

Introduction

This application note describes the feature of moving the frequency by a small amount within the VersaClock[®] 5 (VC5) and VersaClock 6 (VC6) device families. Details are stated on how the frequency changes occur in the device and how to program the frequency changes. Additional measurements made with a Keysight oscilloscope DSO-S 404A illustrate the functionality of this feature. From a few ppm change to a percentage of frequency, the IC can do it all in a seamless programmable fashion.

Diverse applications require glitchless frequency change like the ones mentioned below:

- **Frequency Margining** which is a process where the nominal oscillator frequency is shifted higher, or lower, to understand and evaluate the robustness of a digital system. By increasing or decreasing the frequency, the system designer can test the limits (in other words, margin) of their system.
- Small frequency changes can be made in video applications to enable gunlock synchronization.
- Some applications using spread spectrum may also need small frequency changes.

VersaClock 5/6 Programmable Clocks FOD

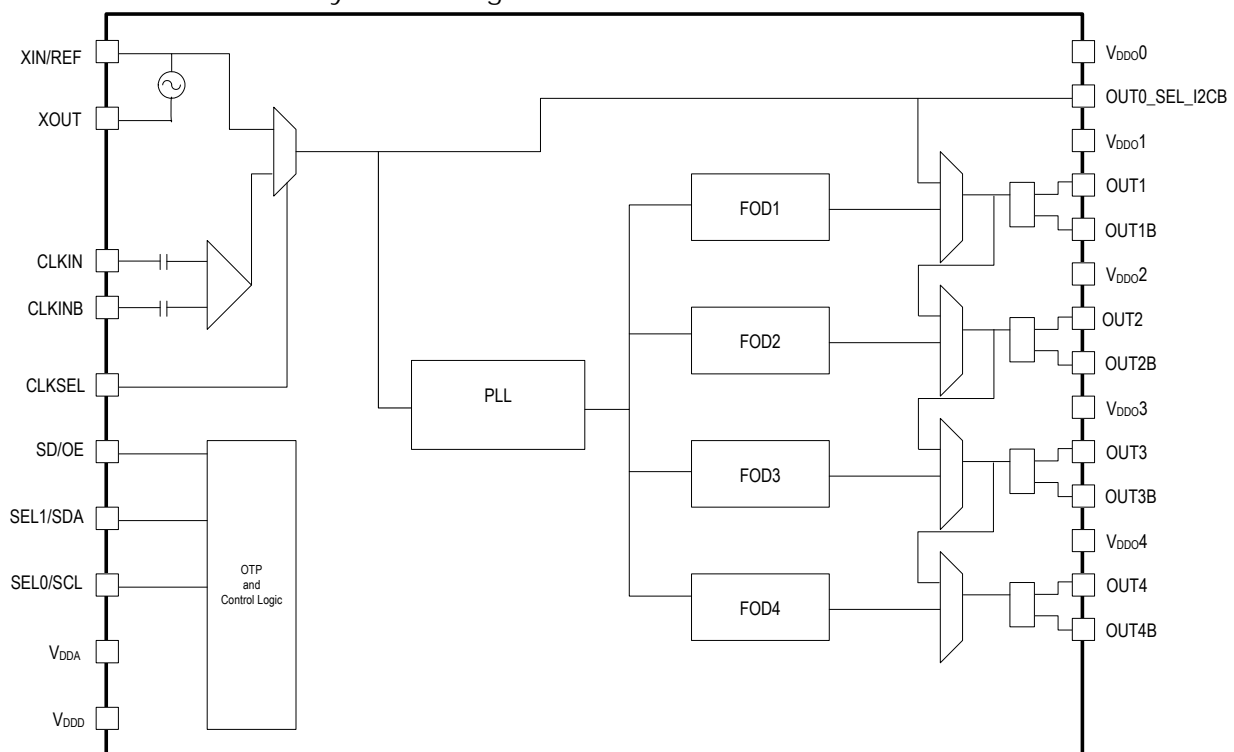
IDT's VersaClock 5 and VersaClock 6 programmable clocks are able to perform a glitchless frequency changes via their FOD (Fractional Output Divider) block.

The resolution will be $1/(N \times 2^P)$ where N is the programmed integer and P is the amount of bits for the fraction. The smallest N is 4 and with 24 bits fractional; the worst case resolution is $1/(4 \times 2^{24}) = 1.5E-8$ or 0.015ppm. The 24-bit accurate FODs are capable of accuracy better than **0.015ppm**.

The FOD can be programmed to get an output from 1MHz to 350MHz for the same VCO frequency. Total FOD division ratio will be $(Int + Frac/2^{24}) \times 2$.

The block diagram in [Figure 1](#) shows the details of the VersaClock 5 and VersaClock 6 output architecture. Each output has its own FOD which enables a flexibility to program different frequency margining changes for each output. The FODs are programmable through an I²C interface. A full description is available in VC5 and VC6 register programming (see <https://www.idt.com/document/mau/versaclock-5-family-register-descriptions-and-programming-guide>).

Figure 1. VersaClock 5/6 Family Block Diagram



Frequency Margin Programming Example

Below is an example of programming the FOD1 for output 1, starting with 100MHz and moving the frequency by +1% and -1%:

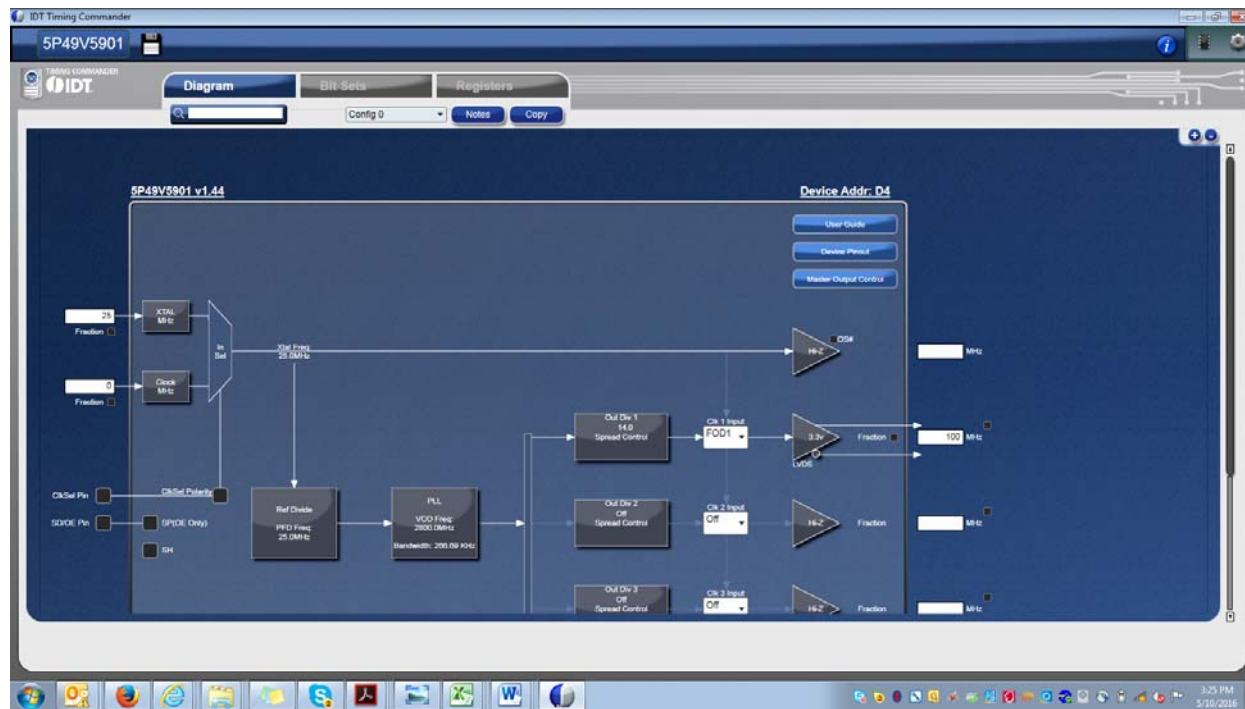
Table 1. FOD1 Settings for OUT1 = 100MHz

FOD1 settings	Output (MHz)	FOD Value Decimal	Integer Registers 0x2D 0x2E	Offset Value Decimal	Offset Registers 0x22 0x23 0x24 0x25
Starting frequency	100	14	00 E0	0	00 00 00 00
+1%	101	13.86138614	00 D0	0.86138614	03 72 0F 34
-1%	99	14.14141414	00 E0	0.14141414	00 90 CE E0

The VCO frequency or PLL block output frequency is 2800MHz in this case. The PLL programming and original FOD setting can be very easily executed with the Timing Commander software supporting the VC5 family (see Figure 2 below).

See more details about Timing Commander at <https://www.idt.com/document/mas/versaclock-5-timing-commander-users-guide>.

Figure 2. Timing Commander Settings for 100MHz Output Clock



After programming the device via I²C to the desired frequency, with all PLL settings and other output type settings, the FOD register can be specifically reprogrammed to change it to a different frequency. The bit setting change can be done with a different I²C Software interface of one's choice, or, contact IDT to obtain access to the internal I²C utility tool. Table 2 below shows an example of the FOD1 bit register change.

Table 2. FOD1 Register Change from 100MHz to 99MHz

Output (MHz)	X22	X23	X24	X25	X26	X27	X28	X29	X2A	X2B	X2C	X2D	X2E	X2F
100	0	0	0	0	0	0	0	0	0	00	00	0	E0	00
99	0	90	CE	E0	0	0	0	0	0	00	00	0	E0	00

After the FOD1 reprogramming occurred, a perfect frequency transition from 100 MHz to 99MHz can be seen without any glitch, ringing or overshoot as shown in Figure 3.

- The green trace shows the final edge in the I²C clock signal that indicates a “stop” of the I²C data transfer.
- The yellow trace shows the output1 clock signal.
- The purple trace is a trend of the output 1 frequency, showing the actual transition.

As seen on the oscilloscope, it takes 1.5µs after the last I²C transaction is done to change to the new frequency. The frequency transition itself, from 100MHz to 99MHz, is almost instantaneous, without any sign of a glitch or overshoot. Nevertheless, the whole sequence of sending new values to the FOD via I²C (until the frequency changes) depends of the I²C speed used by the user and the I²C controller.

In the IDT lab, the I²C transaction took approximately 12ms with the selected speed setting of 100kHz.

Figure 3. Frequency Transition from 100MHz to 99MHz

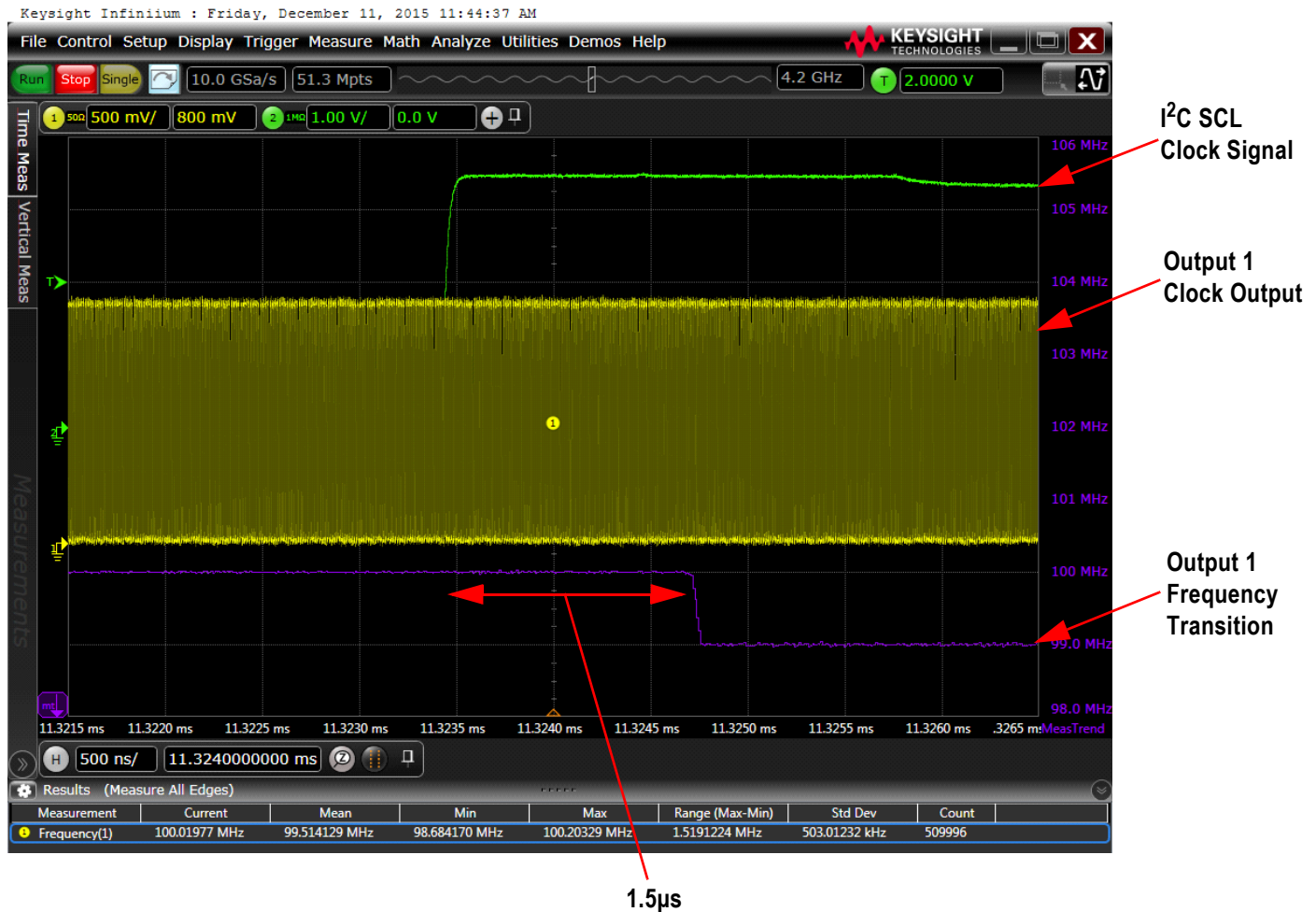


Figure 4. Frequency Transition from 100MHz to 101MHz



Programming 100ppm Offset from 100MHz Clock

A change in 100ppm will be performed in same manner as a 1% change. The programming of the FOD1 register is shown in [Table 3](#).

Table 3. FOD1 Settings for OUT1 = 100MHz

FOD1 settings	Output (MHz)	FOD Value Decimal	Integer Registers 0x2D 0x2E	Offset Value Decimal	Offset Registers 0x22 0x23 0x24 0x25
Starting frequency	100.00	14.25	00 E0	0.25	01 00 00 00
+100 ppm	100.01	14.248575142	00 E0	0.248575142	00 FE 8A 78

The VCO frequency or PLL block output frequency is 2850MHz in this case. The transition time from 100MHz to 100.01MHz (+100ppm) will take the same amount of time as programming a 1% change (~1.5µs).

Frequency Change with Spread Spectrum

This section illustrates how to program the VersaClock 5 or VersaClock 6 FOD with a frequency change of 1% and spread spectrum enabled. [Figure 5](#) below shows an example of programming FOD output1 with SSC bit on, and the modulation rate is at 31.5KHz with -0.5% spread.

Figure 5. Timing Commander Example of Programming FOD1



Table 4. FOD1 Settings to 100MHz with Frequency Change and -0.5% Down Spread

	Output (MHz)	Divider (real)	Integer Registers	Period (hex)	Step (real)	Step (hex)	Offset (real)	Offset Registers
Original	100.0	14.25	00 E0	633	4.4896E-05	2F1	0.25	01 00 00 02
+0.5% Change	100.5	14.17910448	00 E0	63B	4.44486E-05	2E9	0.17910448	00 B7 67 2A

OUT1, -0.5% Spreading

Address: 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F

100.0MHz: 00 81 01 00 00 02 00 02 F1 31 9C 00 00 00 E0 00

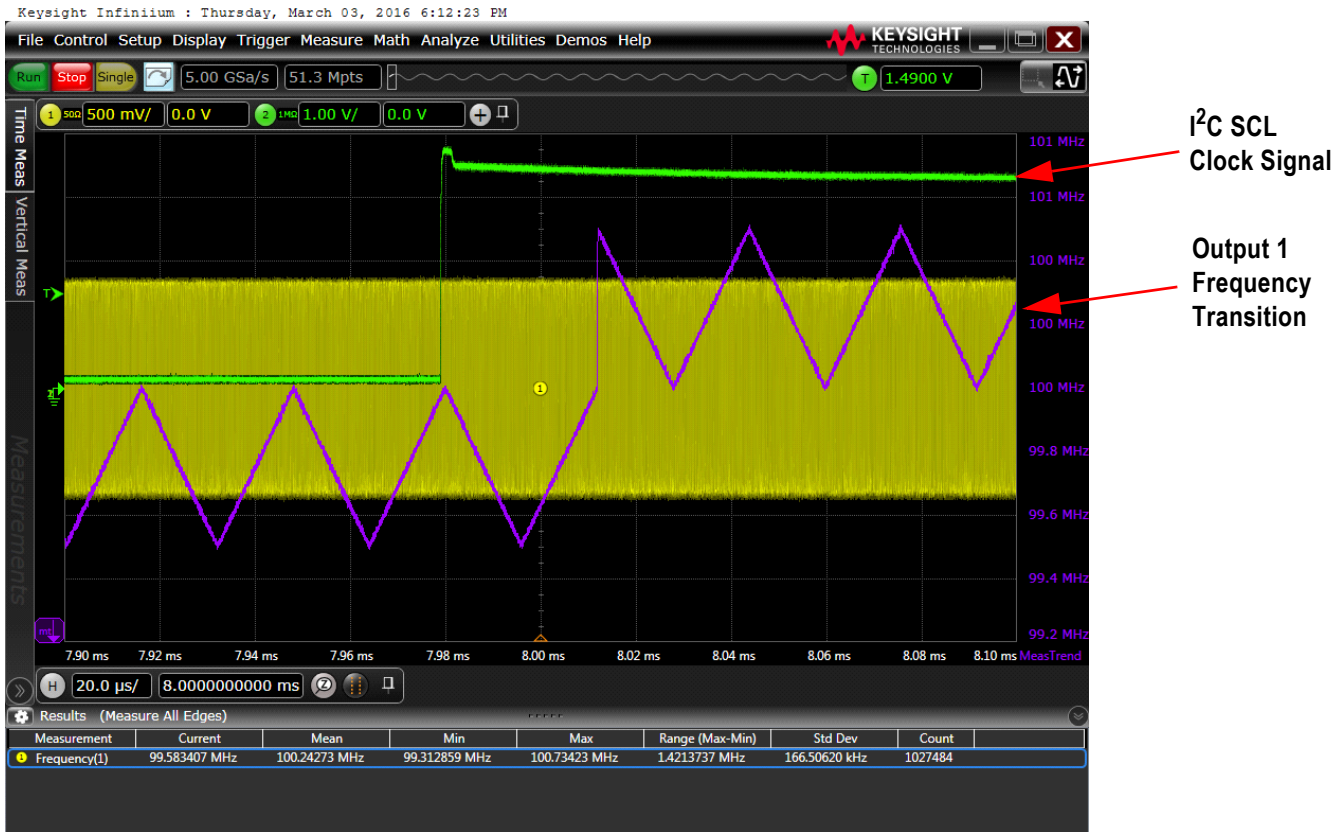
100.5MHz: 00 81 00 B7 67 2A 00 02 E9 31 DC 00 00 00 E0 00

The spread is programmed on top of the margining frequency.

Figure 6 shows an oscilloscope capture of the output clock with -0.5% spread with a frequency change of +0.5%. The original frequency being 100MHz is 0.5% down-spread and the ending frequency is 100.5MHz with 0.5% down-spread.

After the FOD value change has been initiated, the frequency transition will happen when the spread step is at its maximum (top of the triangle). The purple line shows the frequency transition.

Figure 6. Oscilloscope Image of Output Frequency Transition



Conclusion

The different examples that were given in this application note illustrate how easy it is to perform any frequency changes with VersaClock 5/6 Fractional Output Divider programming. From a few ppm to percentage of frequency, the changes can be made without any glitch, ringing or overshoot.

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 be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. 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.
6. 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.
7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. 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.
9. 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.
10. 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.
11. 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.
12. 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.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Disclaimer Rev.5.0-1)

Corporate Headquarters

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

Trademarks

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

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/