# IS-1715ARH

Neutron Testing

TR042
Rev 0.00
November 30, 2016

## Introduction

This report summarizes results of 1MeV equivalent neutron testing of the IS-1715ARH complementary power MOSFET driver. 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 $1x10^{12}n/cm^2$ to $1x10^{14}n/cm^2$. This project was carried out in collaboration with Harris Corporation (Melbourne, FL), and their support is gratefully acknowledged.

## Part Description

The IS-1715ARH is a complementary power MOSFET driver designed for use in synchronous rectification circuits. Soft switching transitions for the two output waveforms may be managed by setting independently programmable delays. The delay pins T1 and T2 can alternatively be configured for zero-voltage sensing to allow for precise switching control. The IS-1715ARH has a single TTL-compatible input and can operate at frequencies up to 1MHz. The AUX output switches immediately at the rising edge of the INPUT, but waits for the T2 delay before responding to the falling edge. A logic low on the enable pin (ENABLE) places both outputs into an active-low mode, and an Undervoltage Lockout (UVLO) function is set at 9.0V maximum. Constructed using the Intersil dielectrically isolated Radiation Hardened Silicon Gate (RSG) process, the IS-1715ARH is immune to Single-Event Latch-Up (SEL) and is designed to provide highly reliable performance in harsh radiation environments.

Specifications for radiation hardened QML devices are controlled by the Defense Logistics Agency Land and Maritime in Columbus, OH. Detailed electrical specifications for the IS-1715ARH are contained in SMD 5962-00521.

## Related Literature

- For a full list of related documents, visit our website
  - IS-1715ARH product page

## Test Description

### Irradiation Facilities

Neutron irradiation was performed at the Fast Burst Reactor facility at White Sands Missile Range (White Sands, NM), which provides a controlled 1MeV equivalent neutron flux. Parts were tested in an unbiased configuration with all leads shorted together in 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 (as expected) significant “cool-down” time before being shipped back to Intersil (Palm Bay, FL) for electrical testing.

### Characterization Equipment and Procedures

Electrical testing was performed before and after irradiation using Intersil production Automated Test Equipment (ATE). All electrical testing was performed at room temperature.

### Experimental Matrix

Testing proceeded in general accordance with the guidelines of MIL-STD-883 Test Method 1017. The experimental matrix consisted of five samples irradiated at $1x10^{12}n/cm^2$, five samples irradiated at $1x10^{13}n/cm^2$, five samples irradiated at $3x10^{13}n/cm^2$, and five samples irradiated at $1x10^{14}n/cm^2$. Two control units were used to insure repeatability. The IS-1715ARH samples were taken from current production inventory.

## Results

### Test Results

Neutron testing of the IS-1715ARH is complete and the results are reported in the balance of this report. It should be realized when reviewing the data that each neutron irradiation was performed on a different five-unit sample; this is not total dose testing, in which the damage is cumulative.

### Variables Data

The plots in Figures 1 through 19 show data plots for key parameters before and after irradiation to each level. The plots show the 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 electrical limits taken from the SMD; it should be carefully noted that these limits are provided for guidance only as the IS-1715ARH is not specified for the neutron environment.

# Variables Data Plots

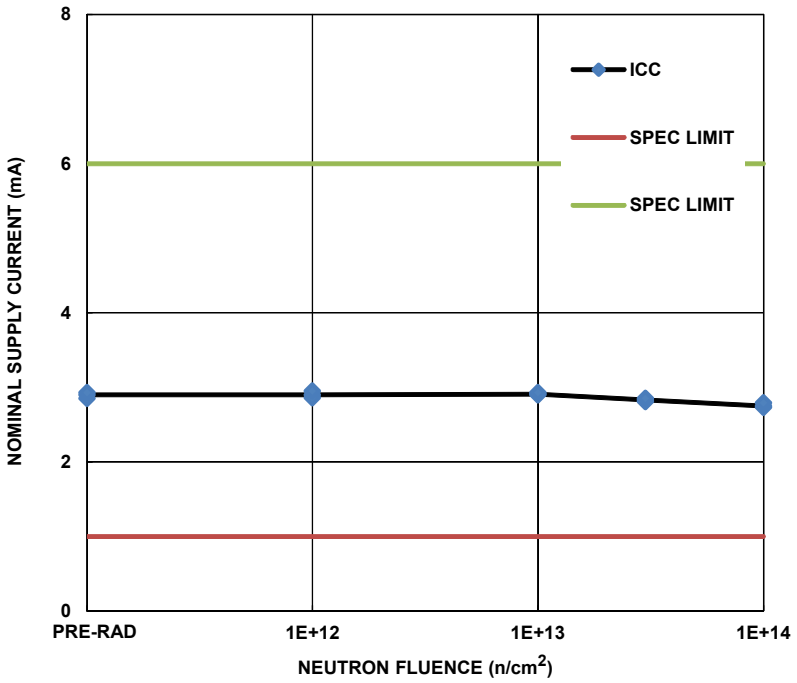


**FIGURE 1. IS-1715ARH nominal supply current as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 1mA to 6mA.**

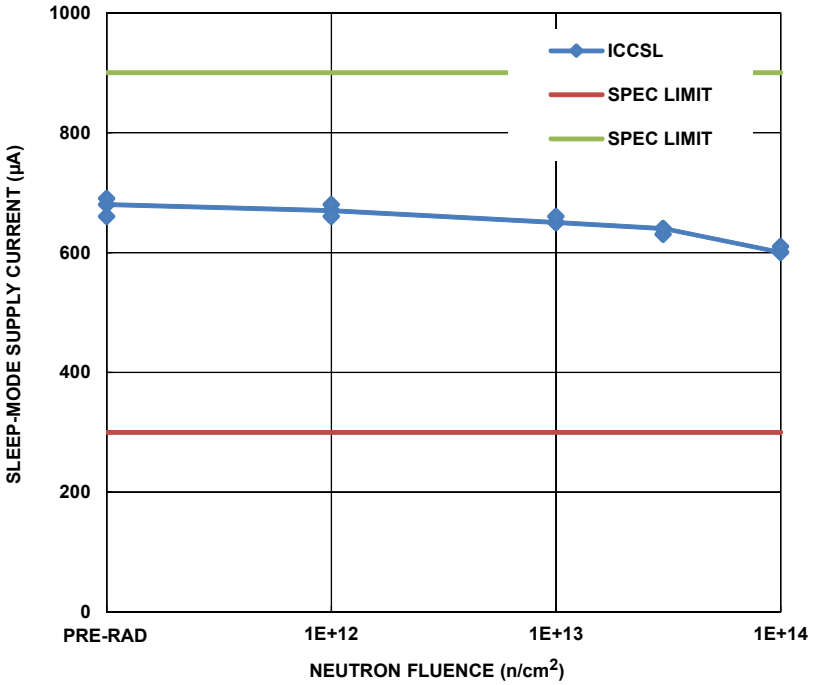


**FIGURE 2. IS-1715ARH Sleep mode supply current as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 300µA to 900µA.**

## Variables Data Plots (Continued)

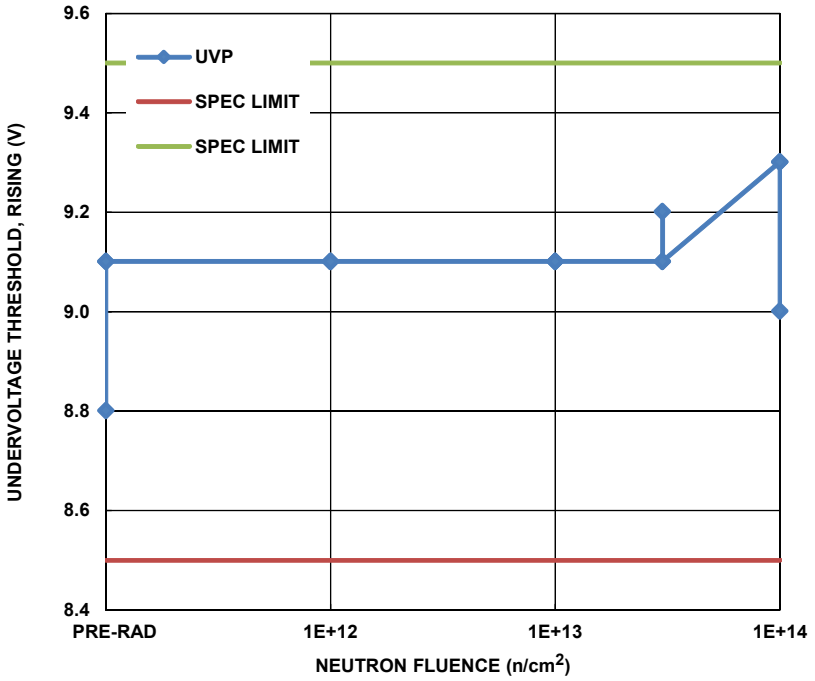


**FIGURE 3. IS-1715ARH Undervoltage Lockout (UVLO) rising threshold as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 8.5V to 9.5V.**

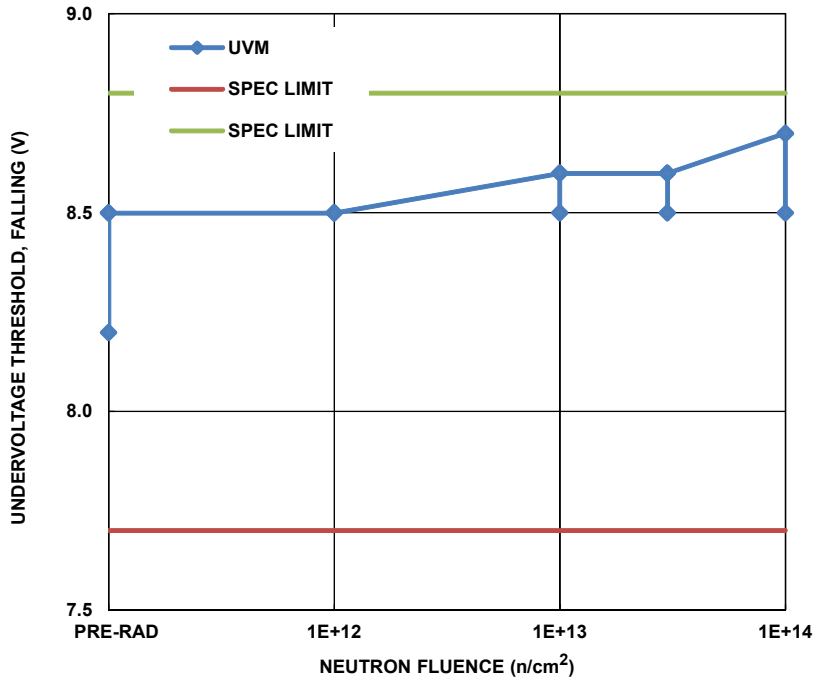


**FIGURE 4. IS-1715ARH Undervoltage Lockout (UVLO) falling threshold as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 7.7V to 8.8V.**

## Variables Data Plots (Continued)

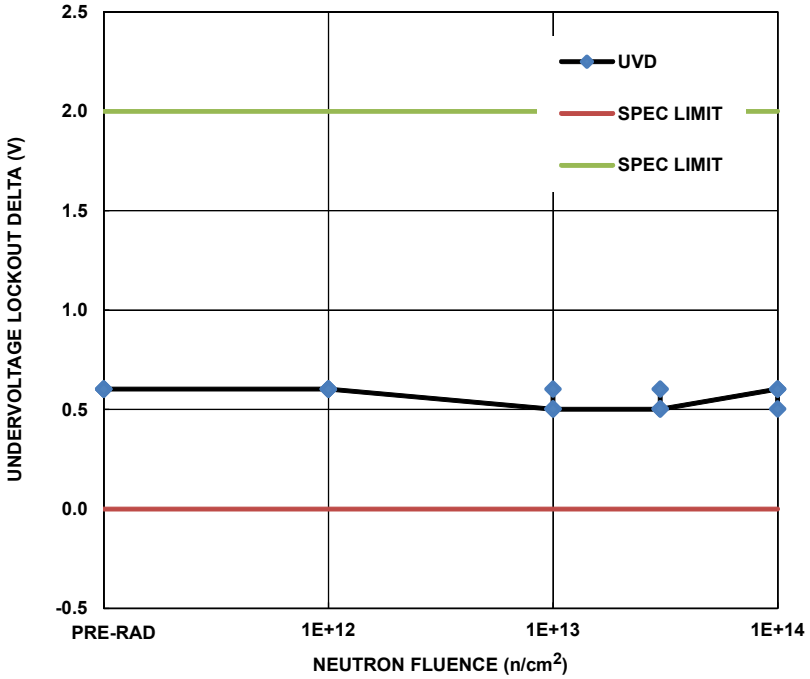


**FIGURE 5. IS-1715ARH Undervoltage Lockout (UVLO) delta as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 0V to 2V.**

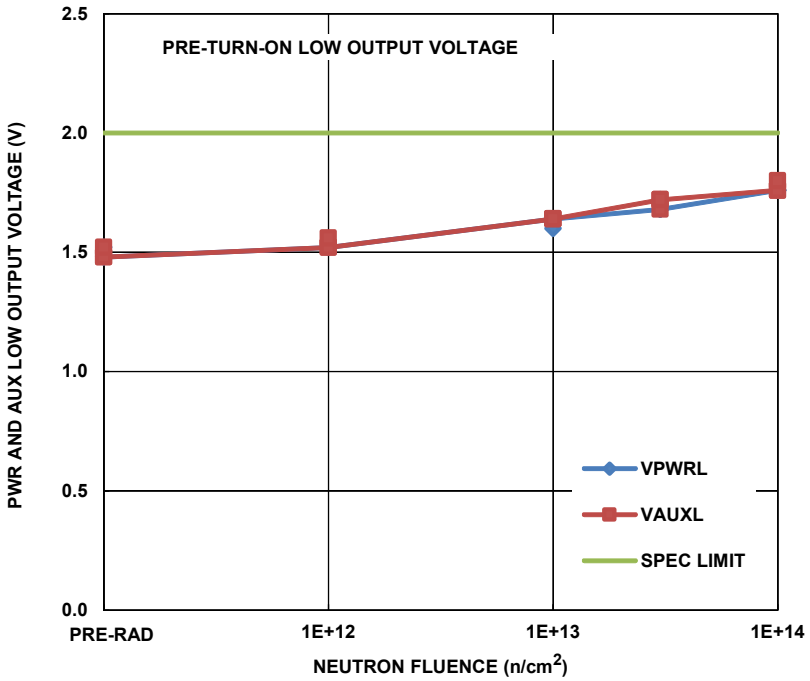


**FIGURE 6. IS-1715ARH pre-turn-on PWR and AUX stage LOW output voltage as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limit is 2V maximum for both parameters.**

## Variables Data Plots (Continued)

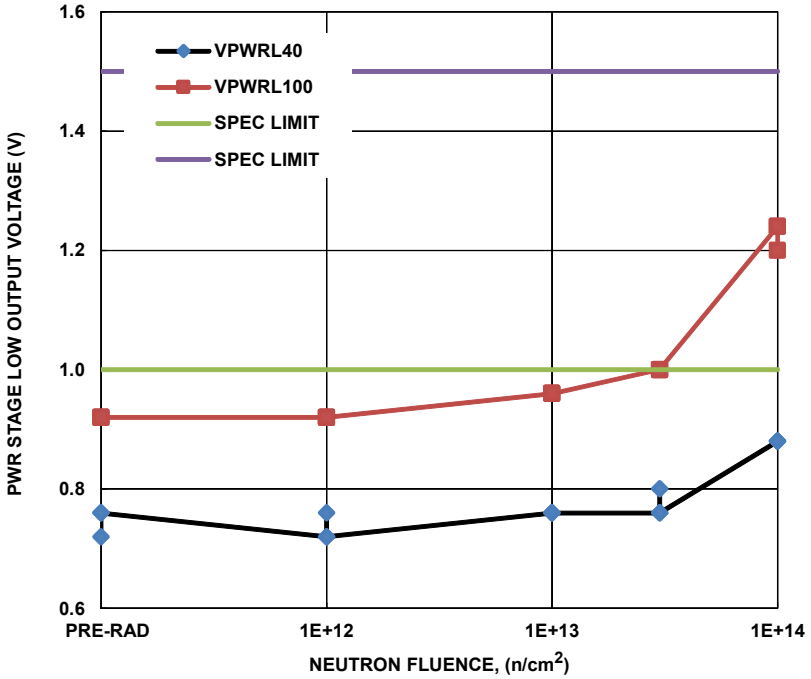


**FIGURE 7. IS-1715ARH PWR stage saturated LOW output voltage, 40mA and 100mA load current cases, as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 1V maximum (40mA load current case) and 1.5V maximum (100mA load current case).**

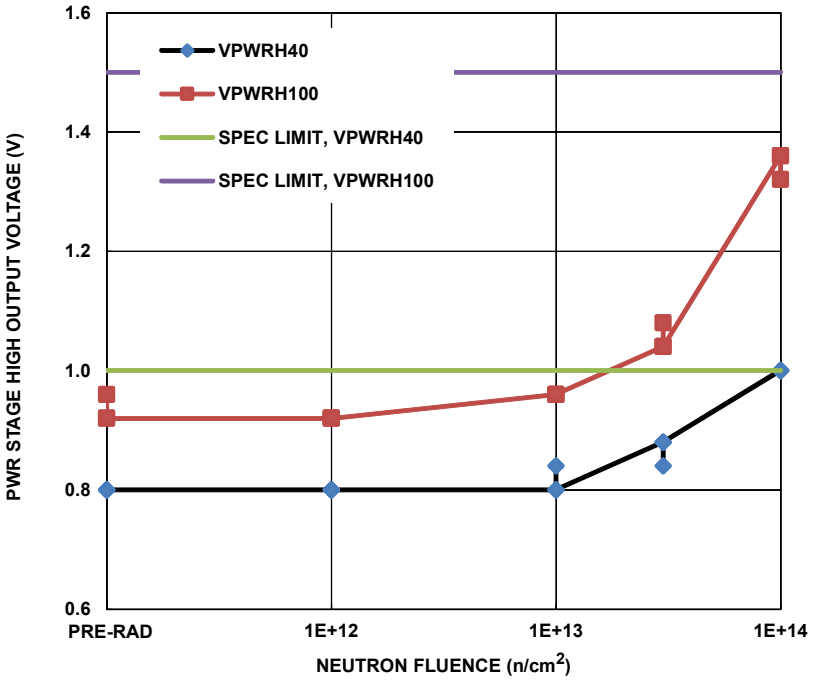


**FIGURE 8. IS-1715ARH PWR stage saturated HIGH output voltage, 40mA and 100mA load current cases, as a function of neutron irradiation, showing the median, minimum and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 1V maximum (40mA load current case) and 1.5V maximum (100mA load current case).**

## Variables Data Plots (Continued)

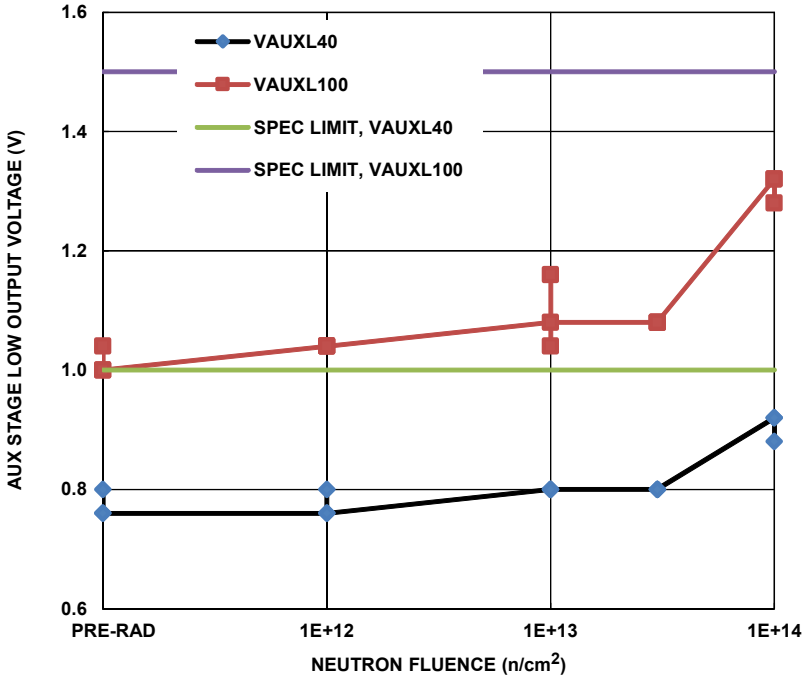


**FIGURE 9.** IS-1715ARH AUX stage saturated LOW output voltage, 40mA and 100mA load current cases, as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 1V maximum (40mA load current case) and 1.5V maximum (100mA load current case).

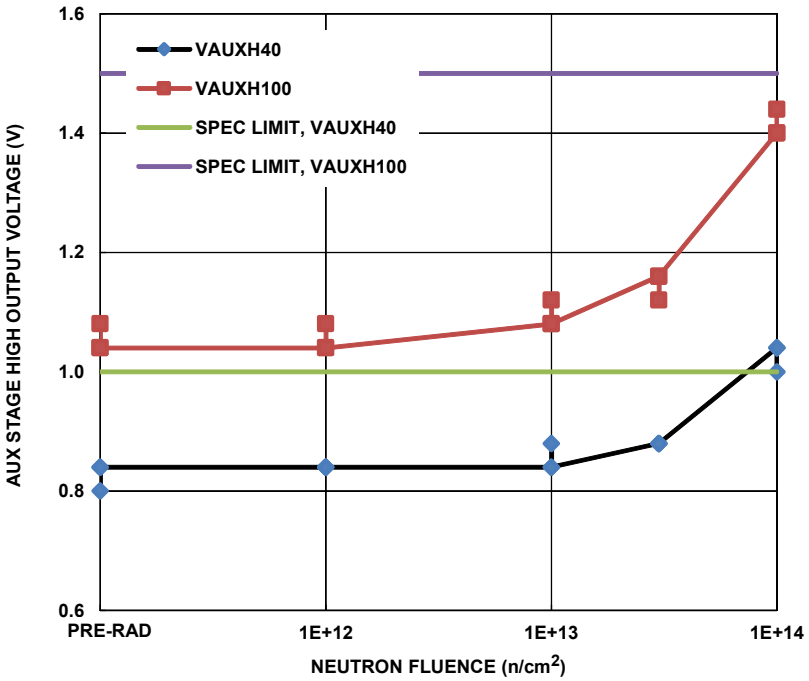


**FIGURE 10.** IS-1715ARH AUX stage saturated HIGH output voltage, 40mA and 100mA load current cases, as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 1V maximum (40mA load current case) and 1.5V maximum (100mA load current case).

## Variables Data Plots (Continued)

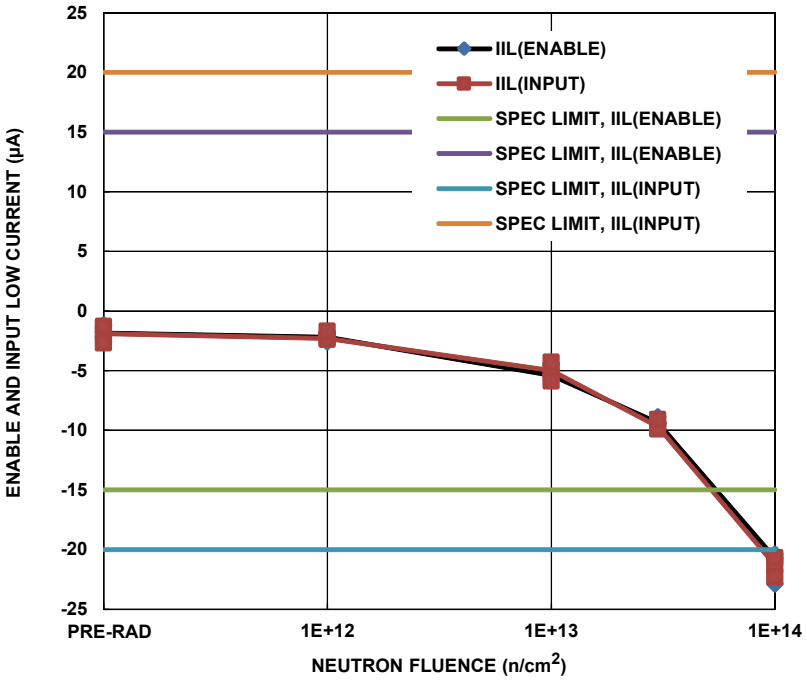


**FIGURE 11. IS-1715ARH Enable and Input LOW input current as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are -15µA to 15µA (Enable) and -20µA to 20µA (Input).**

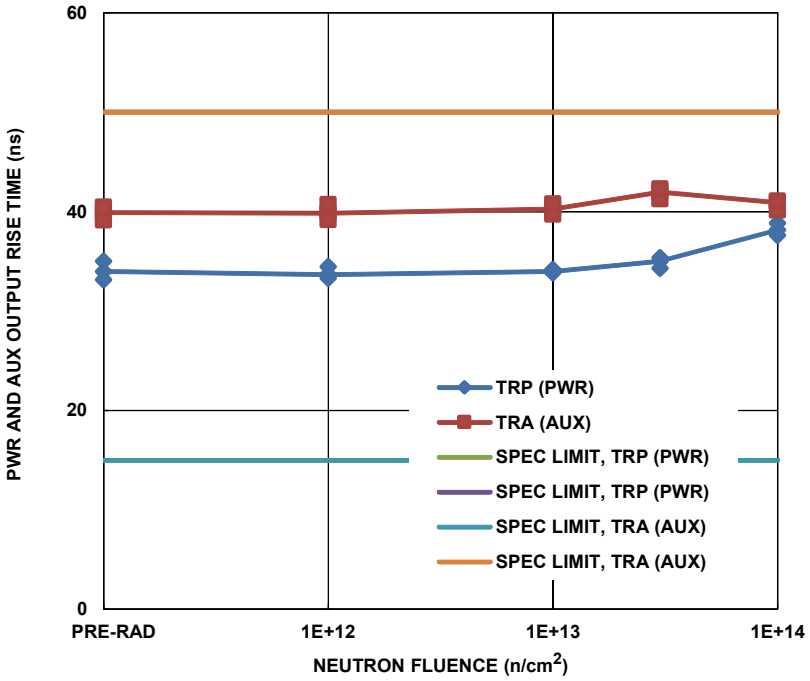


**FIGURE 12. IS-1715ARH PWR and AUX output rise time as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 15ns to 50ns for both parameters.**

## Variables Data Plots (Continued)

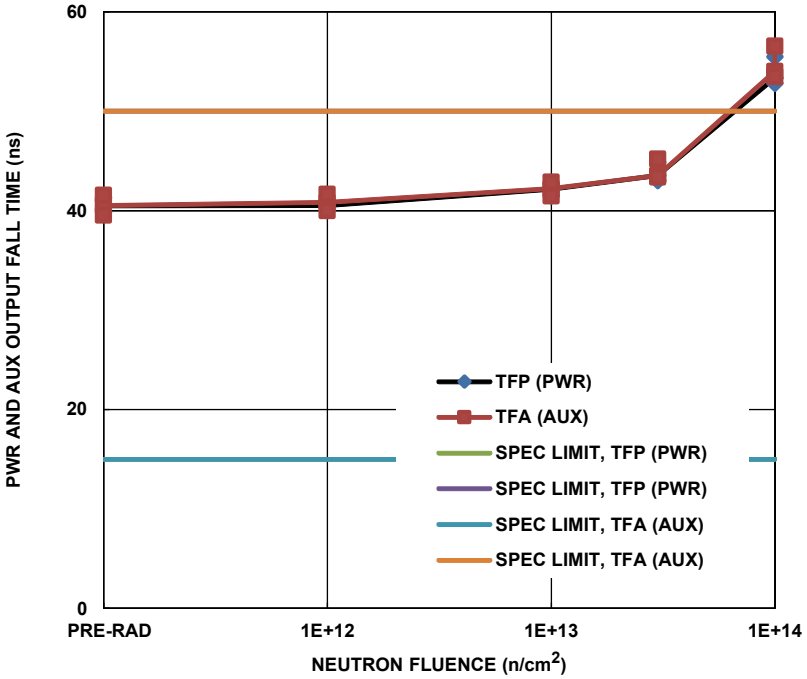


**FIGURE 13. IS-1715ARH PWR and AUX output fall time as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 15ns to 50ns for both parameters.**

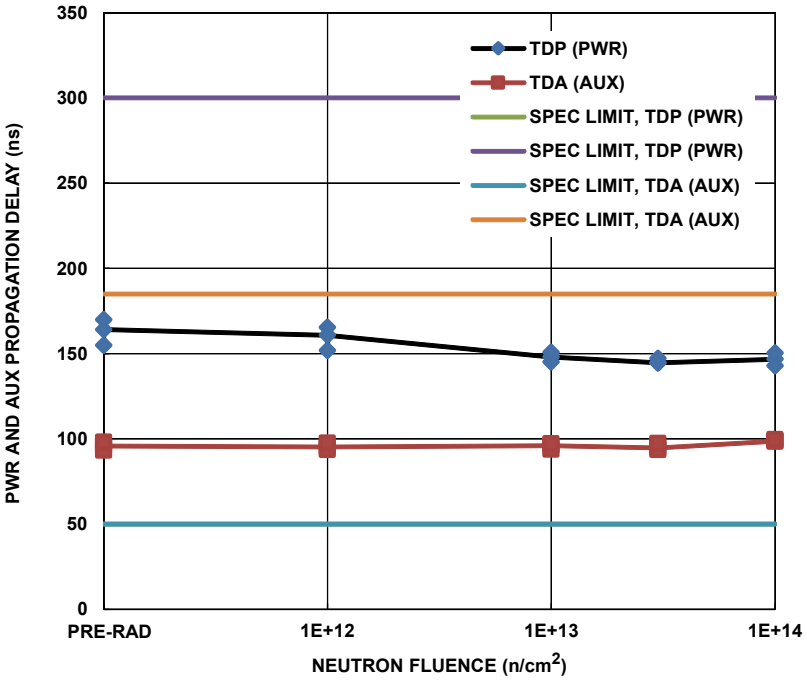


**FIGURE 14. IS-1715ARH PWR and AUX stage propagation delay as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 50ns to 300ns (PWR) and 50ns to 185ns (AUX).**

## Variables Data Plots (Continued)

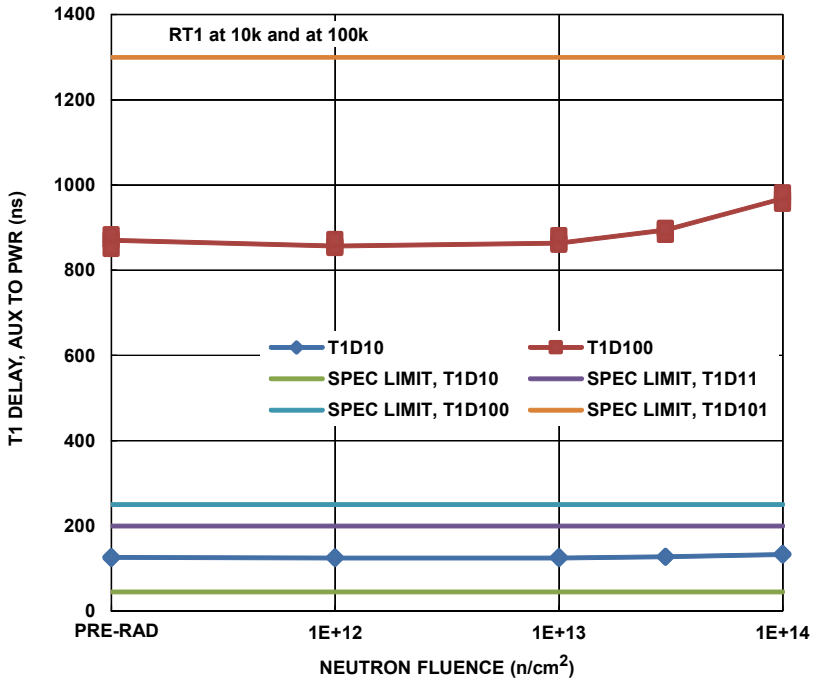


**FIGURE 15. IS-1715ARH T1 input time delay, AUX to PWR, RT1 = 10kΩ and RT1 = 100kΩ, as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 45ns to 200ns (RT1 = 10kΩ) and 250ns to 1300ns (RT1 = 100kΩ).**

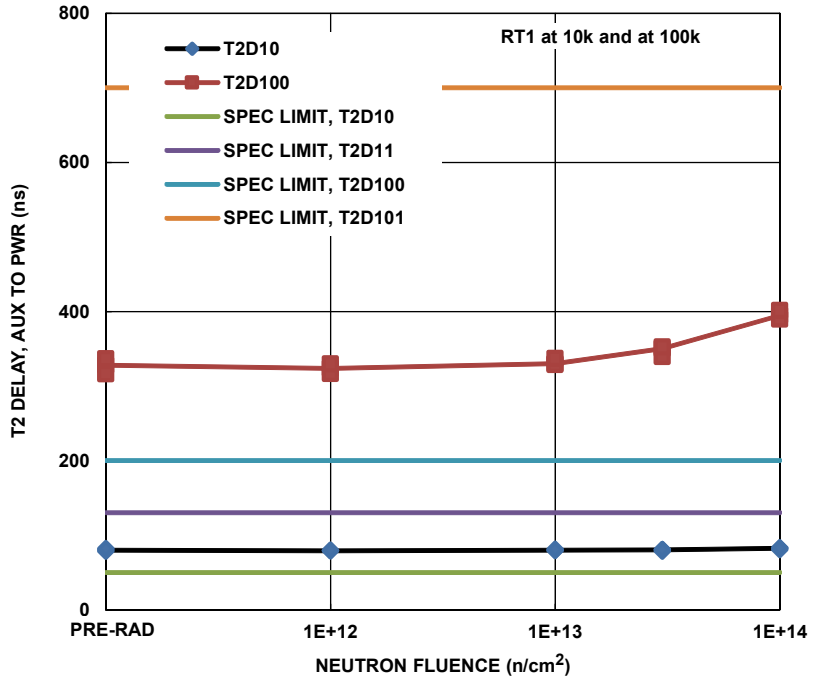


**FIGURE 16. IS-1715ARH T2 input time delay, PWR to AUX, RT1 = 10kΩ and RT1 = 100kΩ, as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 50ns to 130ns (RT1 = 10kΩ) and 200ns to 700ns (RT1 = 100kΩ).**

## Variables Data Plots (Continued)

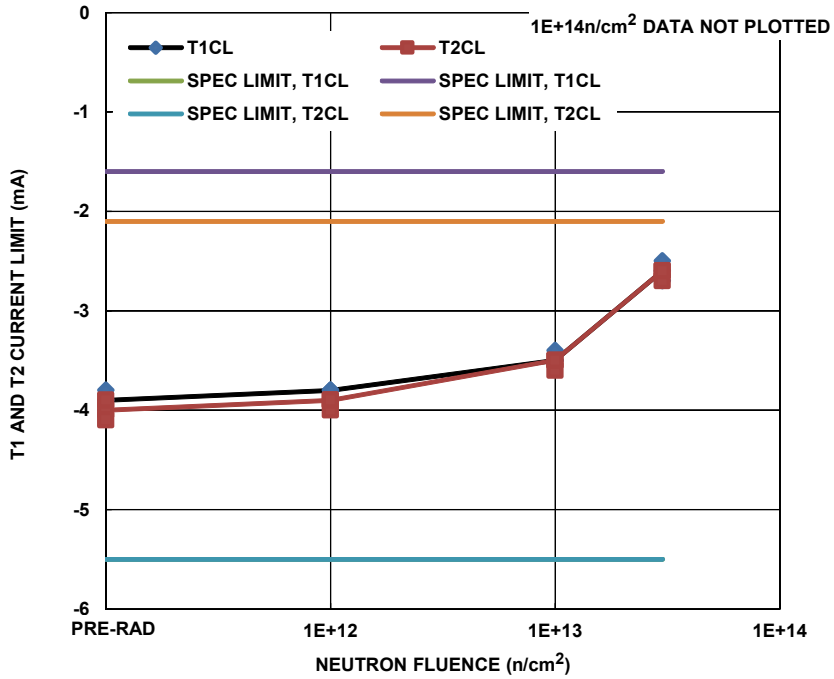


**FIGURE 17. IS-1715ARH T1 and T2 input current limit as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are -5.5mA to -1.6mA (T1) and -5.5mA to -2.1mA (T2). The post $1x10^{14}n/cm^2$ samples were nonfunctional and that data is not plotted.**

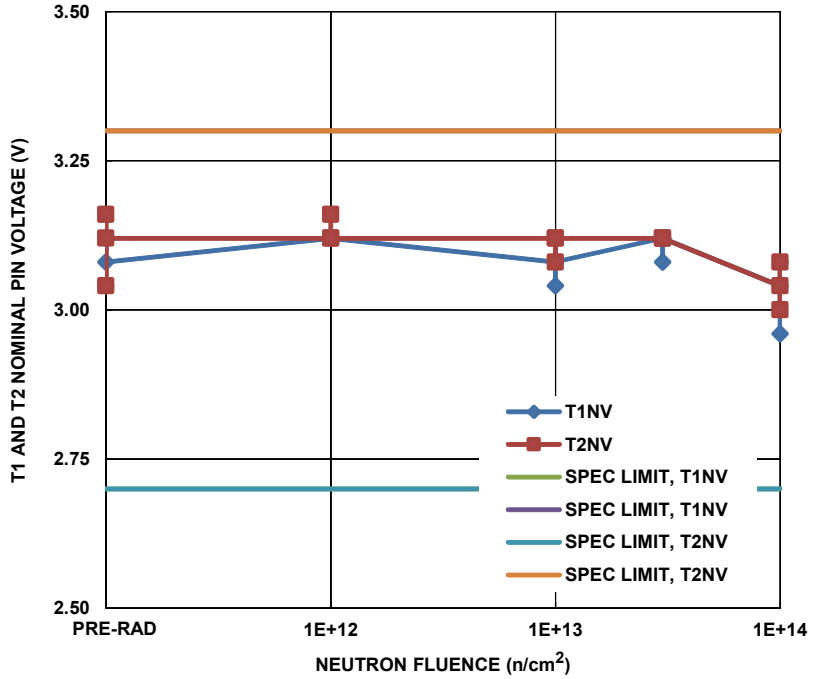


**FIGURE 18. IS-1715ARH T1 and T2 pin nominal voltage as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 2.7V to 3.3V for both parameters.**

## Variables Data Plots (Continued)

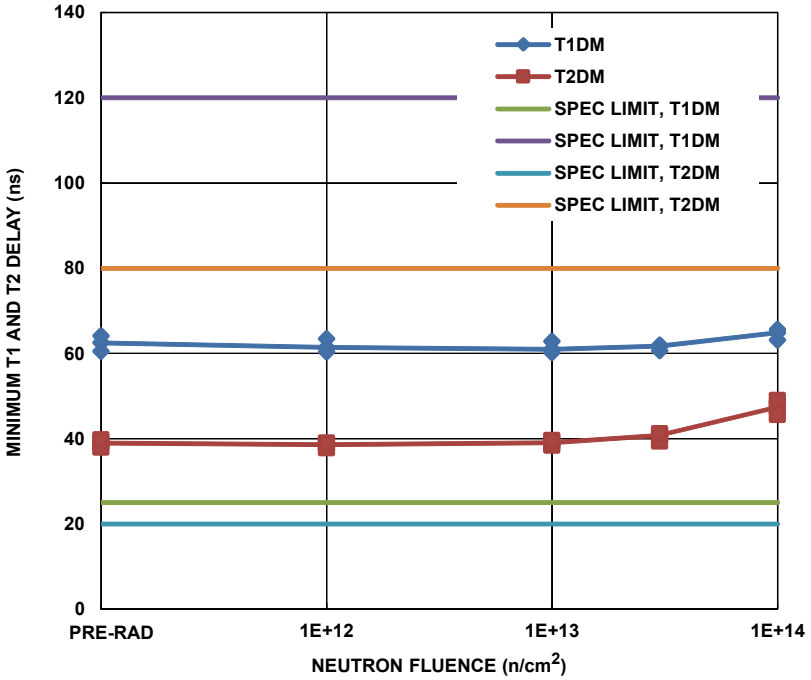


FIGURE 19. IS-1715ARH minimum T1 and T2 input pin delay as a function of neutron irradiation, showing the median, minimum, and maximum of the populations following irradiation to each level. Neutron fluences and sample sizes (in parentheses) were $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$ (five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$ (five samples). For reference, the post total dose SMD limits are 25ns to 120ns (T1) and 20ns to 80ns (T2).

## Discussion and Conclusion

This document reports the results of neutron testing of the IS-1715ARH complementary power MOSFET driver. Samples were irradiated to levels of $1x10^{12}n/cm^2$ (five samples), $1x10^{13}n/cm^2$(five samples), $3x10^{13}n/cm^2$ (five samples), and $1x10^{14}n/cm^2$(five samples). It should again be carefully realized when interpreting the data that each neutron irradiation was performed on a different set of samples; this is not total dose testing, where a single set of samples is used and the damage is cumulative. ATE characterization testing was performed before and after the irradiations, and two control units were used to ensure repeatable data. Variables data for key monitored parameters is presented in Figures 1 through 19.

The IS-1715ARH is not formally designed, screened, or acceptance tested for neutron hardness. The part is built in a dielectrically-isolated BiCMOS process; the bipolar transistors are minority carrier devices with fairly wide active base regions and may be sensitive to displacement damage (DD) at higher neutron fluences.

The PWR and AUX section LOW and HIGH output voltage at $I_{OUT}$ = 40.0mA and $I_{OUT}$ = 40.0mA (Figures 7 through 10) showed good stability through the $3x10^{13}n/cm^2$ level, but was out of specification or nearly so after $1x10^{14}n/cm^2$.

The ENABLE and INPUT pin input LOW currents (Figure 11 on page 7) showed gradual degradation through the $3x10^{13}n/cm^2$ level and were out of specification after $1x10^{14}n/cm^2$.

The PWR and AUX section output fall times (Figure 13 on page 8) showed gradual degradation through the $3x10^{13}n/cm^2$ level and were out of specification after $1x10^{14}n/cm^2$.

The T1 and T2 pin input current limit (Figure 17 on page 10) was stable through $1x10^{13}n/cm^2$, but increased to nearly the SMD limit at $3x10^{13}n/cm^2$ and was nonfunctional at $1x10^{14}n/cm^2$. The post $1x10^{14}n/cm^2$ data is not plotted.

We conclude that the IS-1715ARH is capable of post $3x10^{13}n/cm^2$ operation (likely with some relaxation of parametric specifications) within the post total dose SMD parameters. The part is not capable of post $1x10^{14}n/cm^2$ operation as it was nonfunctional following irradiation to that level, failing several parameters.

# Appendix

## Reported Parameters

TABLE 1. REPORTED PARAMETERS

| FIGURE | PARAMETER | LOW | HIGH | UNITS | NOTES |
|---|---|---|---|---|---|
| 1 | Nominal Power Supply Current | 1 | 6 | mA | |
| 2 | Sleep Mode Power Supply Current | 300 | 900 | µA | |
| 3 | Undervoltage Lockout Threshold, Rising | 8.5 | 9.5 | V | |
| 4 | Undervoltage Lockout Threshold, Falling | 7.7 | 8.8 | V | |
| 5 | Undervoltage Lockout Delta | 0 | 2 | V | |
| 6 | PWR and AUX Output Voltage | - | 2 | V | Pre-turn-on |
| 7 | PWR Stage LOW Output Voltage | - | 1/1.5 | V | $I_{OUT}$ = 40mA and 100mA |
| 8 | PWR Stage HIGH Output Voltage | - | 1/1.5 | V | $I_{OUT}$ = 40mA and 100mA |
| 9 | AUX Stage LOW Output Voltage | - | 1/1.5 | V | $I_{OUT}$ = 40mA and 100mA |
| 10 | AUX Stage HIGH Output Voltage | - | 1/1.5 | V | $I_{OUT}$ = 40mA and 100mA |
| 11 | Enable LOW Current | -15 | 15 | µA | |
| | Input LOW Current | -20 | 20 | µA | |
| 12 | PWR and AUX Rise Time | 15 | 50 | ns | |
| 13 | PWR and AUX Fall Time | 15 | 50 | ns | |
| 14 | PWR Propagation Delay | 50 | 300 | ns | |
| | AUX Propagation Delay | 50 | 185 | ns | |
| 15 | T1 Input Time Delay | 45 | 200 | ns | RT1 = 10kΩ |
| | T1 Input Time Delay | 250 | 1300 | ns | RT1 = 100kΩ |
| 16 | T2 Input Time Delay | 50 | 130 | ns | RT1 = 10kΩ |
| | T2 Input Time Delay | 200 | 700 | ns | RT1 = 100kΩ |
| 17 | T1 Input Current Limit | -5.5 | -1.6 | mA | |
| | T2 Input Current Limit | -5.5 | -2.1 | mA | |
| 18 | T1 Nominal Pin Voltage | 2.7 | 3.3 | V | |
| | T2 Nominal Pin Voltage | 2.7 | 3.3 | V | |
| 19 | T1 Input Pin Delay | 25 | 120 | ns | |
| | T2 Input Pin Delay | 20 | 80 | ns | |

# Notice

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**Renesas Electronics America Inc.**
1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.
Tel: +1-408-432-8888, Fax: +1-408-434-5351

**Renesas Electronics Canada Limited**
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

**Renesas Electronics Europe Limited**
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

**Renesas Electronics Europe GmbH**
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

**Renesas Electronics (China) Co., Ltd.**
Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

**Renesas Electronics (Shanghai) Co., Ltd.**
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

**Renesas Electronics Hong Kong Limited**
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

**Renesas Electronics Taiwan Co., Ltd.**
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

**Renesas Electronics Singapore Pte. Ltd.**
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

**Renesas Electronics Malaysia Sdn.Bhd.**
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

**Renesas Electronics India Pvt. Ltd.**
No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

**Renesas Electronics Korea Co., Ltd.**
17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5338




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