RENESAS
BIG IDEAS FOR EVERY SPACE

RX23W | **Bluetooth® LE Solution & Resource Quick Start Guide**

Introducing solutions and resources (including related information) for each development phase of your product.

Development Phase

Bluetooth Specification Survey	
Bluetooth Specifications	

Device Specification Survey	
Hardware Specifications	Software Specifications

PoC (Proof of Concept)	
Evaluation Boards	Evaluation Tools
Smartphone Sample Apps	Windows Sample Apps

Product Board Prototype/Development	
Board Design Guides	

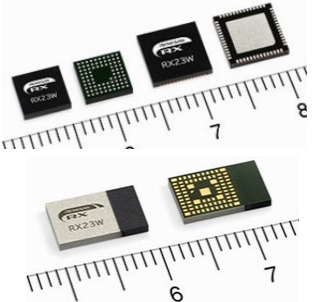| Software Development	
Evaluation Boards	Development Tools
Development Guidelines	Software Library
Bluetooth LE Sample Programs	Bluetooth Mesh Sample Programs
Smartphone Sample Apps	Smartphone App Development Environment
Windows Sample Apps	Windows App Development Environment
Evaluation Tools	

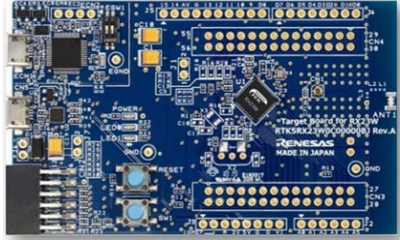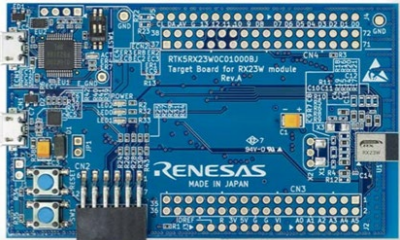| Product Registration	
Bluetooth Qualification	Radio Law Certification

[Find from Development Phase]

Bluetooth Specifications

	All Specifications	WEB	Bluetooth SIG WEB Site - Active All Specifications
	Bluetooth Core Specification	WEB	Bluetooth SIG WEB Site - Active Core Specifications
	Bluetooth Mesh Specification	WEB	Bluetooth SIG WEB Site - Active Mesh Specifications

Hardware Specifications

RX23W IC(R5F523WxxDBL) RX23W Module(R5F523WxxDLN)		WEB	The RX23W 32-bit Bluetooth LE MCU offers the full functions of Bluetooth 5.0 LE and the built-in security functions essential to IoT devices, as well as rich peripheral features such as touch keys, USB and CAN. As a result, system control for devices and wireless communication can be realized on a single chip. The RX23W also provide a dedicated library that complies with the Bluetooth Mesh Networking specification for multipoint-to-multipoint communication. Renesas also has a lineup of the world's smallest module products with built-in antennas and oscillators.
	RX23W Group Datasheet	PDF	This is a Microcomputer Datasheet.
	RX23W Group User's Manual: Hardware	PDF	Understand the hardware functions and electrical characteristics of microcomputer.

Software Specifications

	RX Family RXv2 Instruction Set Architecture User's Manual: Software	PDF	Understand the CPU features and Instruction Set Architecture.

[Specifications]
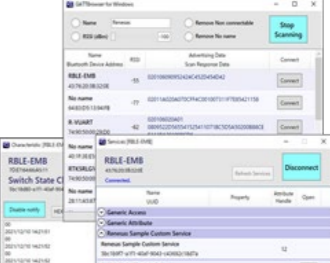
Evaluation Boards

Target Board for RX23W : RTK5RX23W0C00000BJ	WEB	Provides an entry point to evaluation, prototyping and developing for the RX23W MCU. Moreover, since this board incorporates an emulator circuit, you can use it for your own application design without the need for further tool investments. This product provides through-holes for pin headers that allow access to all MCU signal pins, allowing an easy prototyping with a breadboard.	
Target Board for RX23W User's Manual	PDF	Describes the hardware specifications.	
RX23W Group Target Board for RX23W Quick Start Guide	PDF	This is a guide for initial operation confirmation.	
USB cable	—	Please prepare USB A-micro B. Two cables are required to use the emulator and USB serial communication at the same time.	
Target Board for RX23W module : RTK5RX23W0C01000BJ	WEB	Provides an entry point to evaluation, prototyping and developing for the RX23W module. Moreover, since this board incorporates an emulator circuit, you can use it for your own application design without the need for further tool investments. This product provides through-holes for pin headers that allow access to all MCU signal pins, allowing an easy prototyping with a breadboard.	
RX23W Group Target Board for RX23W module User's Manual	PDF	Describes the hardware specifications.	
RX23W Group Target Board for RX23W module Quick Start Guide	PDF	This is a guide for initial operation confirmation.	
USB cable	—	Please prepare USB A-micro B. Two cables are required to use the emulator and USB serial communication at the same time.	
Renesas Solution Starter Kit (RSSK) for RX23W	WEB	The perfect starter kit for developers who are new to the RX23W (Code Flash 512KB, Pin Count 85-pin). The kit includes an LCD display module and an on-chip debugging emulator. Download the integrated development environment from the Renesas website and start evaluating RX23W performance, right after unboxing the Renesas Solution Starter Kit.	
Renesas Solution Starter Kit for RX23W User's Manual	PDF	Describes the CPU board hardware specifications.	
Renesas Solution Starter Kit for RX23W Quick Start Guide	PDF	This is a guide for easy setup.	
USB cable	—	Please prepare USB A-micro B.	

[Evaluation Boards]

Attached Document : Evaluation Board Design Data

Target Board for RX23W Design Data			
	Target Board for RX23W Schematic	PDF	Schematic of Target Board for RX23W.
	Target Board for RX23W Bomlist	PDF	Bom List for Target Board for RX23W.
	Target board for RX23W Board Description File	ZIP	A file containing terminal setting information used by the Target board for RX23W. The Board Description File (bdf) is available in the Renesas Smart Configurator.
Target Board for RX23W module Design Data			
	Target Board for RX23W module Schematic	PDF	Schematic of Target Board for RX23W module.
	Target Board for RX23W module BOM list	PDF	Bom List for Target Board for RX23W module.
	Target Board for RX23W module Board Description File	ZIP	A file containing terminal setting information used by the Target board for RX23W module. The Board Description File (bdf) is available in the Renesas Smart Configurator.

[Evaluation Boards]

Board Design Guides

	RX Family Hardware Design Guide	PDF	Describes board design precautions and layout examples when using the RX family.
	RX23W Group Guidelines for Bluetooth Board Design	PDF	Describes guidelines for board design of RX23W Bluetooth 5.0 RF transceiver part.
	Bluetooth Low Energy microcomputer Design Guidelines for a Pattern Antenna	PDF	Introducing an outline of antenna and procedures and examples for designing pattern antenna for the Bluetooth LE MCU.
	RX23W Group Tuning procedure of Bluetooth dedicated clock frequency	PDF	Describes a series of steps to optimally tune the frequency of the dedicated Bluetooth clock (32MHz) of the RX23W group.

[Board Design Guides]

Evaluation Tools

GATTBrowser (Smartphone Application)			A generic data communication application for checking the operation of Bluetooth LE. You can experience data communication with Bluetooth LE by scanning Bluetooth LE devices operating in the vicinity and connecting to those devices.	Display the scanned devices / Display the service on connected device / Providing specialized function for RL78/G1D
	GATTBrowser for iOS Smartphone Application Instruction manual	PDF	Describes how to use the iOS smartphone application "GATTBrowser" for confirm the operation of Bluetooth LE.	
	GATTBrowser for Android Smartphone Application Instruction manual	PDF	Describes how to use the Android smartphone application "GATTBrowser" for confirm the operation of Bluetooth LE.	
	GATTBrowser (for iOS) (App Store)	WEB	GATT Browser download link for iOS.	
	GATTBrowser (for Android) (Google Play)	WEB	GATT Browser download link for Android.	
GATTBrowser (Windows Application)			This is a general-purpose data communication application for confirm the operation of Bluetooth LE. You can use the Windows PC to scan nearby Bluetooth LE devices and connect to them to experience Bluetooth LE data communication.	
	GATTBrowser for Windows Windows Application Instruction manual	ZIP	GATTBrowser download link for Windows. Describes how to use the Windows application "GATTBrowser" to confirm the operation of Bluetooth LE.	
Bluetooth Test Tool Suite (BTTS) (Windows Application)			BTTS is a tool suite for controlling an MCU evaluation board connected to a Windows PC via USB Serial and evaluating the three functions of RF, beacon communication, and data communication in Bluetooth 5.0 LE.	
	Bluetooth LE MCU Bluetooth Test Tool Suite operating instructions	ZIP	BTTS for Windows and download link for operation manual.	HCI firmware for RX23W evaluation board is included.

[Evaluation Tools]

Development Tools

Integrated Development Environment (IDE)			
e² studio	WEB	An integrated development environment for Renesas microcontrollers based on the open source Eclipse IDE and CDT (C/C++ development Tooling).	
e² studio User's Manual : Quick Start Guide	PDF	Understand the features of e² studio when starting hardware and software system development using target devices.	
RX Smart Configurator User's Guide: e² studio	PDF	Understand the basic usage of the e² studio plug-in tool RX Smart Configurator.	
IAR Embedded Workbench for Renesas RX	WEB	A development environment that integrates the C / C ++ compiler and debugger for the RX family of IAR Systems.	

e² studio Extension Plug-in			
QE for BLE[RA,RE,RX]	WEB	QE for BLE is a QE tool for designing and code generating for application profiles using the GUI. Code is generated based on the template file provided by the QE Utility module.	

C/C++ Compiler			
C/C++ Compiler Package for RX Family	WEB	Renesas C/C++ Compiler. In development of embedded systems, C/C++ Compilers for the RX Family offer powerful optimizations for enhancing execution speed and code efficiency, and the utilities to increase productivity.	
CC-RX Compiler User's Manual	PDF	Understand the software functions of CC-RX.	
IAR C/C++ Compiler for Renesas RX version	WEB	IAR Systems C/C++ compiler. The IAR C/C++ Compiler supports various dialects of the C and C++ programming languages and various extensions for embedded programming.	

On-chip Debugging Emulator (When using RSSK)			
E2 Emulator[RTE0T00020KCE00000R]	WEB	The E2 emulator is an advanced on-chip debugging emulator and flash programmer developed with the concept of greater efficiency in development. The combination of its high-speed downloading and various software and hardware solutions will contribute to reducing development times. A USB cable (A-miniB) is included in the product package.	
E2 emulator Lite [RTE0T0002LKCE00000R]	WEB	The E2 emulator Lite (abbreviated as "E2 Lite") is an on-chip debugging emulator and flash programmer for MCUs of the RX families. The E2 Lite is more economical than the E1, and is suitable for work across the whole range from hobbyist projects and education to professional development. A USB cable (A-miniB) is included in the product package.	
Renesas Flash Programmer	WEB	On-chip flash memory writing tool of Renesas microcontrollers (Programming GUI).	
Terminal Emulator Tera Term	WEB	Used as a serial terminal tool.	Used in Windows 10 Bluetooth LE Application and Mesh Demo Sample Program.

[Development Tools]

Development Guidelines

Bluetooth LE wireless communication			
	RX23W Group Bluetooth Low Energy Application Developer's Guide	PDF	Describes how to develop an application for point-to-point or broadcast data communication using the Bluetooth Low Energy Protocol Stack on the integrated development environment e2 studio. This guideline includes the Beacon, Peripheral, Central, and Multi-role sample programs that operates on the Target Board for RX23W.
Bluetooth Mesh			
	RX23W Group Bluetooth Mesh Stack Development Guide	PDF	Describes the software configuration of the Bluetooth Mesh stack package, an overview of each layer, and how to develop a Mesh application.
	RX23W Group Bluetooth Mesh Stack Startup Guide	PDF	Describes how to install the Bluetooth Mesh Stack Package.
Profile			
	Bluetooth LE microprocessor / module Profile Developer's Guide	PDF	Describes how to develop an application that supports Bluetooth SIG standard profiles or custom profile over the Bluetooth Low Energy Protocol Stack using the e^2 studio extension function "QE for BLE [RA, RE, RX]".

[Development Guidelines]

Software Library

Software Library			
Bluetooth LE Protocol Stack			
	RX23W Group BLE Module Firmware Integration Technology (Bluetooth Low Energy Protocol Stack Basic Package)	ZIP	The Bluetooth Low Energy Protocol Stack Basic Package includes a protocol stack library (Bluetooth Low Energy Protocol Stack Library) compliant with Bluetooth Core Spec Ver 5.0, an API reference document for using it, and an application demo project for checking the operation. You can add it to your project from the smart configurator on e^2 studio and start developing Bluetooth LE applications.
	Bluetooth Low Energy Protocol Stack Basic Package User's Manual	PDF	Describe about an overview of the Bluetooth Low Energy protocol stack basic package, how to install it, how to build it, and how to use the provided functions.
Bluetooth Mesh Stack			
	RX23W Group Bluetooth Mesh Module Using Firmware Integration Technology (Bluetooth Mesh Stack Package)	ZIP	The Bluetooth Mesh Stack Package provides multi-to-multi point wireless communication capabilities that comply with the Bluetooth Mesh Networking specification. The package contains a sample program that executes the Provisioning, Configuration, Model Communication, and Node Removal each demo phases, and Mesh Mobile Application for executing demos that operate on smartphone.
QE Utility Module (Bluetooth LE Profile)			
	RX23W Group BLE QE Utility Module Firmware Integration Technology	ZIP	Template files for developing application profiles using the QE for BLE

[Software Library]

Bluetooth LE Sample Programs

	RX23W Group Firmware update over the air sample program **Addition of Firmware Update Function**	ZIP	This sample program to operate on the RX23W and enables Over The Air (OTA) firmware updates via Bluetooth LE wireless communication.
	RX23W Group Apple Notification Center Service Sample Program **Application Development for Connecting to Smartphone**	ZIP	The Apple Notification Center Service (ANCS) sample program to operates on the Target Board for RX23W and connects to iOS device using Bluetooth LE wireless communication.
	RX23W Group Sample Program for Highspeed Communication **Make Wired System Wireless**	ZIP	This sample application sets the GAP parameters to optimal values between pairs of Target Board for RX23W and uses LE 2MPHY for high-throughput Bluetooth LE wireless data communication. Provides projects on the central and peripheral sides.
	Beacon Sample Program **Beacon Application Development**	ZIP	These are sample programs for the Target Board for RX23W that Included in the RX23W Group Bluetooth Low Energy Application Developer's Guide.
	Peripheral Sample Program **Implementation of Peripheral Function**		
	Central Sample Program **Implementation of Central Function**		
	Multi-role Sample Program **Implementation of Both Central and Peripheral Functions**		
	Custom Profile Sample Program **Develop Custom Profile Application**	ZIP	Provided as a demo project "LED Switch Service" of RX23W Group BLE Module Firmware Integration Technology.

Bluetooth Mesh Sample Programs

	RX23W Group Temperature and Humidity Sensor Data Communication Sample Code Using Bluetooth Mesh Network **Bluetooth Mesh Application Development**	ZIP	This is a sample program that communicates temperature / humidity sensor data using the Sensor Model included in the Bluetooth Mesh module.
	Mesh Demo Sample Program **Bluetooth Mesh Application Development**	ZIP	This is a demo sample program included in the RX23W Group Bluetooth Mesh Module Using Firmware Integration Technology (Bluetooth Mesh Stack Package) and can execute each phases of Bluetooth Mesh (Provisioning, Configuration, Model Communication, and Node Removal).

Smartphone Sample Apps

TryBT			TryBT provides projects, source code, and icon image data that can be used with iOS and Android development environments, and is a sample application that can be used as a development base for Bluetooth LE communication apps for smartphones. TryBT is equipped with the functions required for communication with Bluetooth LE products, and you can confirm the linked operation (LED blinking, virtual temperature / humidity display) with the firmware preinstalled in the RX23W evaluation board.	
	When using TryBT as a development base for Bluetooth LE communication apps for smartphone			
	Bluetooth Low Energy Smartphone Application Example TryBT for iOS Smartphone Application Development	ZIP	The project, source code, and icon image data included in the package to operate with Xcode and can be used as a development base for Bluetooth LE communication app.	
	Bluetooth Low Energy Smartphone Application Example TryBT for Android Smartphone Application Development	ZIP	The project, source code, and icon image data included in the package can be used as a development base for Bluetooth LE communication apps by importing them into Android Studio.	
	When using TryBT as an evaluation app			
	Bluetooth Low Energy Smartphone Application Example TryBT for iOS	PDF	Describing the basic operation of TryBT for iOS.	
	Bluetooth Low Energy Smartphone Application Example TryBT for Android	PDF	Describing the basic operation of TryBT for Android.	
	TryBT for iOS (App Store)	WEB	Download link for TryBT for iOS.	
	TryBT for Android (Google Play)	WEB	Download link for TryBT for Android.	
MeshMobile (Mesh Mobile)			MeshMobile is a mobile application that works as a Provisioner and a Configuration of Bluetooth Mesh wireless communication. You can easily evaluate Bluetooth Mesh communication operation with the RX23W.	
	When using MeshMobile as a development base for Bluetooth Mesh communication apps for smartphone			
	Mesh Mobile Application Mesh Smartphone Application Development	ZIP	A suite of build environment for the smartphone (iOS, Android) application "Mesh Mobile" used in the Mesh demo is included in the RX23W Group Bluetooth Mesh Module Using Firmware Integration Technology (Bluetooth Mesh Stack Package).	
	When using MeshMobile as an evaluation app			
	MeshMobile for iOS (App Store)	WEB	Download link for MeshMobile for iOS.	
	MeshMobile for Android (Google Play)	WEB	Download link for MeshMobile for Android.	

Smartphone App Development Environment

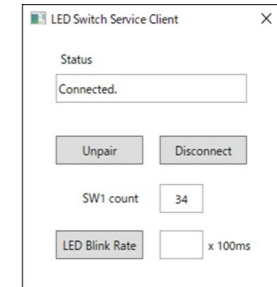|	Smartphone (iOS / Android common) App Development Environment			
	Node.js	WEB	Node.js is an asynchronous event-driven JavaScript environment designed to build scalable network applications over the V8 JavaScript engine. Includes the development tools **npm** (Node Package Manager) needed to build Mesh Mobile.	Used in Mesh Mobile Application.
	Python	WEB	Python is a language that can be used in a variety of fields, from embedded application development and website construction to deep learning.	Used in Mesh Mobile Application.
	Capacitor	WEB	Capacitor is a cross-platform native library that makes it easy to build applications that execute natively on iOS and Android.	Used in Mesh Mobile Application.
	Ionic Framework	WEB	Ionic Framework is a framework for creating mobile apps with web technology.	Used in Mesh Mobile Application.
	Smartphone (iOS) App Development Environment			
	Apple Developer Program	WEB	A paid license is required to develop iOS applications. The Apple Developer Program is a license for applications distributed via the App Store.	
	Apple Developer Enterprise Program	WEB	A paid license is required to develop iOS applications. The Apple Developer Enterprise Program is a license for in-house applications.	
	Xcode	WEB	Xcode is an integrated development environment for iOS. Works only on Mac PCs. You will need **Apple ID** to download.	Used in Try BT and Mesh Mobile Application.
	Homebrew	WEB	Homebrew is a package manager for installing and managing various libraries in the Mac OS environment.	Used in Try BT.
	CocoaPods	WEB	CocoaPods is a tool for managing third-party libraries for iOS apps.	Used in Try BT.
	Smartphone (Android) App Development Environment			
	Android Studio	WEB	Tools for building apps on all types of Android devices.	Used in Try BT and Mesh Mobile Application.
	USB driver for Android devices	WEB	The Google USB driver for Windows required for adb debugging on Google devices.	Used in Try BT and Mesh Mobile Application.

[Developing Mobile Apps]

Windows Sample Apps

Windows 10 Bluetooth LE Application			The Windows 10 Bluetooth LE application provides a set of projects that can be used in Visual Studio 2017, and is a application example that can be used as a development base for Bluetooth LE communication apps for Windows. This sample application communicates with the firmware pre-installed on the evaluation board equipped with RX23W, controls the LED blinking interval on the evaluation board, and counts the number of times the switch is pressed.	
	Bluetooth LE microcomputer / module Windows 10 Bluetooth LE Application **Windows Application Development**	ZIP	When using a Windows 10 Bluetooth LE application as a development base for a Bluetooth LE communication app that executes on Windows 10.	
			Download a suite of project available in Visual Studio 2017 and use it as a development base for Bluetooth LE communication apps that execute on Windows 10.	
			When using the Windows 10 Bluetooth LE application as an evaluation app	
			Download the Windows 10 Bluetooth LE application for Windows and operating instructions manual.	

[PC Software]

Windows App Development Environment				
Windows App Development Environment				
	Visual Studio 2017	EXE	Visual Studio 2017 supports building to management applications and native desktop applications.	Used in Windows 10 Bluetooth LE Application.
	Windows 10 SDK Version 2004 (10.0.19041.0)	EXE	The Windows SDK provides headers, libraries, metadata, and tools for building Windows apps. You can use this SDK to build Universal Windows Platform (UWP) and Win32 applications.	Used in Windows 10 Bluetooth LE Application.

[Developing PC Software]

Bluetooth Qualification

	Bluetooth LE microcomputer / module Bluetooth qualification acquisition Application Note	PDF	When selling a device equipped with a Renesas Bluetooth LE microcomputer or module as a Bluetooth product, product registration (declaration) using the Qualified Design Identification number (QDID) of our certified and registered design is required. This document describes how to do it.
	Launch Studio	WEB	Interface to guide the Bluetooth qualification process (login required).
	Listing Search	WEB	Search for qualified designs and declared products.
	Bluetooth Qualification Test Facility (BQTF)	WEB	Bluetooth Qualification Test Facility (BQTF) is recognized by the Bluetooth SIG as competent to execute qualification test cases identified within the Test Case Reference List (TCRL) as "Category A at or below the Host Controller Interface (HCI) layer." A list of BQTFs is published on this site.
	Test Case Reference List (TCRL)	WEB	The Test Case Reference List (TCRL) is a qualification reference for all Bluetooth Special Interest Group (SIG) members. It is a document that introduces new test cases, removes test cases, and categorizes test cases.
	Profile Tuning Suite (PTS)	WEB	Test software that automates compliance testing of the Bluetooth Host part.

Thies informations are required when implementing profiles / services of versions or specifications that are unsupported by Renesas.

Radio Law Certification

	RX23W Group Testing for Certification of Compliance with the Radio Law (Japan) Application Note	PDF	Describes how to prepare an application for obtaining certification of compliance with the Radio Law in Japan and the operations involved in testing.
	RF Test Tool	—	The Bluetooth Test Tool Suite (BTTS) is available as an RF test tool.

[Product Certification]

Revision History

Rev.	Date	Description
1.00	May.30.22	First edition issued
1.01	Jun.30.22	Added the description about the included sample program to the explanation column of RX23W Group Bluetooth Low Energy Application Developer's Guide.
		Added Central / Peripheral sample programs to Bluetooth LE Sample Programs.
		Changed name and link due to commonalization of the Profile Developer's Guide.
1.02	Jul.05.22	Moved Node.js from Smartphone (iOS) App Development Environment to Smartphone (iOS / Android common) App Development Environment.
1.03	Dec.23.22	Changed the framework library of the smartphone application development environment from "Apache Cordova" to "Capacitor".
		Added application store download link to MeshMobile.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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.

(Rev.5.0-1 October 2020)

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/