

RV1S9353A

Optically Isolated Delta-Sigma Modulator

R08AN0013EJ0100

Rev.1.00

Jul.13 2020

Summary

This application note describes the features of the RV1S9353A optically isolated delta-sigma modulators and provides usage examples.

Devices on Which Operation Has Been Confirmed

RV1S9353A

Contents

1. Introduction	2
2. Product Overview	2
3. Operation and Functions	3
3.1 Operation of RV1S9353A	3
4. Peripheral Circuits	5
4.1 Current Detection Circuit	5
4.1.1 Shunt Resistor	6
4.1.2 Anti-Aliasing Filter	6
4.1.3 Differential Input	7
4.1.4 Power Supply Block	7
4.2 Voltage Detection Circuit	8
5. Conclusion	9

1. Introduction

Demand for delta-sigma modulators has increased in recent years for applications such as high-precision control in motor drive units incorporating general-purpose inverters or AC servos, as well as power conditioner output stabilization control in fields such as solar power and wind power. Delta-sigma modulators are necessary in motor drive units for high-precision detection of the bus voltage or phase currents between inverter and motor, and in power conditioners for high-precision detection of the output voltage and current.

The RV1S9353A is optically isolated delta-sigma modulators that produce digital output ideal for such current and voltage detection applications. They combine high noise tolerance (high CMR) and high linearity (low integral nonlinearity), making them ideal for current and voltage detection applications.

This document describes the features of the RV1S9353A and presents usage examples.

2. Product Overview

Figure 2.1 shows the pin connections of the RV1S9353A. The RV1S9353A is optically isolated A/D converters. Each incorporates a high-precision delta-sigma A/D converter and converts analog voltage input to a one-bit data stream. By connecting the RV1S9353A to a digital filter such as a Sinc³ filter in a later stage, digital signal output with an effective number of bits (ENOB) of 13.8 bits (typ.) can be obtained.

The product features are listed below. For a detailed listing of characteristics, refer to the datasheets of the RV1S9353A.

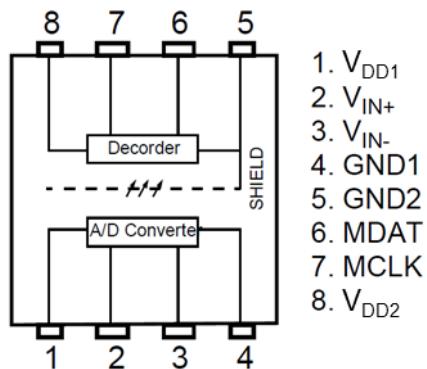


Figure 2.1 RV1S9353A Equivalent Circuit

Features

- Small variation in reference voltage ($G_E = \pm 0.5\% \text{ max.}$)
- High resolution (ENOB = 13.8 bits typ.)
- Low integral nonlinearity (INL = 25 LSB max.)
- Low input offset ($V_{OS} = 2 \text{ mV max.}$)
- Small input offset drift vs. temperature ($|dV_{OS}/dT_A| = 0.2 \mu\text{V}/^\circ\text{C}$ typ.)
- Operating temperature range ($T_A = -40 \text{ to } 110^\circ\text{C}$)
- Clock output ($f_{CLK} = 10 \text{ MHz}$ typ.)
- High common mode transient immunity (CMR = 15 kV/ μs min.)
- Package: 8-pin SDIP long creepage distance (8 mm) surface mount lead forming
- Conformance with international safety standards: UL, VDE, CSA

3. Operation and Functions

3.1 Operation of RV1S9353A

Figure 3.1 shows an overview of operation. The RV1S9353A accepts an analog input signal and converts it to digital output consisting of a one-bit serial bit stream with a time average proportional to the input signal (Figure 3.2). This signal output can be connected to a digital filter in a later stage or to a microcontroller with in integrated digital filter.

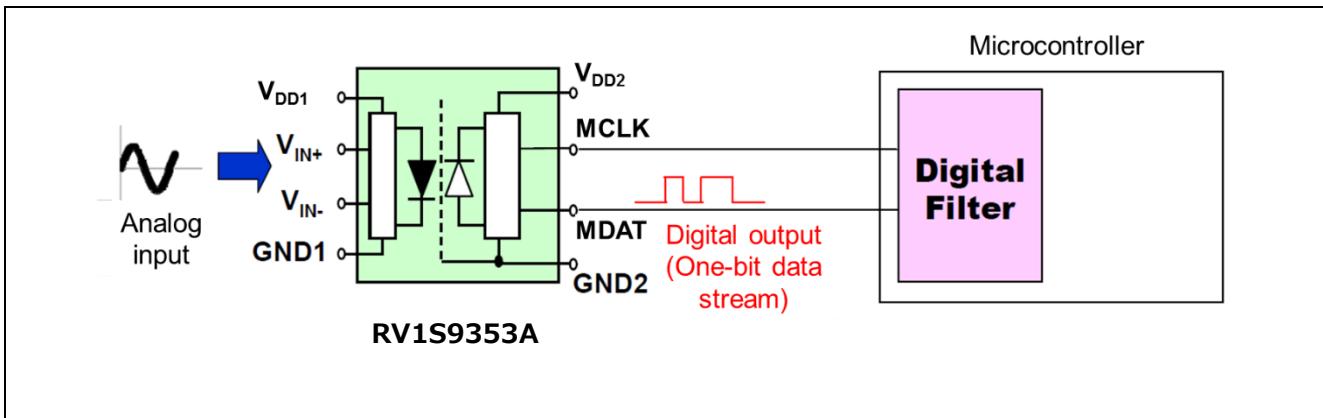


Figure 3.1 RV1S9353A Operation Overview

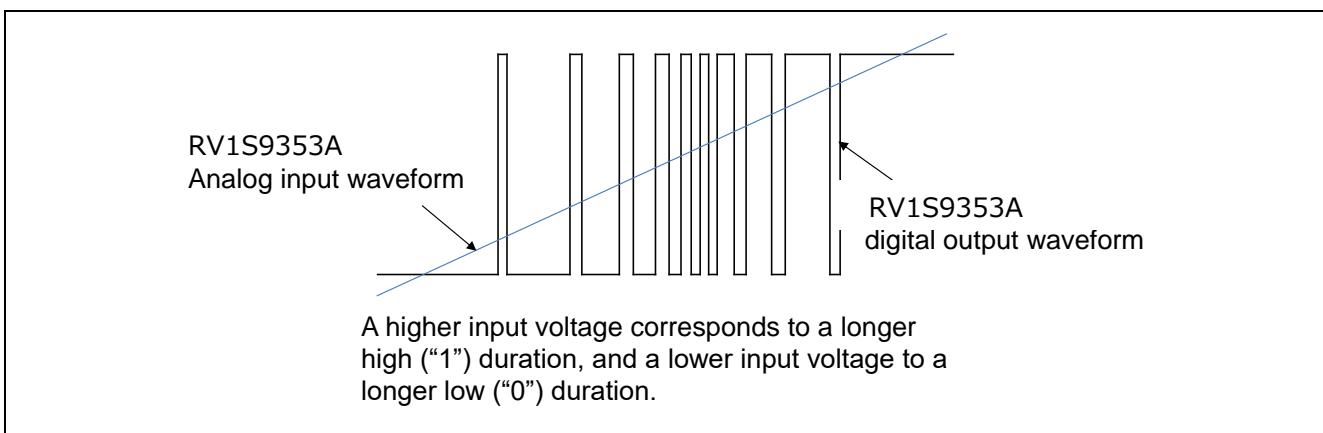


Figure 3.2 RV1S9353A Input / Output

Figure 3.3, below, shows an example of I/O characteristics with 16-bit digital output using the RV1S9353A.

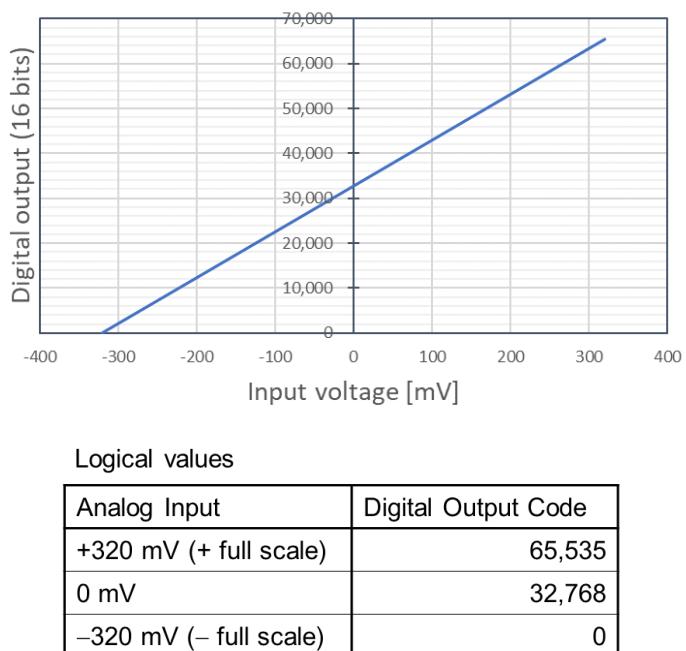


Figure 3.3 Example RV1S9353A I/O Characteristics

4. Peripheral Circuits

4.1 Current Detection Circuit

Figure 4.1 shows a recommended circuit example for motor current detection using the RV1S9353A. It comprises a shunt resistor, input filter circuit, and digital filter (Sinc^3 filter). The shunt resistor converts the motor current to a voltage, the input filter (anti-aliasing filter) removes unwanted high-frequency components from this signal, and the result is input to the RV1S9353A. The digital output A/D converted by the RV1S9353A is connected to the digital filter.

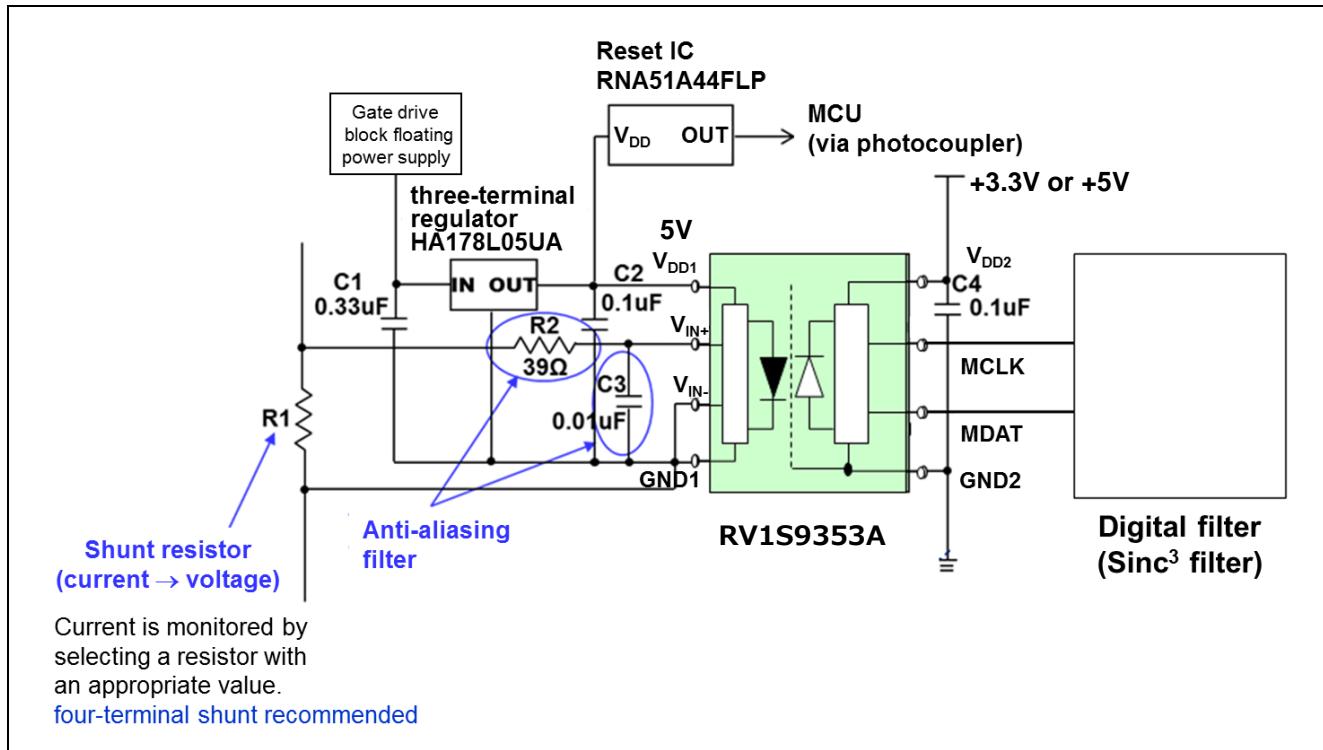


Figure 4.1 Recommended Current Detection Circuit Using RV1S9353A

4.1.1 Shunt Resistor

The shunt resistor converts the motor current to a voltage. The following points should be considered when selecting a shunt resistor for current detection:

- (1) Maximum current
- (2) Recommended maximum input voltage range of RV1S9353A (200 mV)
- (3) Low power consumption (low resistance)
- (4) four-terminal shunt (Kelvin connection)
- (5) High precision
- (6) Low temperature coefficient
- (7) Low inductance to minimize the di/dt inductance voltage

Select a shunt resistor that can provide the maximum recommended input voltage of 200 mV from the maximum current used.

Example:

If the maximum effective current value = 20 Arms, and providing an overload tolerance of up to 50% during normal operation:

Peak current = 42.4 A ($= 20 \text{ Arms} \times 1.414 \times 1.5$)

So if the maximum input voltage of the RV1S9353A is 200 mV, the maximum value of the shunt resistor is approximately $5 \text{ m}\Omega$ ($= 200 \text{ mV} / 42.4 \text{ A}$).

In this case, the maximum power consumption during normal operation is approximately 2 W ($= I^2R = 20 \text{ Arms} \times 20 \text{ Arms} \times 5 \text{ m}\Omega$).

Also, select the shunt resistor such that the input voltage of the RV1S9353A is kept below the rated value if a short occurs in the motor drive circuit (arm short, load short, short to ground).

When the current value is large the voltage drop in the leads of the shunt resistor can also cause error, so a four-terminal shunt resistor (Kelvin connection) is recommended. Also, resistance accuracy can be affected by ambient temperature and self-heating. Refer to the datasheet of the shunt resistor and if necessary take appropriate measures to disperse heat, such as optimizing the board pattern layout or using a heat sink.

4.1.2 Anti-Aliasing Filter

To avoid the effects of aliasing in the sampling performed internally by the RV1S9353A, do not fail to insert an anti-aliasing filter (RC filter) in the input block of the RV1S9353A, as shown in Figure 4.1, to eliminate frequencies above the required band. In the example shown in Figure 4.1, a filter is inserted with $f_c = \text{approx. } 400 \text{ kHz}$ ($= 1 / (2 \pi \times 39 \Omega \times 0.01 \mu\text{F})$) when $R_2 = 39 \Omega$ and $C_3 = 0.01 \mu\text{F}$. Also, the anti-aliasing filter should be located as close to the input pins of the RV1S9353A as possible due to the high input sensitivity of the RV1S9353A.

Note that caution is necessary when selecting a resistor with a comparatively high value as R_2 because the voltage drop due to the input bias current I_{IN+} of the RV1S9353A acts as an offset voltage. In such cases differential input, as described in 4.1.3, should be considered. Using differential input requires resistors for both pin 2 (V_{IN+}) and pin 3 (V_{IN-}) of the RV1S9353A, so the effect of the error of the resistors can be reduced.

4.1.3 Differential Input

If the effects of noise and offset are problematic with the current detection circuit employing the RV1S9353A shown in Figure 4.1, consider the differential input circuit for the RV1S9353A shown in Figure 4.3. By employing symmetrical anti-aliasing filters (R_{2a} , C_{3a} , R_{2b} , and C_{3b}) between the shunt resistor and the V_{IN+} and V_{IN-} pins, respectively, of the RV1S9353A, using twisted-pair wire, and shortening the distances on the board, it is possible to take advantage of the features of differential input and improve the performance characteristics. In addition, C_{3c} reduces noise from the input switched capacitor circuit of the RV1S9353A.

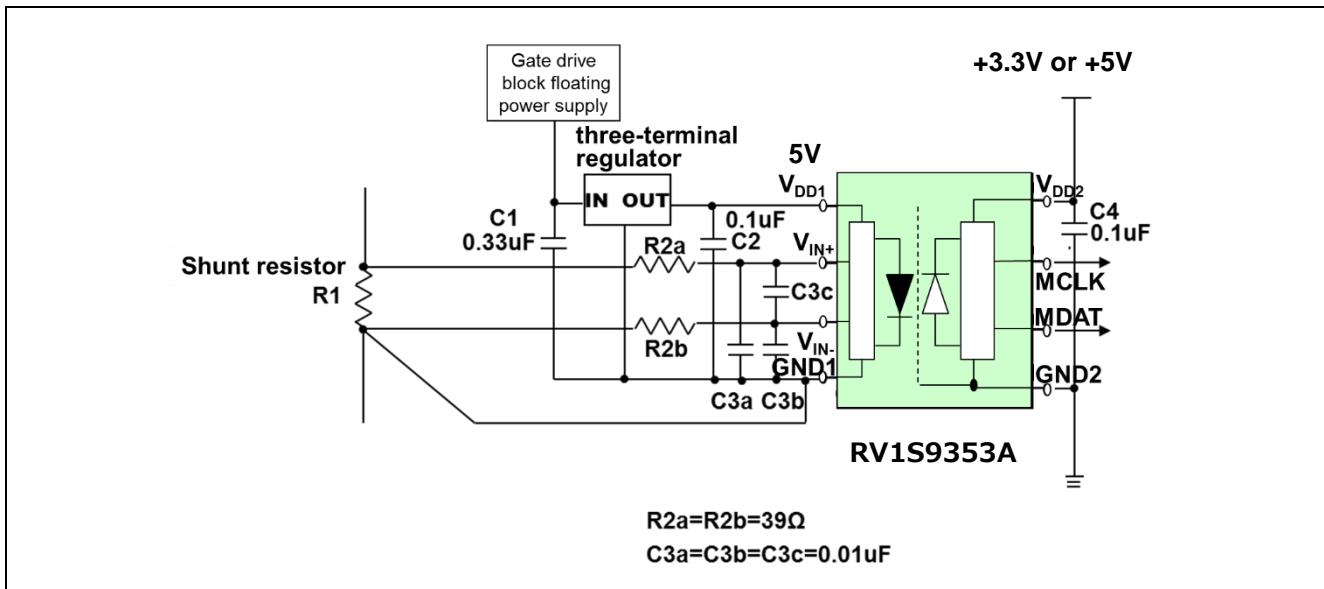


Figure 4.2 RV1S9353A Current Detection Circuit (Differential Input)

4.1.4 Power Supply Block

The primary-side power supply of the RV1S9353A is configured as an isolated DC-DC converter and, in simple terms, can be used with a gate drive circuit floating power supply ($V_{CC} = 15$ to 18 V) and three-terminal regulator to form a 5 V power supply, as shown in Figure 4.1. Select the capacitor to be inserted at the input side of the three-terminal regulator after consulting the datasheets of the various components.

4.2 Voltage Detection Circuit

For bus voltage detection (DC line: voltage between $+HV$ and $-HV$) a resistive voltage divider can be used to keep the signal amplitude voltage within the recommended input voltage range of the RV1S9353A and for voltage measurement (Figure 4.3). Voltage divider resistor R_8 should have a resistance rating well below the input resistance of the RV1S9353A ($R_{IN} = 500 \text{ k}\Omega$); for example, $1 \text{ k}\Omega$ or less. R_8 and the internal input resistance (R_{IN}) of the RV1S9353A is configured as parallel resistances, and this can cause gain error due to current division. When the resistance of R_7 and R_{IN} is sufficiently greater than R_8 , the error becomes R_8 / R_{IN} . The RV1S9353A has comparatively high input resistance (R_{IN}), making it well suited for voltage detection. Note that due to the voltage divider resistors, the anti-aliasing filter does not require any resistors.

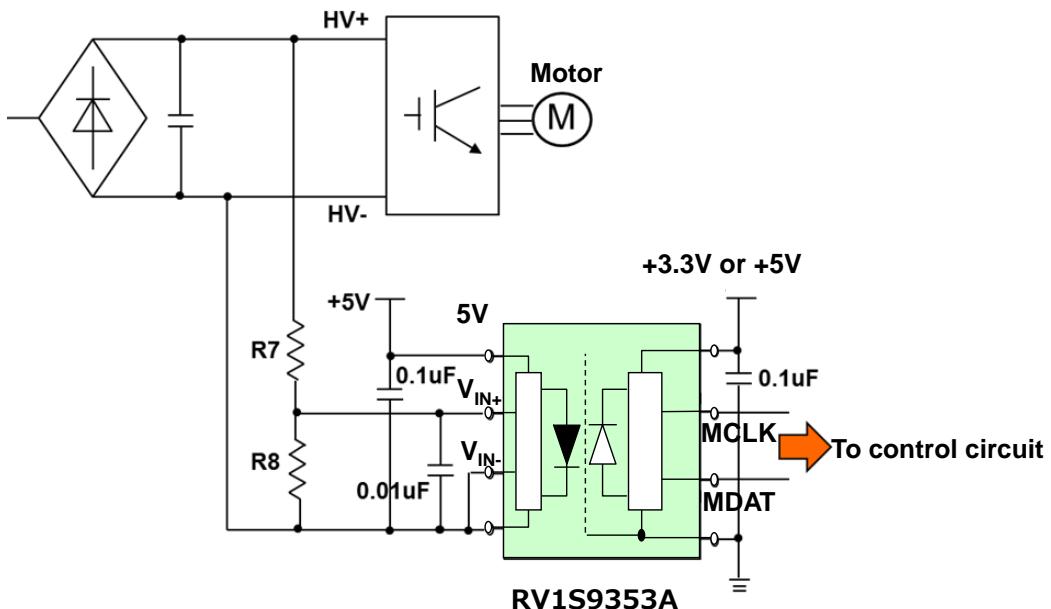


Figure 4.3 Voltage Detection Circuit

5. Conclusion

This concludes the description of the characteristics of and presentation of usage examples for the RV1S9353A delta-sigma modulators. It is hoped that this document will serve as a reference for customers designing their own systems. Renesas Electronics believes that this product category will contribute to the emergence of even more highly precise inverter systems, an area where future market growth is anticipated. Renesas Electronics will continue to aggressively market these products and to develop new ones offering even higher precision.

Caution GaAs Products	<p>These products contain gallium arsenide (GaAs). GaAs vapor and powder are hazardous to human health if inhaled or ingested, so the following points should be observed without fail.</p> <ul style="list-style-type: none">• Dispose of the product as recommended below:<ol style="list-style-type: none">1. Commission a disposal company qualified to collect, transport, and dispose of materials that contain arsenic and other such industrial waste materials.2. Exclude the product from general industrial waste and household garbage, and ensure that the product is properly managed (as industrial waste subject to special control) up until final disposal.• Do not burn, destroy, cut, crush, or chemically decompose the product.• Do not lick the device or allow it to enter the mouth.
------------------------------	--

Website and Support

Renesas Electronics Website

<http://www.renesas.com/>

Inquiries

<http://www.renesas.com/contact/>

All trademarks and registered trademarks are the property of their respective owners.

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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

Access to reserved addresses is prohibited.

- The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

- The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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 of 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 implants; 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 Corporation

TOYOSU FORESIA, 3-2-24 Toyosu, Koto-ku, Tokyo 135-0061, Japan

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 GmbH

Arcadiastrasse 10, 40472 Düsseldorf, Germany

Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.

Room 101-T01, Floor 1, Building 7, Yard No. 7, 8th Street, Shangdi, Haidian District, Beijing 100085, 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, 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 No 3A-1 Level 3A Tower 8 UOA Business Park, No 1 Jalan Pengaturcara U1/51A, Seksyen U1, 40150 Shah Alam, Selangor, Malaysia

Tel: +60-3-5022-1288, Fax: +60-3-5022-1290

Renesas Electronics India Pvt. Ltd.

No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India

Tel: +91-80-67208700

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