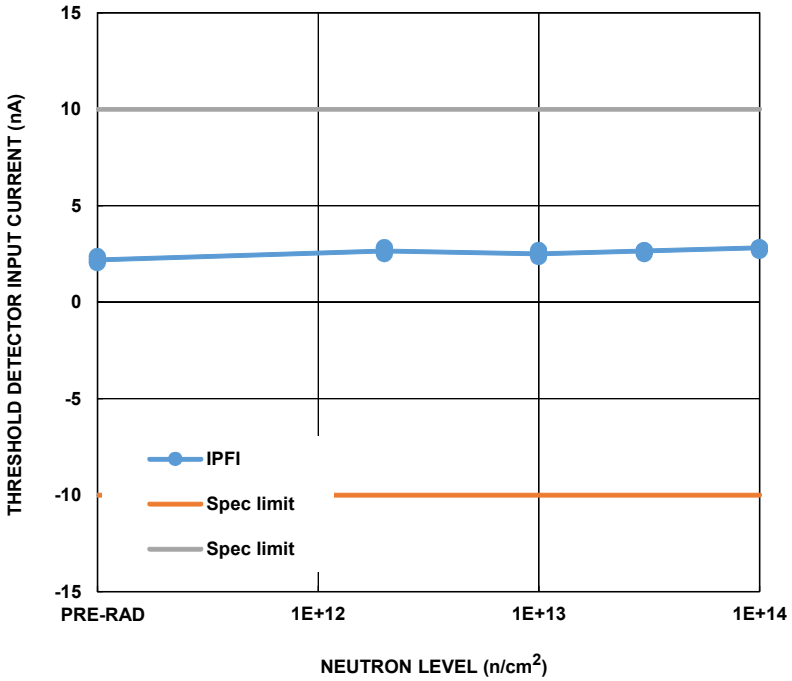

FIGURE 12. ISL705AEH threshold detector input current as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -10nA to 10nA.

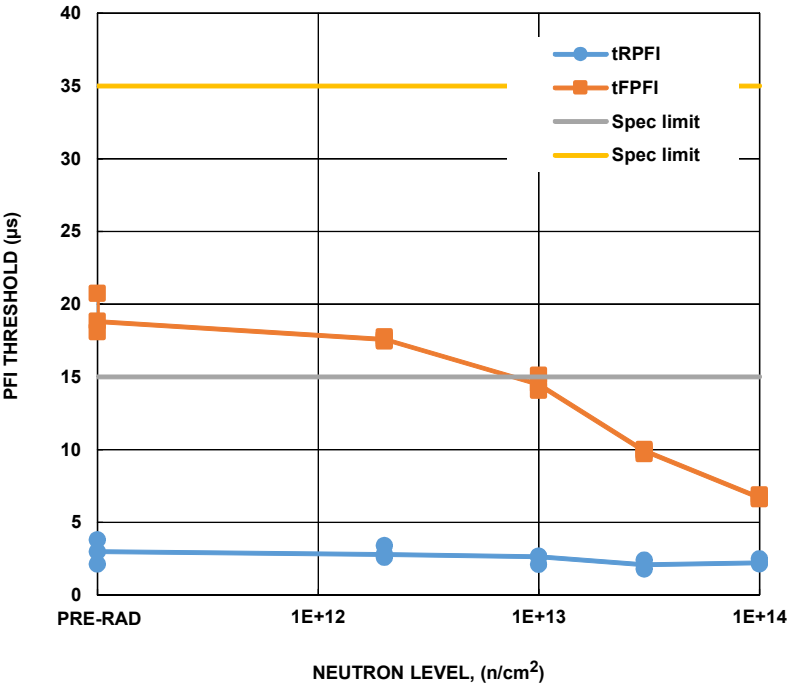

FIGURE 13. ISL705AEH threshold detector input rising threshold crossing to threshold detector output delay and falling threshold crossing to threshold detector output delay as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median, minimum and maximum at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 15µs maximum (rising) and 35µs maximum (falling).

Conclusion

This report summarizes results of 1MeV equivalent neutron testing of the ISL705AEH microprocessor supervisory circuit. The test was conducted in order to determine the sensitivity of the part to Displacement Damage (DD) caused by neutron or proton environments in space. Neutron fluences ranged from $2x10^{12}n/cm^2$ to $1x10^{14}n/cm^2$. This test was carried out as part of a collaborative project with Boeing (El Segundo, CA), whose support is gratefully acknowledged.

The samples met all specifications ('Bin 1') after $2x10^{11}n/cm^2$, $1x10^{13}n/cm^2$ and $3x10^{13}n/cm^2$. One sample was nonfunctional after the $1x10^{14}n/cm^2$ irradiation testing.

Appendices

Reported Parameters

Reported parameters are shown in Table 3. The limits are taken from the applicable SMD and are provided for guidance only as the part is not designed or guaranteed for the neutron environment. The plots show the population median and minimum and maximum error bars at each downpoint.

TABLE 3. REPORTED PARAMETERS

FIGURE	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNIT	NOTES
1	Supply current	-	530	µA	V_{DD} = 5.5V
2	Reset threshold voltage	4.5	4.75	V	
3	Reset threshold hysteresis	-	20	mV	
4	Reset pulse width	140	280	ms	
5	Reset output voltage	3.5	-	V	Sourcing, 800µA
	Reset output voltage	-	0.4	V	Sinking, 3.2mA
6	Watchdog timeout period	1	2.25	s	
7	Watchdog input current	-	100	µA	HIGH
	Watchdog input current	-100	-	µA	LOW
8	Watchdog output voltage	3.5	-	V	Sourcing, 800µA
	Watchdog output voltage	-	0.4	V	Sinking, -800µA
9	Manual reset pullup current	-500	-100	µA	
10	Manual reset delay	-	100	ns	
11	Threshold detector input threshold	1.2	1.3	V	
12	Threshold detector input current	-10	10	nA	
13	Threshold detector delay	-	15	µs	Rising
	Threshold detector delay	-	35	µs	Falling

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(Rev.4.0-1 November 2017)

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