

HS-117RH

Neutron Testing

TR029
Rev 0.00
May 5, 2016

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the HS-117RH linear voltage regulator. 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 $2 \times 10^{12} \text{ n/cm}^2$ to $1 \times 10^{14} \text{ n/cm}^2$. 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
- [HS-117RH](#) data sheet
- Standard Microcircuit Drawing (SMD) [5962-99547](#)

Part Description

The radiation hardened HS-117RH is an adjustable positive linear voltage regulator capable of operating with input voltages up to 40VDC. The output voltage is adjustable from 1.25V to 37V with two external resistors. The device is capable of sourcing from 5mA to 1.25A maximum (0.5A maximum for the TO-39 package). Current protection is provided by on-chip thermal shutdown and output current limiting circuitry.

Constructed in the Intersil dielectrically isolated Radiation Hardened Silicon Gate (RSG) process, the HS-117RH is immune to single event latch-up and has been specifically designed to provide reliable performance in harsh radiation environments.

The HS-117RH is acceptance tested to a total dose (TID) level of 300krad(Si) at high dose rate (50-300rad(Si)/s). The HS-117EH variant is acceptance tested to a total dose level of 300krad(Si) at high dose rate and to 50krad(Si) at low dose rate (<0.01rad(Si)/s).

TABLE 1. HS-117RH PIN ASSIGNMENTS

TERMINAL NUMBER	TERMINAL SYMBOL
1	IN
2	ADJ
3	OUT

Specifications for radiation hardened QML devices are controlled by the Defense Logistics Agency (DLA) Land and Maritime. The SMD numbers listed in the [HS-117RH](#) datasheet Ordering Information table must be used when ordering. Detailed Electrical Specifications for the HS-117RH and HS-117EH are contained in SMD [5962-99547](#).

Test Description

Irradiation Facilities

1MeV equivalent neutron irradiation was performed by the Boeing team at the White Sands Missile Range fast burst reactor. 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 (Palm Bay, FL) for electrical testing.

Test Fixturing

No formal irradiation test fixturing was involved, as these DD tests are termed 'bag tests' in the sense that the parts are irradiated in an electrically 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 $2 \times 10^{12} \text{ n/cm}^2$, 5 irradiated at $1 \times 10^{13} \text{ n/cm}^2$, 5 irradiated at $3 \times 10^{13} \text{ n/cm}^2$ and 5 irradiated at $1 \times 10^{14} \text{ n/cm}^2$. Five control units were used. HS-117RHF/PROTO samples were drawn from fabrication lot EOM5PAHC and were packaged in the standard hermetic SMD.5 three-terminal CLCC production package. Samples were screened to the SMD limits over temperature before the start of neutron testing.

Results

Neutron testing of the HS-117RH 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. HS-117RH ATTRIBUTES DATA

PART	SERIAL	SAMPLE SIZE	FLUENCE (n/cm ²)	PASS (Note 1)	FAIL	NOTES
HS-117RH	1-5	5	2x10 ¹²	5	0	All passed
HS-117RH	6-10	5	1x10 ¹³	5	0	All passed
HS-117RH	11-15	5	3x10 ¹³	0	5	All failed, parametric
HS-117RH	16-20	5	1x10 ¹⁴	0	5	All failed, nonfunctional

NOTE:

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

Variables Data

The plots in Figures 1 through 7 show data plots for key parameters before and after irradiation to each level. The reported parameters and their datasheet limits are shown in "Appendices" on page 6. As indicated in Table 2 all samples were nonfunctional after exposure to 1x10¹⁴n/cm². For Figure 7, we elected to not plot the data at this level as it has little meaning and makes the data at the other three levels more difficult to interpret. For reference, Figure 6 shows the same parameter (load regulation) for all four neutron levels.

The plots show the population median of each parameter as a function of neutron irradiation as well as population maximum and minimum error bars. 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 HS-117RH 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

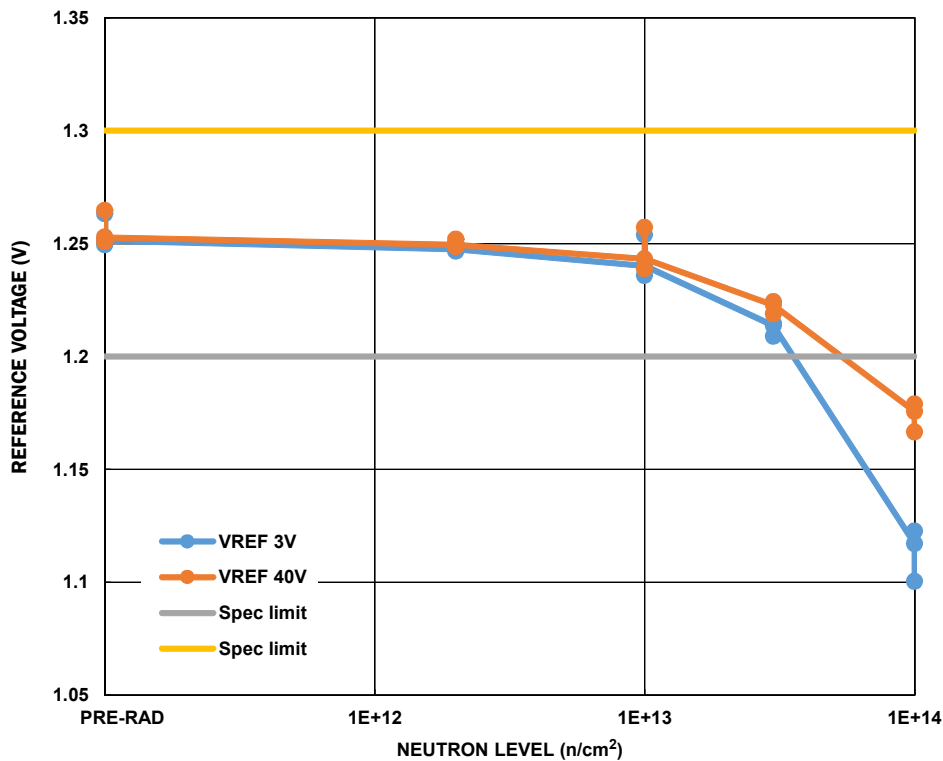


FIGURE 1. HS-117RH reference voltage for the 3V and 40V supply cases, as a function of 1MeV equivalent neutron irradiation at 2x10¹²n/cm², 1x10¹³n/cm², 3x10¹³n/cm² and 1x10¹⁴n/cm². The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 1.2V to 1.3V.

Variables Data Plots (Continued)

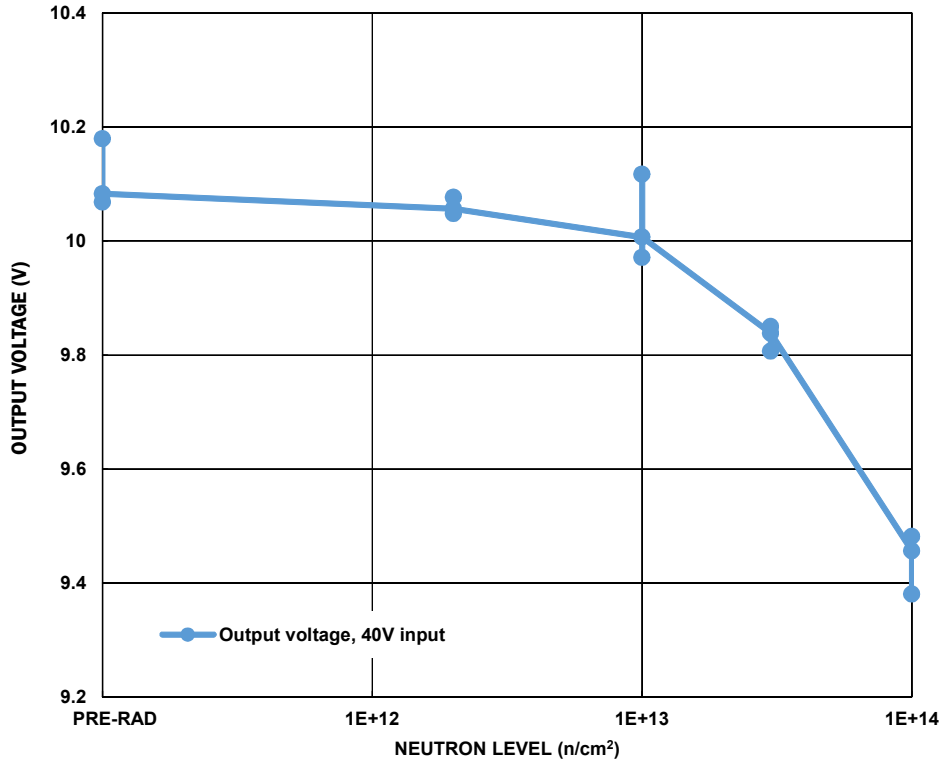


FIGURE 2. HS-117RH output voltage at 40V input as a function of 1MeV equivalent neutron irradiation at $2 \times 10^{12} \text{ n/cm}^2$, $1 \times 10^{13} \text{ n/cm}^2$, $3 \times 10^{13} \text{ n/cm}^2$ and $1 \times 10^{14} \text{ n/cm}^2$. The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. This is an informational parameter only and is not specified in the SMD.

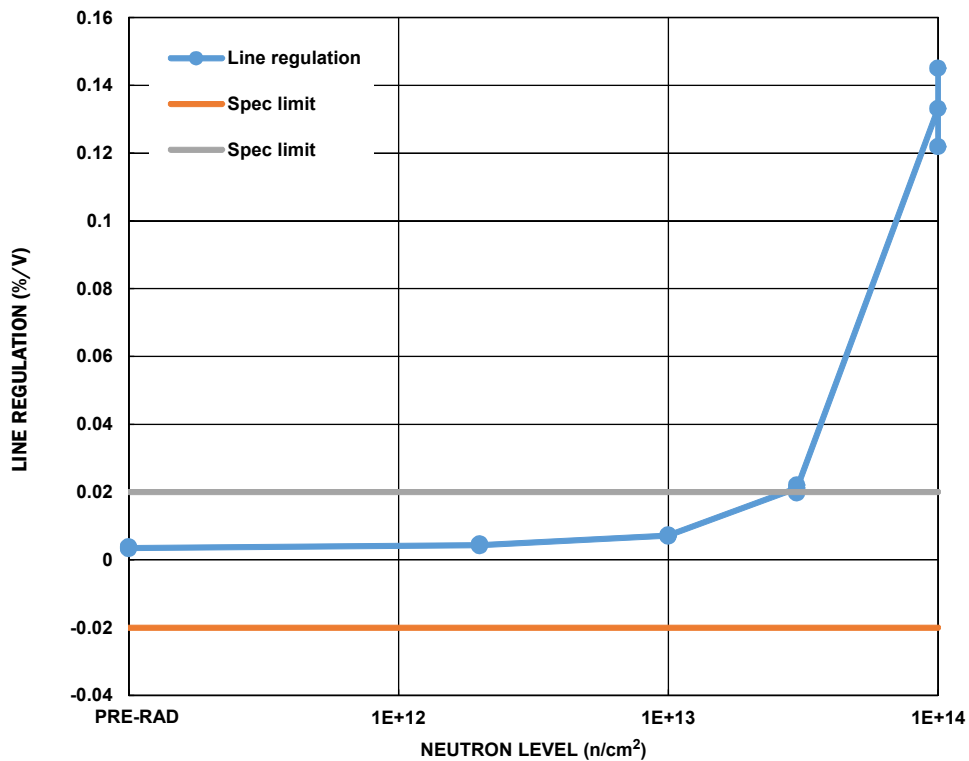


FIGURE 3. HS-117RH line regulation, 3V to 40V, as a function of 1MeV equivalent neutron irradiation at $2 \times 10^{12} \text{ n/cm}^2$, $1 \times 10^{13} \text{ n/cm}^2$, $3 \times 10^{13} \text{ n/cm}^2$ and $1 \times 10^{14} \text{ n/cm}^2$. The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -0.02%/V to 0.02%/V.

Variables Data Plots (Continued)

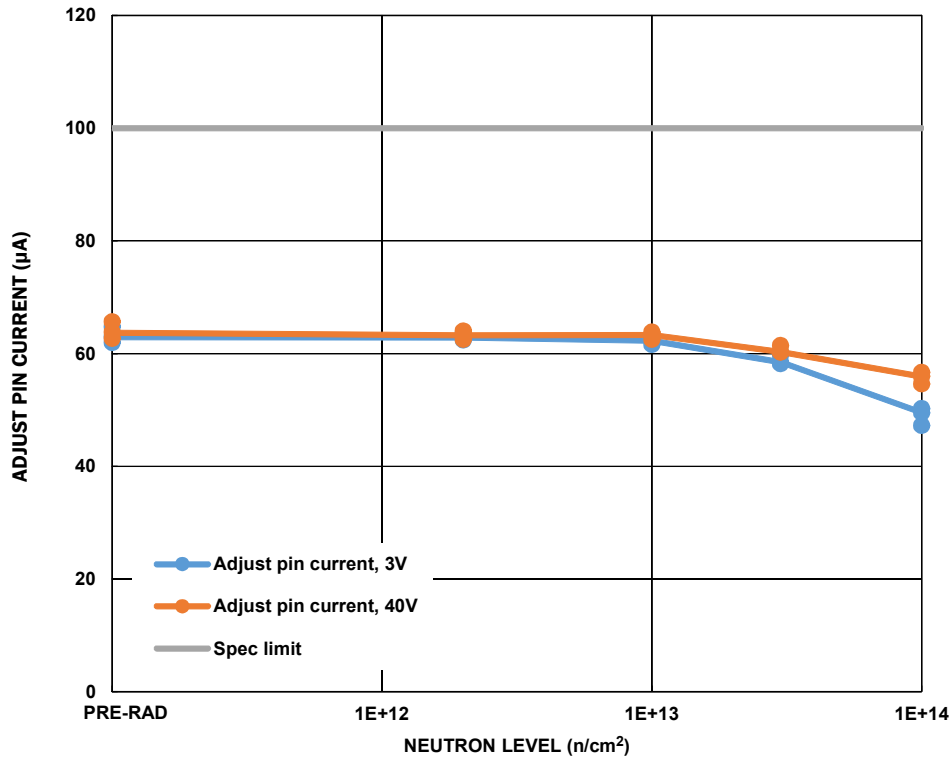


FIGURE 4. HS-117RH adjust pin current, 3V and 40V cases, as a function of 1MeV equivalent neutron irradiation at $2 \times 10^{12} \text{ n/cm}^2$, $1 \times 10^{13} \text{ n/cm}^2$, $3 \times 10^{13} \text{ n/cm}^2$ and $1 \times 10^{14} \text{ n/cm}^2$. The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is 100µA maximum.

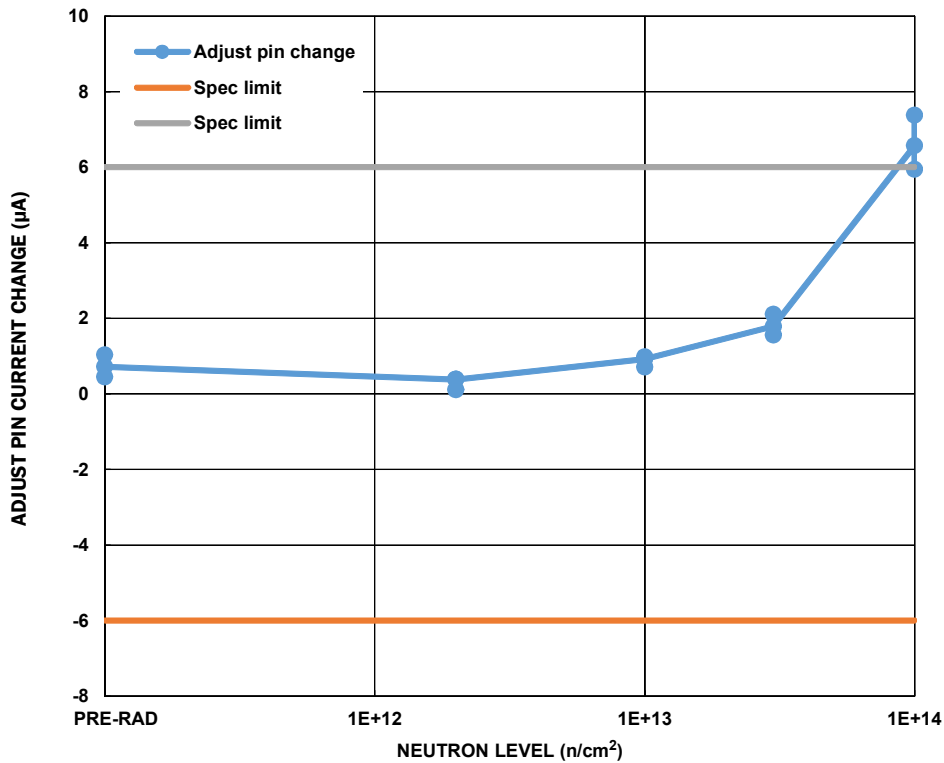


FIGURE 5. HS-117RH adjust pin current change, difference of the adjust pin current at 3V and 40V, as a function of 1MeV equivalent neutron irradiation at $2 \times 10^{12} \text{ n/cm}^2$, $1 \times 10^{13} \text{ n/cm}^2$, $3 \times 10^{13} \text{ n/cm}^2$ and $1 \times 10^{14} \text{ n/cm}^2$. The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -6µA to 6µA.

Variables Data Plots (Continued)

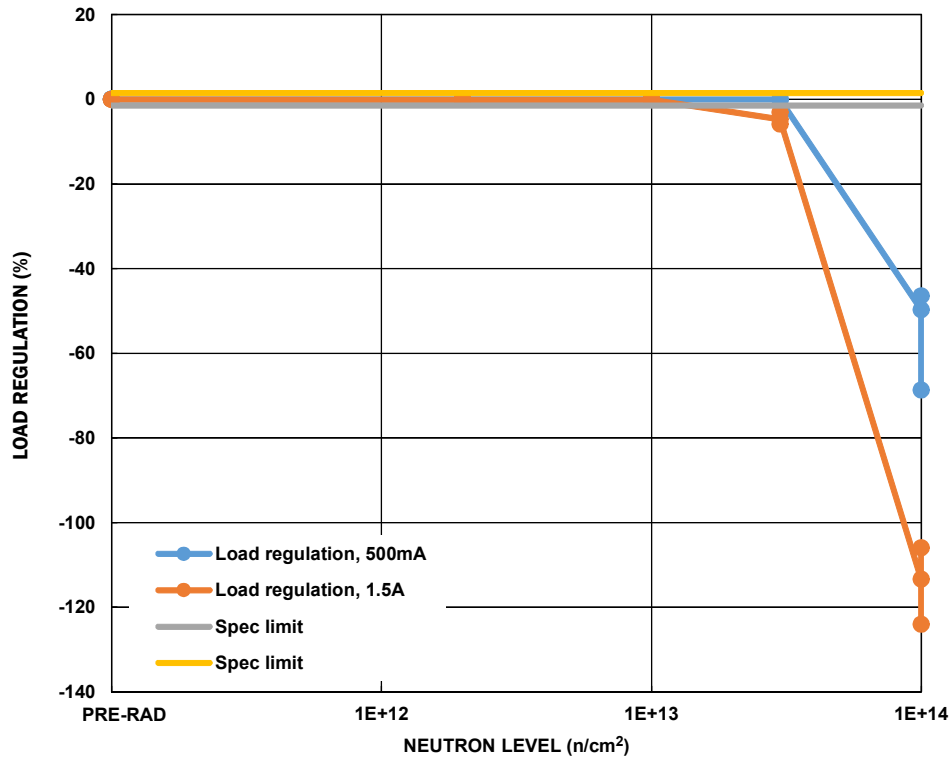


FIGURE 6. HS-117RH load regulation, 500mA and 1.5A cases, as a function of 1MeV equivalent neutron irradiation at $2 \times 10^{12} \text{ n/cm}^2$, $1 \times 10^{13} \text{ n/cm}^2$, $3 \times 10^{13} \text{ n/cm}^2$ and $1 \times 10^{14} \text{ n/cm}^2$. The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -1.5% to 1.5%.

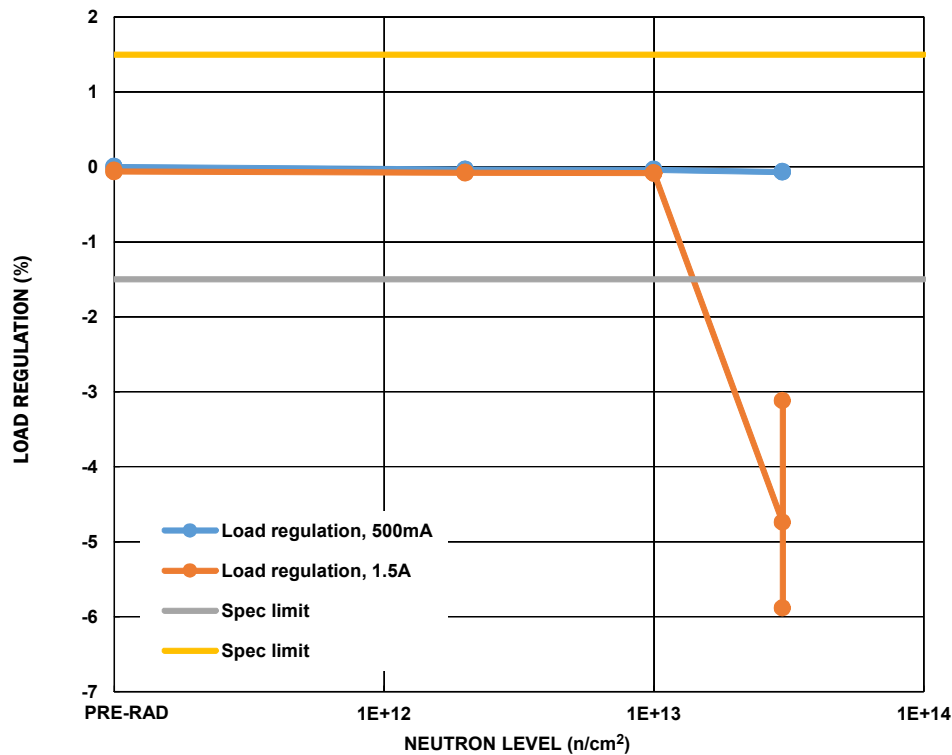


FIGURE 7. HS-117RH load regulation, 500mA and 1.5A cases, as a function of 1MeV equivalent neutron irradiation at $2 \times 10^{12} \text{ n/cm}^2$, $1 \times 10^{13} \text{ n/cm}^2$ and $3 \times 10^{13} \text{ n/cm}^2$. The plot is the same as Figure 6 with the $1 \times 10^{14} \text{ n/cm}^2$ data suppressed in order to enable evaluation of the parameter's response after $3 \times 10^{13} \text{ n/cm}^2$. The plot shows the population median and minimum and maximum error bars at each datapoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -1.5% to 1.5%.

Conclusion

This report summarizes results of 1MeV equivalent neutron testing of the HS-117RH linear voltage regulator. 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 $2 \times 10^{12} \text{ n/cm}^2$ to $1 \times 10^{14} \text{ n/cm}^2$. 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 $2 \times 10^{11} \text{ n/cm}^2$ and $1 \times 10^{13} \text{ n/cm}^2$. All five samples failed the several load regulation parameters after $3 \times 10^{13} \text{ n/cm}^2$. All samples were nonfunctional after the $1 \times 10^{14} \text{ n/cm}^2$ irradiation testing, and we

omitted plotting the resulting extreme ATE overrange values for [Figure 7](#) as they are meaningless and make the data at the other three levels much more difficult to interpret by distorting the vertical axis scale.

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. A number of parameters are plotted in the same figure in order to save space. The plots show the population median, minimum and maximum error bars at each downpoint.

TABLE 3.

FIGURE #	PARAMETER	LIMIT, LOW	LIMIT, HIGH	UNITS	NOTES
1	Reference Voltage	1.2	1.3	V	3V and 40V
2	Output Voltage	-	-	V	Information only
3	Line Regulation	-0.02	0.02	%/V	
4	Adjust Pin Current	-	100	μA	
5	Adjust Pin Current Change	-6	6	μA	3V to 40V
6	Load Regulation	-1.5	1.5	%	
7	Load Regulation	-1.5	1.5	%	Expanded scale plot

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.
Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

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