HS-117RH

1MeV Equivalent Neutron Testing of the HS-117RH Linear Voltage Regulator

Introduction

This report summarizes results of 1MeV equivalent neutron testing of the HS-117RH linear voltage regulator. The test was conducted 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 $1x10^{14}n/cm^2$. This project was carried out in collaboration with Boeing (El Segundo, CA), whose support is gratefully acknowledged.

Related Literature

- MIL-STD-883 test method 1017
- HS-117RH datasheet
- Standard Microcircuit Drawing (SMD) 5962-99547

Product 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 Renesas 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.

1. Test Description

1.1 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 Renesas (Palm Bay, FL) for electrical testing.

1.2 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.

1.3 Characterization Equipment and Procedures

Electrical testing was performed before and after irradiation using the Renesas Palm Bay, FL automated test equipment (ATE). All electrical testing was performed at room temperature.

1.4 Experimental Matrix

The experimental matrix consisted of 5 samples irradiated at $2x10^{12}n/cm^2$, 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. HS-117RHF/PROTO samples were drawn from fabrication lot E0M5PAHC 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.

2. 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.

2.1 Attributes Data

Table 2. HS-117RH Attributes Data

Part	Serial	Sample Size	Fluence (n/cm^2)	Pass[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

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

2.2 Variables Data

The plots in Figure 1 through Figure 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. As indicated in Table 2 all samples were nonfunctional after exposure to $1x10^{14}n/cm^2$. 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.

2.2.1 Variables Data Plots

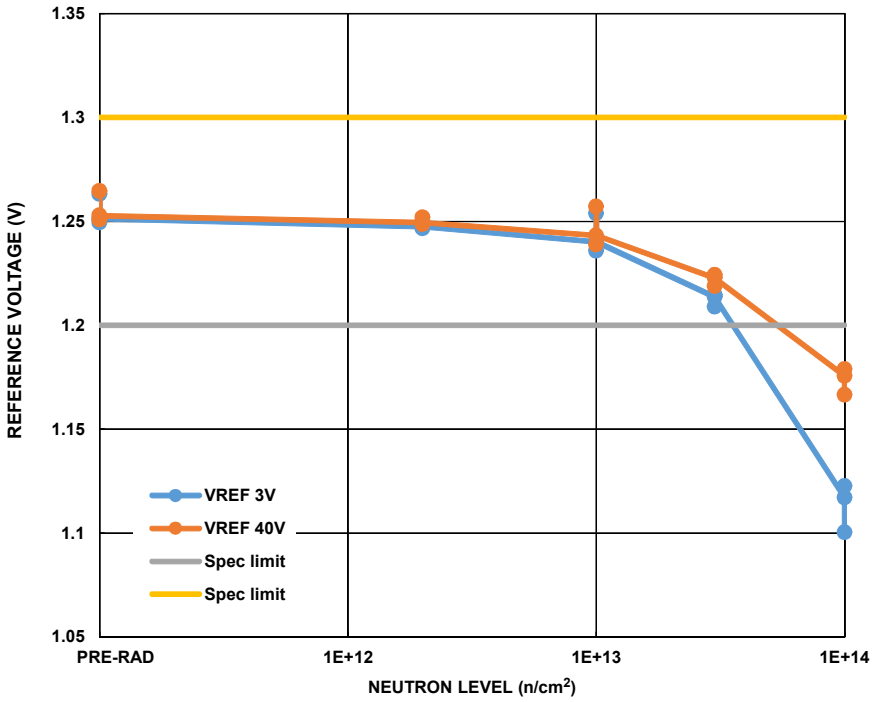

Figure 1. HS-117RH reference voltage for the 3V and 40V supply cases, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are 1.2V to 1.3V.

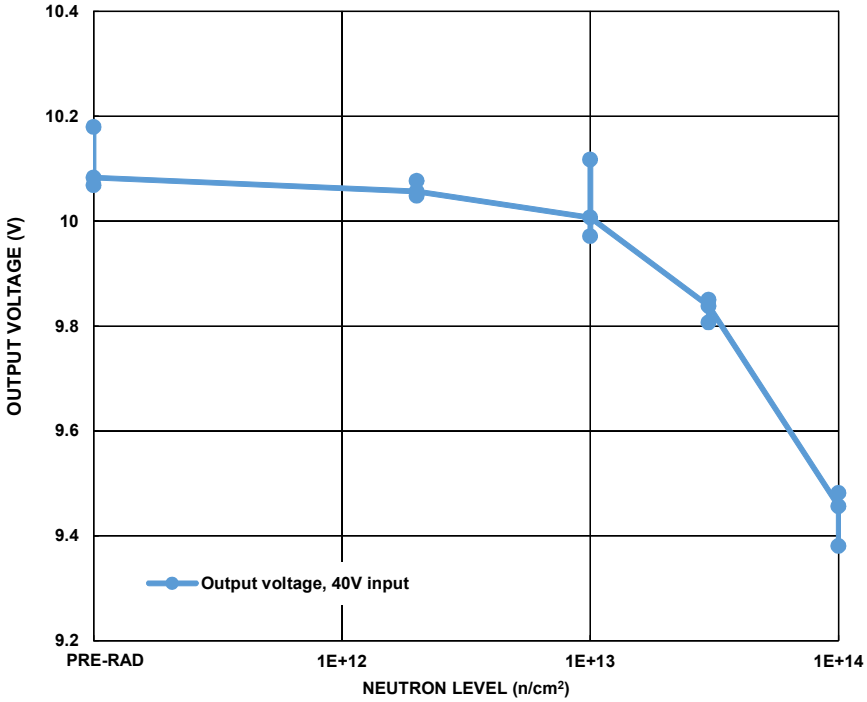

Figure 2. HS-117RH output voltage at 40V input as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. This is an informational parameter only and is not specified in the SMD.

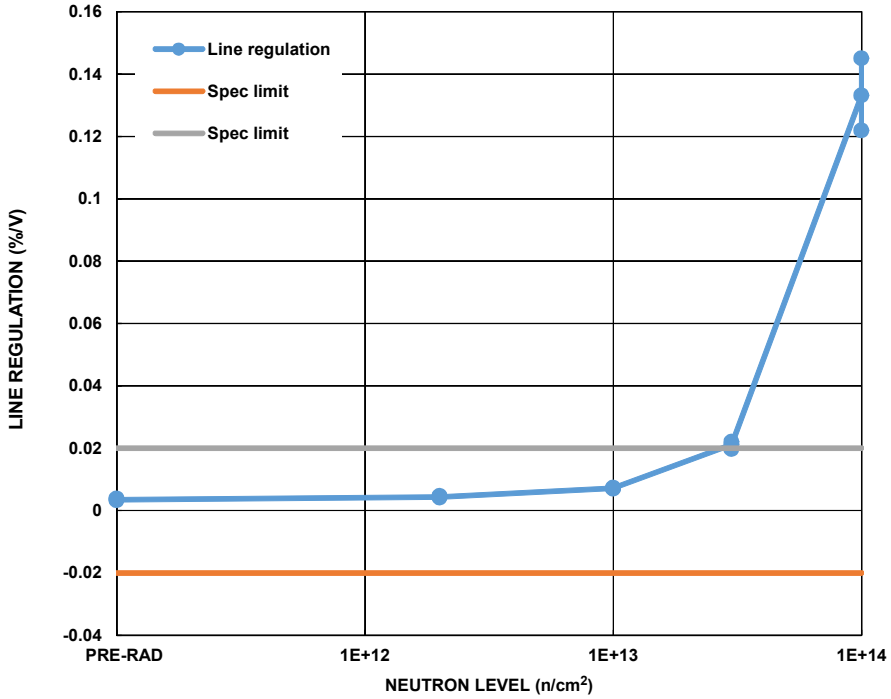

Figure 3. HS-117RH line regulation, 3V to 40V, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -0.02%/V to 0.02%/V.

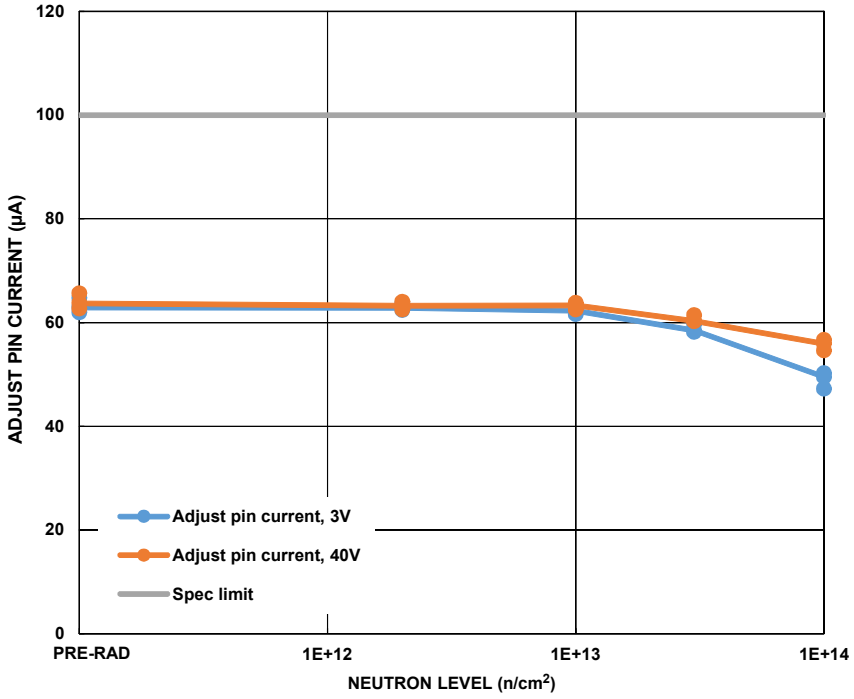

Figure 4. HS-117RH adjust pin current, 3V and 40V cases, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limit is 100µA maximum.

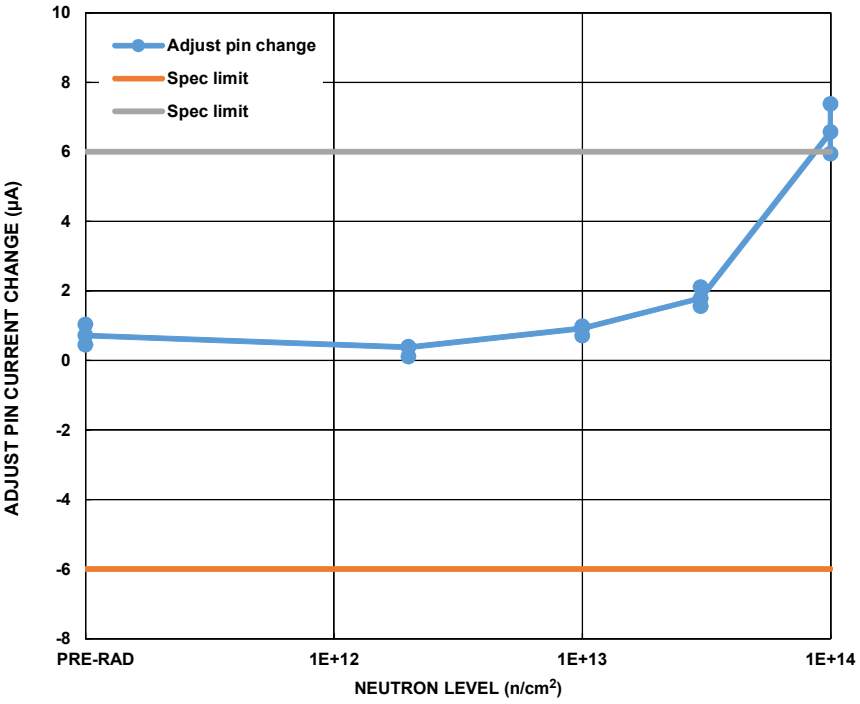

Figure 5. HS-117RH adjust pin current change, difference of the adjust pin current at 3V and 40V, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -6µA to 6µA.

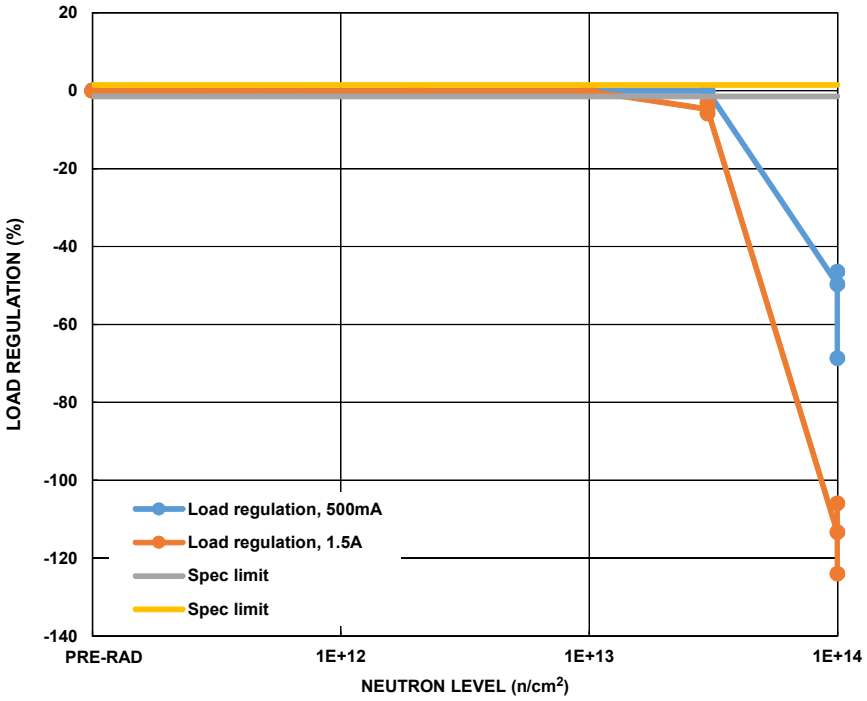

Figure 6. HS-117RH load regulation, 500mA and 1.5A cases, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$, $3x10^{13}n/cm^2$ and $1x10^{14}n/cm^2$. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -1.5% to 1.5%.

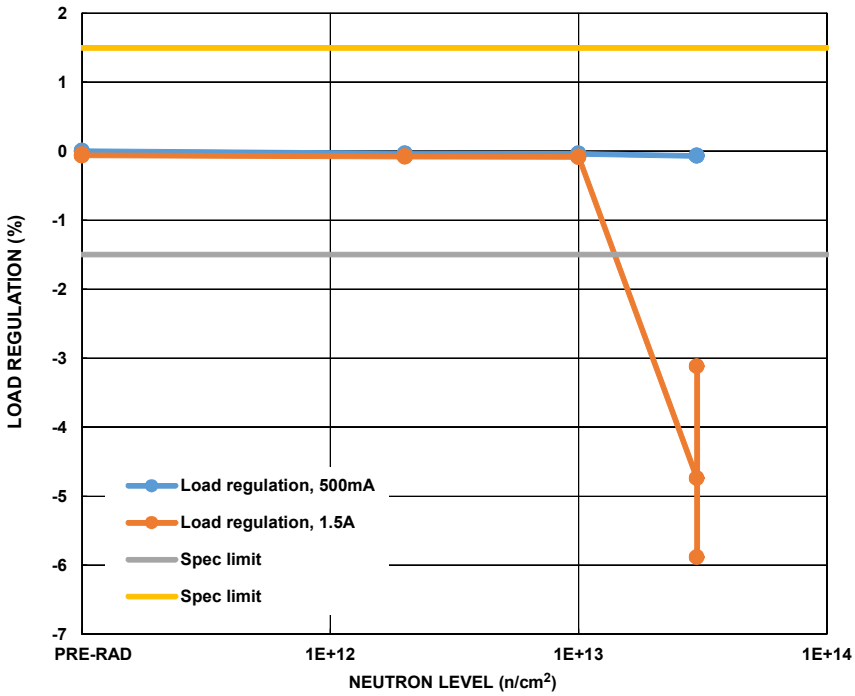

Figure 7. HS-117RH load regulation, 500mA and 1.5A cases, as a function of 1MeV equivalent neutron irradiation at $2x10^{12}n/cm^2$, $1x10^{13}n/cm^2$ and $3x10^{13}n/cm^2$. The plot is the same as Figure 6 with the $1x10^{14}n/cm^2$ data suppressed in order to enable evaluation of the parameter's response after $3x10^{13}n/cm^2$. The plot shows the population median and minimum and maximum error bars at each downpoint. Sample size for each cell was 5. The post-total dose irradiation SMD limits are -1.5% to 1.5%.

3. 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 $2x10^{12}n/cm^2$ 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 $2x10^{12}n/cm^2$ and $1x10^{13}n/cm^2$. All five samples failed the several load regulation parameters after $3x10^{13}n/cm^2$. All samples were nonfunctional after the $1x10^{14}n/cm^2$ 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.

4. Appendices

4.1 Reported Parameters

Reported parameters are shown in Table 3. The limits are taken from the applicable SMD. 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. Reported Parameters

Figure Number	Parameter	Low Limit	High Limit	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

5. Revision History

Revision	Date	Description
1.00	Apr 28, 2025	Applied new template. Updated the Variables Data section. Fixed typo in the Conclusion section. Updated the Reported Parameters section. Added Revision History section.
0.00	May 5, 2016	Initial release.

IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD-PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers who are designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only to develop an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third-party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising from your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Disclaimer Rev.1.01)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit www.renesas.com/contact-us/.

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.