LLDRAM-Ⅲ [RMHE41A364AGBG/ RMHE41A184AGBG]

Control IP Solution

R10AN0011EJ0100
Rev. 1.00
Jul. 20, 2016

This document is an overview Renesas Low-Latency-DRAM [LLDRAM-III] Control IP

Contents

1. Control IP Solution

1.1 Introduction

The motivation behind Renesas' LLDRAM-III control IP development is to provide high random access memory solution for network applications.

This user-friendly control IP makes it possible to develop a variety of memory subsystems like the one shown in figure 1. From statistical memory, which stores packet statistics to buffer memory for packets storage. Although LLDRAM-III is optimized for network accesses, it can also be used in non-network applications.

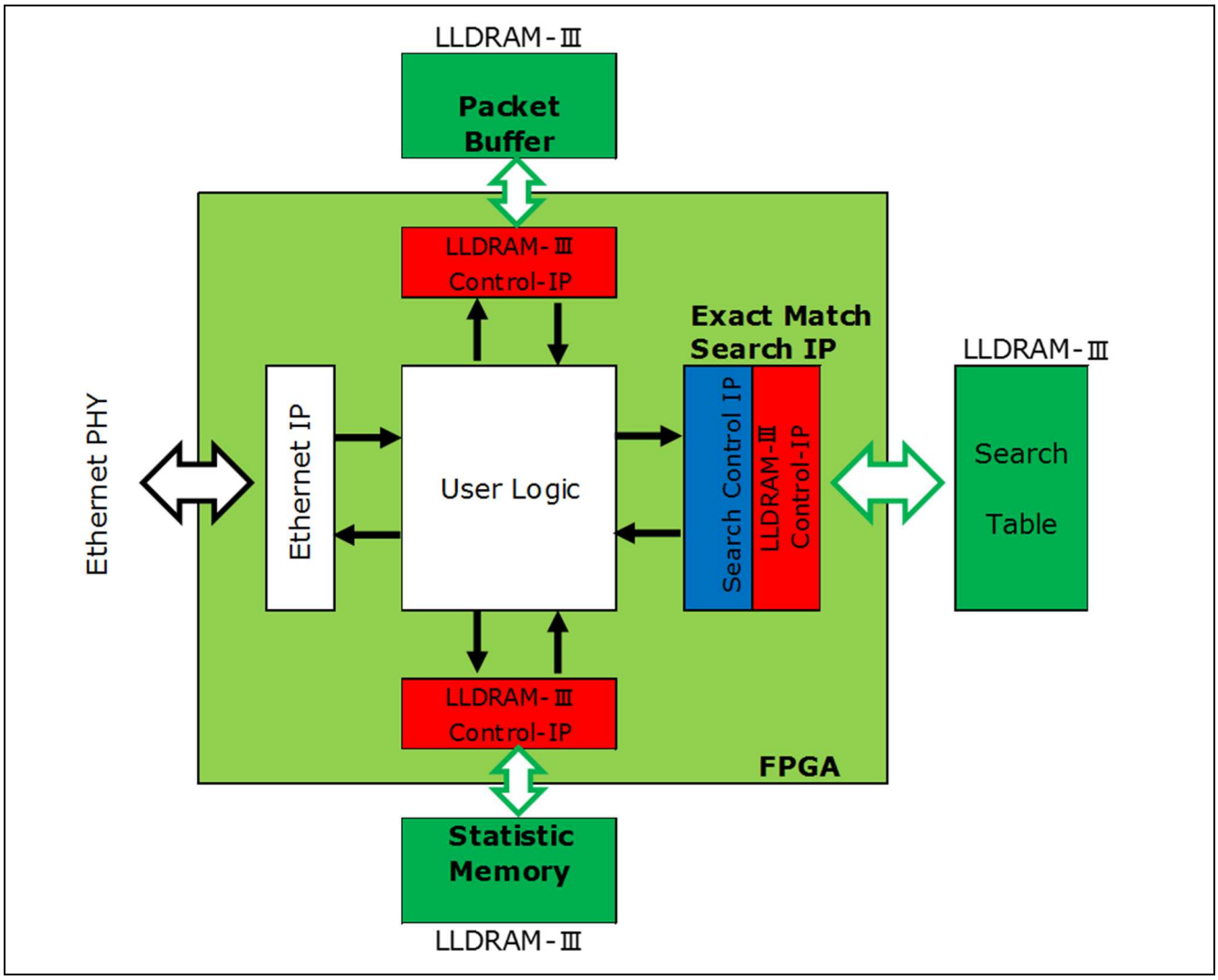

Figure 1 Example of Network Application Memory Sub-System using LLDRAM-Ⅲ

1.2 What's LLDRAM-III ?

Renesas' Low-latency memory LLDRAM-III is a specialized DRAM that is capable of performing 400M accesses per second. This is four times higher access when compared to standard DDR3 SDRAM. Moreover, power consumption is kept to an extremely low 2 watts.

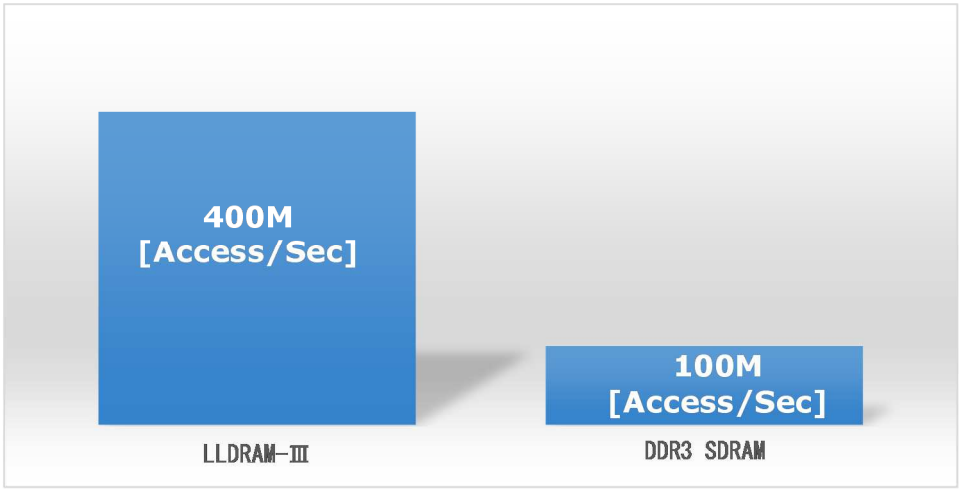

Figure 2 Access rate comparison between LLDRAM-III and DDR3 SDRAM

There are 2 types of product lineups of LLDRAM-III

- 『RMHE41A364AGBG』 Data width 36bits (x36)
- 『RMHE41A184AGBG』 Data width 18bits (x18)

Key features

- ✓ Density: 1.1Gbit
- ✓ Organization
  - ➢ 8M words x 18bits x 8 bank (x18)
  - ➢ 4M words x 36bits x 8 bank (x36)
- ✓ Operating frequency 800 MHz (MAX.) @ t_{RC}=13.75 ns
- ✓ Burst length: 4
- ✓ Address bus 2 cycle DDR address
- ✓ Package 180-pin FCBGA(18.5 mm x 14 mm)
- ✓ Power supply
  - ➢ V_{EXT} 2.5 V
  - ➢ V_{DD} 1.5 V
  - ➢ V_{DDQ} 1.0 V or 1.2 V

For more information, please refer to the datasheet.

1.3 Control IP Structure and Features

LLDRAM-III control IP is composed of 3 blocks – User I/F, Controller block and PHY block (See figure.3)

Key features of each block

- User I/F block
  - 200Mhz parallel I/F
- Controller block
  - Scheduler to achieve Higher Access Rate
  - Automatic Refresh by refresh counter integrated in controller block
- PHY block
  - Power on auto calibration
  - Debug I/F for calibration

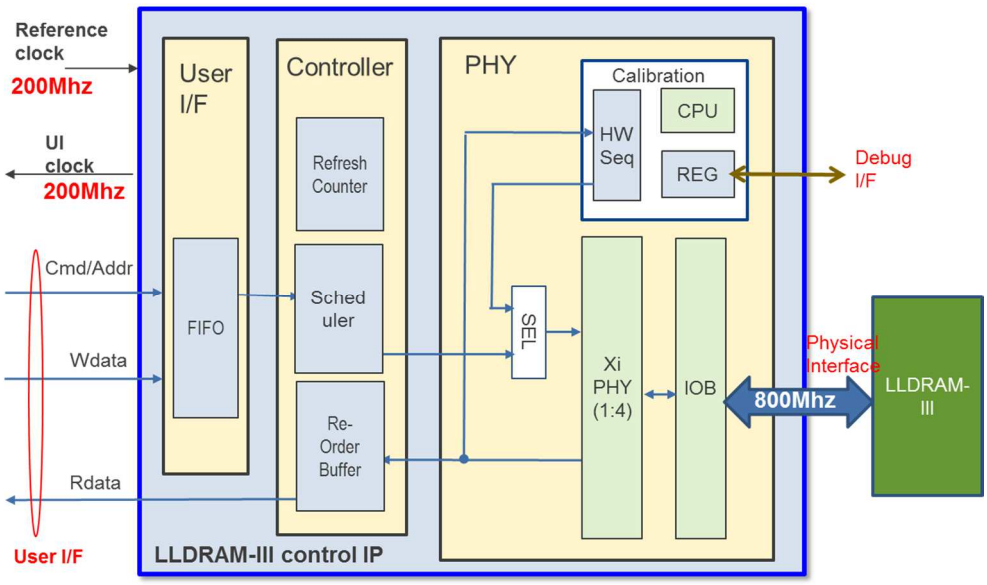

Figure 3 Structure of LLDRAM-III control IP

1.4 Performance

LLDRAM-III control IP has an intelligent scheduler which is optimized to bring out the maximum performance during random access. In order to achieve this level of performance, the scheduling function changes orders of memory access commands such as WRITE/READ issued by user and refresh commands issued by internal refresh counter to avoid access limitation such as bank conflict.

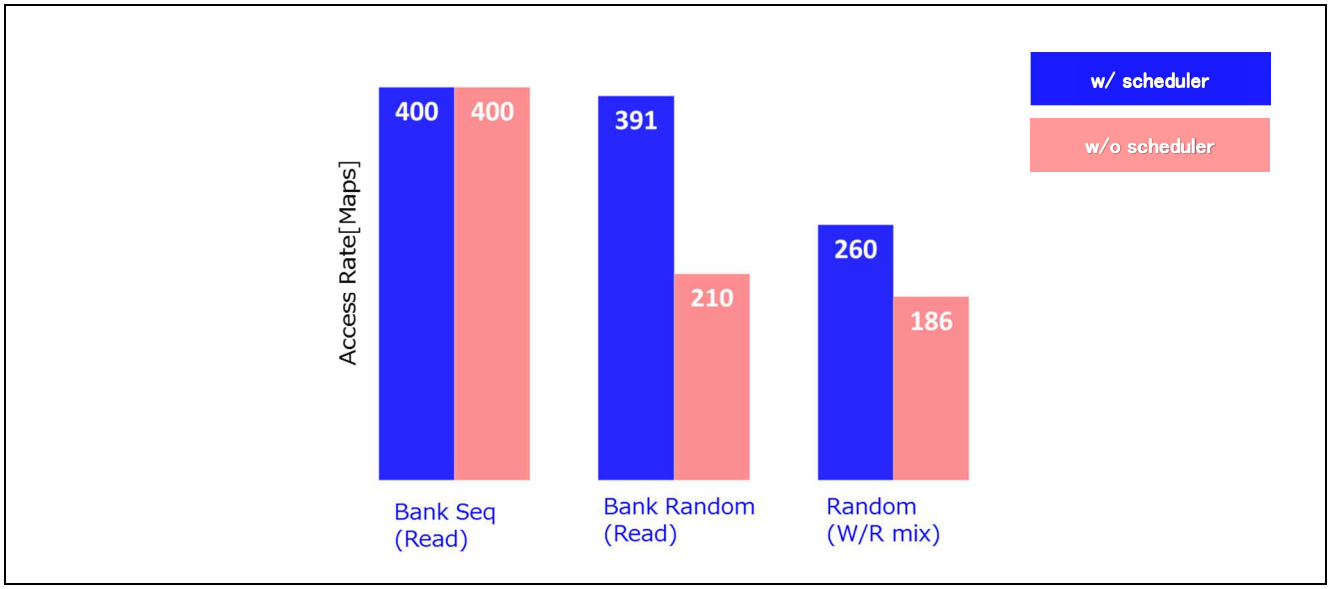

Figure 4 Comparison of LLDRAM-III access rate between w/ scheduler and w/o scheduler

Figure.4 shows the actual LLDRAM-III access rate comparison between w/ scheduler and w/o scheduler control IP implementations on FPGA.

- BANK sequential access [Bank seq(Read) at left]

  This graph shows access rate with BANK sequential pattern which is the ideal access for LLDRAM-III. It is found that both w/ scheduler and w/o scheduler implementations achieve 400M access per second, which is peak performance of the memory.

- READ Only Random access [Bank Random(Read) at middle]

  This graph shows access rate with READ only random access pattern which is assumed that some applications need to access to the memory with except BANK sequential pattern. In the case of w/o scheduler, the access rate fell 50% of peak access rate of the memory. In the case of w/ scheduler, Renesas' control IP can maintain peak access rate by scheduling function.

- WRITE/READ mixed Random access [Random(W/R mix) at right]

  This graph shows access rate with mixed WRITE and READ random access patterns which assume that some applications need more complex accesses to the memory. As the memory needs more than 1 cycle to change the direction of data transfer (WRITE to READ or READ to WRITE), the access rates are less than the access rate during same types of commands. Though in case of w/ scheduler, it is found that LLDRAM-III performs over 200 M access per second.

Renesas' control IP contributes to reducing system development time because users do not need to build a scheduler or consider various access patterns.

1.5 Configurations

Multiple configurations of LLDRAM-III control IP is available to accommodate different user requirements.

Type	Refresh Control Needed
w/ scheduler **x18/x36**	No
w/o scheduler	Yes
x18/x36	No

Figure.5 Configurations of control IP

- For x36 and x18

  This control IP requires 2 banks of FPGA IO BANKs in X36 mode. In X18 mode, Control IP is composed of a single FPGA IO BANK.

- Selection of scheduler

  There are three types of scheduler

  - ✓ w/ schedule and Refresh Control Needed:No
    - ➢ WRITE/READ commands issued by user and refresh commands from internal refresh counter of control IP are sent to LLDRAM-III with changing the order. It enables to bring out maximum access rate of LLDRAM-III.
  - ✓ w/o schedule and Refresh Control Needed:Yes
    - ➢ WRITE/READ commands and REFRESH commands issued by user are sent to LLDRAM-III in order. Users need to consider how to avoid access limitation, like bank conflict, in order to bring out maximum access rate of LLDRAM-III.
  - ✓ w/o schedule and Refresh Control Needed:No
    - ➢ WRITE/READ commands issued by user are sent to the memory in order. Internal refresh counter issues refresh commands on a regular basis. A slight drop in access rate will occur due to the commands issued by user will have to wait during intensive refresh.

1.6 Reliable Interoperability by Calibration

LLDRAM-III is high speed memory using 1.6Gbps high speed DDR parallel interface which requires strict timing calibration to execute stable communication between devices. LLDRAM-III enables stable high speed communications by automatically executing timing calibration sequence which includes skew adjustment between pins. By providing reliable interoperability by calibration, LLDRAM-III control IP reduces the complexity of system board design.

Key features of calibration

- Per pin skew adjustment from data pins, address pins to clock pins
- Programmable calibration sequence control using CPU on FPGA + C program
- Calibration debug tool which can execute calibration sequence step by step. See figure.6.

Sequence No	Action
SEQ0	Reset LLDRAM-III
SEQ1	Read DQ Calibration Test with Loop Back mode
SEQ2	Address and Command pins Calibration Test with Loop Back mode
SEQ3	Turn on the PLL of LLDRAM-III
SEQ4	QVLD Calibration test with Read operation
SEQ5	Set read data for Read Calibration (SEQ6 and 7) with auto DM mode
SEQ6	Read DQ Calibration Test with Read operation
SEQ7	Read DINV Calibration Test with Read operation
SEQ8	Write DQ Calibration Test with Write operation
SEQ9	Write DM Calibration Test with Write operation
SEQ10	Write DINV Calibration Test with Write operation
SEQ11	Set Mode register

Figure.6 Calibration Sequence

2. Development Support Environment

2.1 Reference Design with Verified Interoperability

Renesas development support tools consist of 1) reference board (RDK board) with voltage, current and power sensors 2) sample design including verified control IP, 3) a complete verification environment, and 4) a complete evaluation environment. With already verified interoperability between the FPGA and LLDRAM-III, these tools enable any user to get started with internal FPGA design and verification in parallel with network equipment system development. This will reduce the total development time and time-to-market.

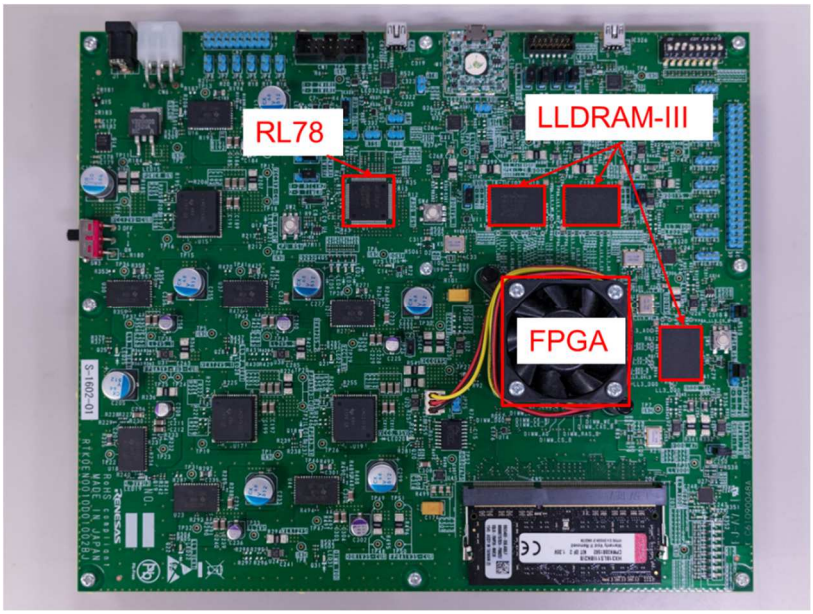

Figure.7 Reference Design Board (RDK board)

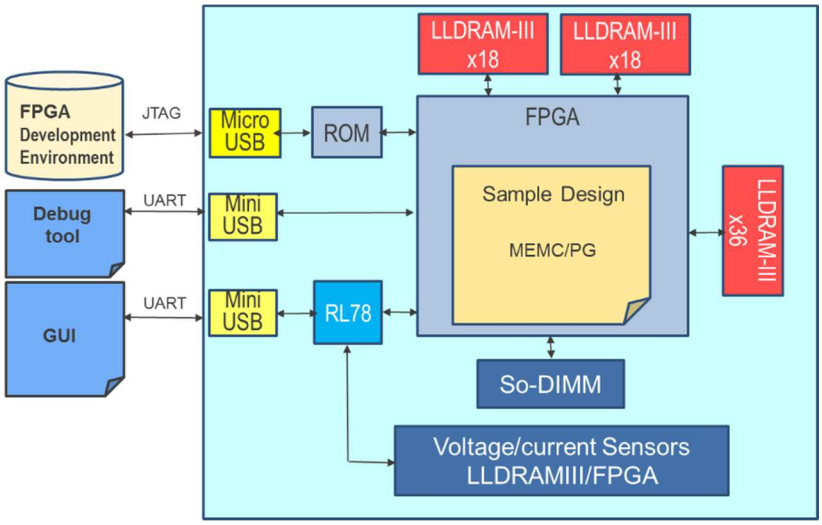

Figure.8 Structure of Reference Design Board

Website and Support

Renesas Electronics Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/contact/

Revision History

Rev.	Date	Description	
		Page	Summary
Rev. 1.00	2016.07.20		Rev. 1.00 Issued

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 these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
3. Renesas Electronics does not assume any liability for infringement of 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. 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 should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from such alteration, modification, copy or otherwise misappropriation of Renesas Electronics product.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The recommended 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; and industrial robots etc.
   "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; and safety equipment etc.
   Renesas Electronics products are neither intended nor 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 damages (nuclear reactor control systems, military equipment etc.). You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application for which it is not intended. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for which the product is not intended by Renesas Electronics.
6. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, 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, please evaluate 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. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technology may 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 should not use Renesas Electronics products or technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. When exporting the Renesas Electronics products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, who distributes, disposes of, or otherwise places the product with a third party, to notify such third party in advance of the contents and conditions set forth in this document, Renesas Electronics assumes no responsibility for any losses incurred by you or third parties as a result of unauthorized use of Renesas Electronics products.
11. This document may not be 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, or if you have any other inquiries.

(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.

(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

RENESAS

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

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

Renesas Electronics America Inc.
2801 Scott Boulevard Santa Clara, CA 95050-2549, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3
Tel: +1-905-237-2004

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-585-100, Fax: +44-1628-585-900

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
Room 1709, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100191, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, P. R. China 200333
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2265-6688, Fax: +852 2886-9022

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics India Pvt. Ltd.
No.777C, 100 Feet Road, HAL II Stage, Indiranagar, Bangalore, India
Tel: +91-80-67208700, Fax: +91-80-67208777

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

Colophon 5.0