

ISL28133EVAL1Z

High Gain Evaluation Board User Guide

AN1499
Rev.0.00
Oct 2, 2009

Introduction

The maximum useful signal range of a high gain DC amplifier is limited by the amplifiers own DC offset and low frequency noise. For battery powered amplifiers the problem is further compounded due to limits of low battery voltage. For example, the useful input voltage range of an ideal amplifier with 10kV/V gain operating from a 3V Lithium cell would be 300µV, which would drive the to the maximum possible +3V output. A standard low offset amplifier with 100µV VOS would reduce the maximum useful input voltage range from 300µV to 200µV, since the input offset voltage alone would drive the amplifier output to 10k times that, taking up 1V of the 3V total available voltage range. Further reductions due to offset voltage drift, low frequency 1/f noise, and the inability to swing the output close to the power supply rails can limit the best amplifiers to DC gains no higher than several hundred V/V.

The [ISL28133](#) chopper stabilized rail-to-rail op amp features a low 8µV maximum VOS over-temperature and a 0.1Hz 1/f noise corner frequency enabling very high gain single-stage DC amplifiers that can operate from single cell batteries while consuming only 20µA of current. The ISL28133EVAL1Z evaluation board is configured as a precision high-gain ($G = 10,000$) differential amplifier and demonstrates the level of performance possible with this type of amplifier while operating from battery voltages as low as 2.4V.

Reference Documents

- Data Sheet ([ISL28133](#))

Evaluation Board Key Features

The ISL28133EVAL1Z is designed to enable the IC to operate from a single supply, +2.4VDC to +5.5VDC or from split supplies, ±1.2VDC to ±2.75V. The board is configured for a single op amp connected for single-ended or differential input with a closed loop gain of 10,000. A single external reference voltage (VREF) pin and provisions for a user-selectable voltage divider-filter are included.

Power Supplies (Figure 2)

External power connections are made through the V+, V-, VREF, and Ground connections on the evaluation board. For single supply operation, the -V and Ground pins are tied together to the power supply negative terminal. For split supplies, +V and -V terminals connect to their respective supply terminals. Decoupling capacitors C2 and C4 provide low-frequency power-supply filtering, while four additional capacitors, C1, C5, C7 and C8, which are connected close to the part, filter out high frequency noise. Anti-reverse diodes D1 and D2 (optional) protect the circuit in the case of accidental polarity reversal.

The circuit can operate from a single supply or from dual supplies. The VREF pin can be connected to ground to establish a ground referenced input for split supply operation, or can be externally set to any reference level for single supply operation.

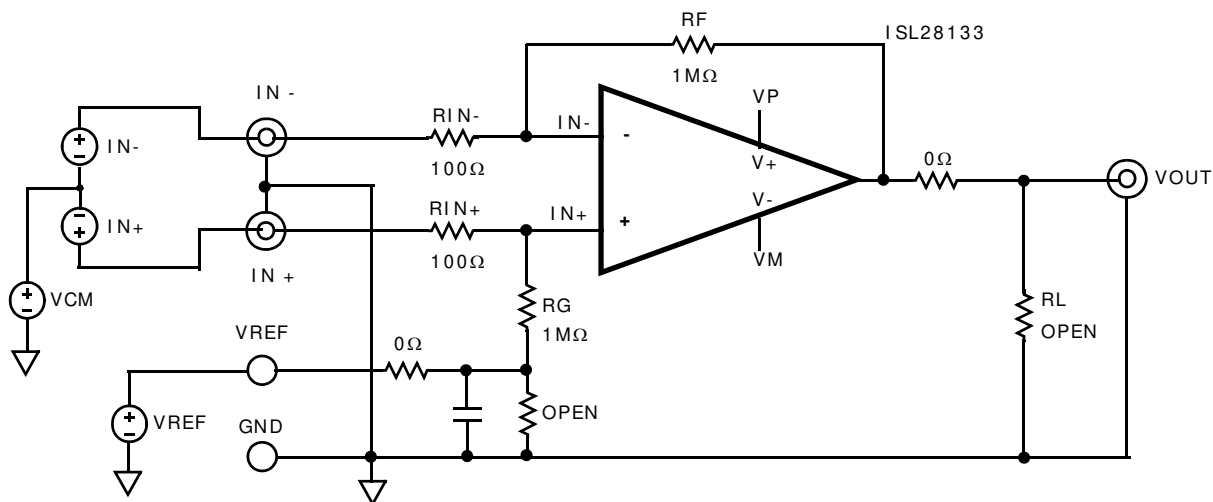


FIGURE 1. BASIC AMPLIFIER CONFIGURATION

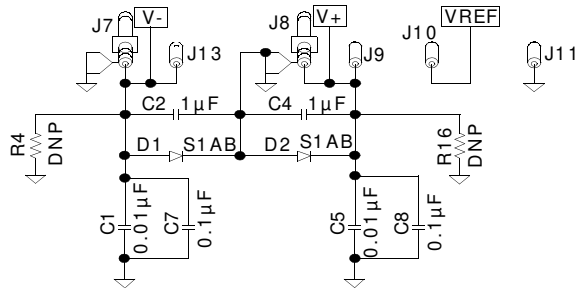


FIGURE 2. POWER SUPPLY CIRCUIT

Amplifier Configuration (Figure 2)

The schematic of the op amp with the components supplied is shown in Figure 2, with a closed loop gain of 10,000. The circuit implements a Hi-Z differential input with unbalanced common mode impedance. The differential amplifier gain is expressed in Equation 1:

$$V_{OUT} = (V_{IN+} - V_{IN-}) \cdot (R_F / R_{IN-}) + V_{REF} \quad (EQ. 1)$$

where: $R_F = R_G$ and $R_{IN+} = R_{IN-}$ and the differential input impedance is $\sim 1M\Omega$ with V_{REF} at GND. The IN- input connects to the amplifier summing junction and its impedance to ground is a low 100Ω . The impedance of the IN+ input to ground is much higher at $1.001M\Omega$ to VREF.

For single-ended input inverting operation ($G = -10001$), the IN+ input is grounded and the signal is supplied to the IN- input. V_{REF} must be connected to a reference voltage between the V+ and V- supply rails. For non-inverting operation ($G = 10,000$), the IN- input is grounded and the signal is supplied to the IN+ input. The non-inverting gain is strongly dependent on any resistance from IN- to GND. For good gain accuracy, a 0Ω resistor should be installed on the empty J7 pads.

User-selectable Options (Figures 3 and 4)

Component pads are included to enable a variety of user-selectable circuits to be added to the amplifier inputs, the VREF input, outputs and the amplifier feedback loops.

A voltage divider and filter option (Figure 3) can be added to establish a power supply-tracking common mode reference at the VREF input. The inverting and non-inverting inputs have additional resistor placements for adding input attenuation, or to establish input DC offsets through the VREF pin.

The output (Figure 4) also has additional resistor and capacitor placements for filtering and loading.

NOTE: Operational amplifiers are sensitive to output capacitance and may oscillate. In the event of oscillation, reduce output capacitance by using shorter cables, or add a resistor in series with the output.

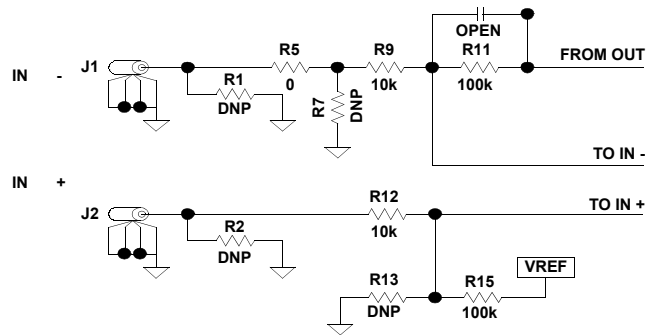


FIGURE 3. INPUT STAGE

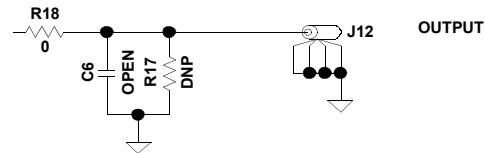
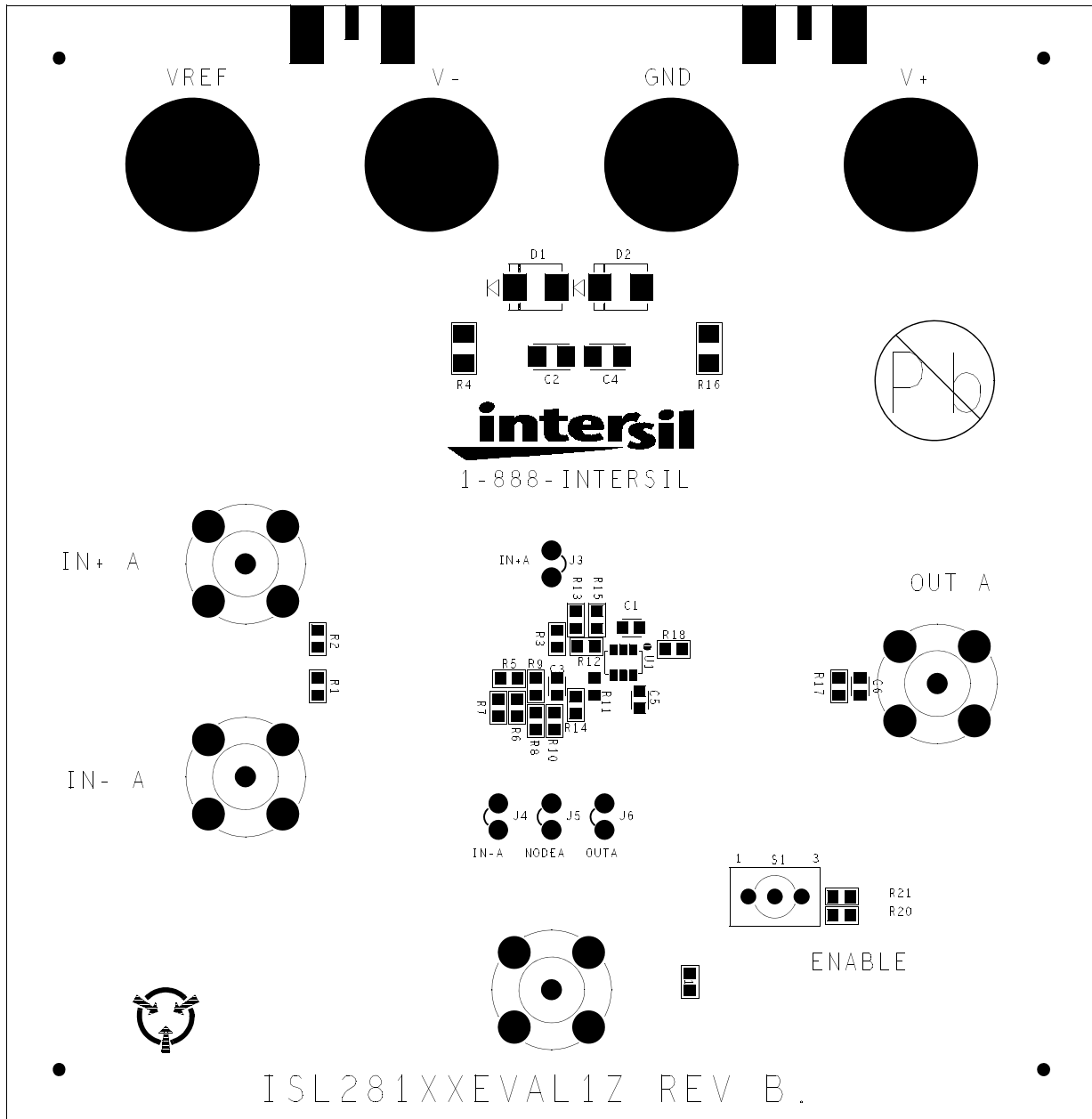


FIGURE 4. OUTPUT STAGE

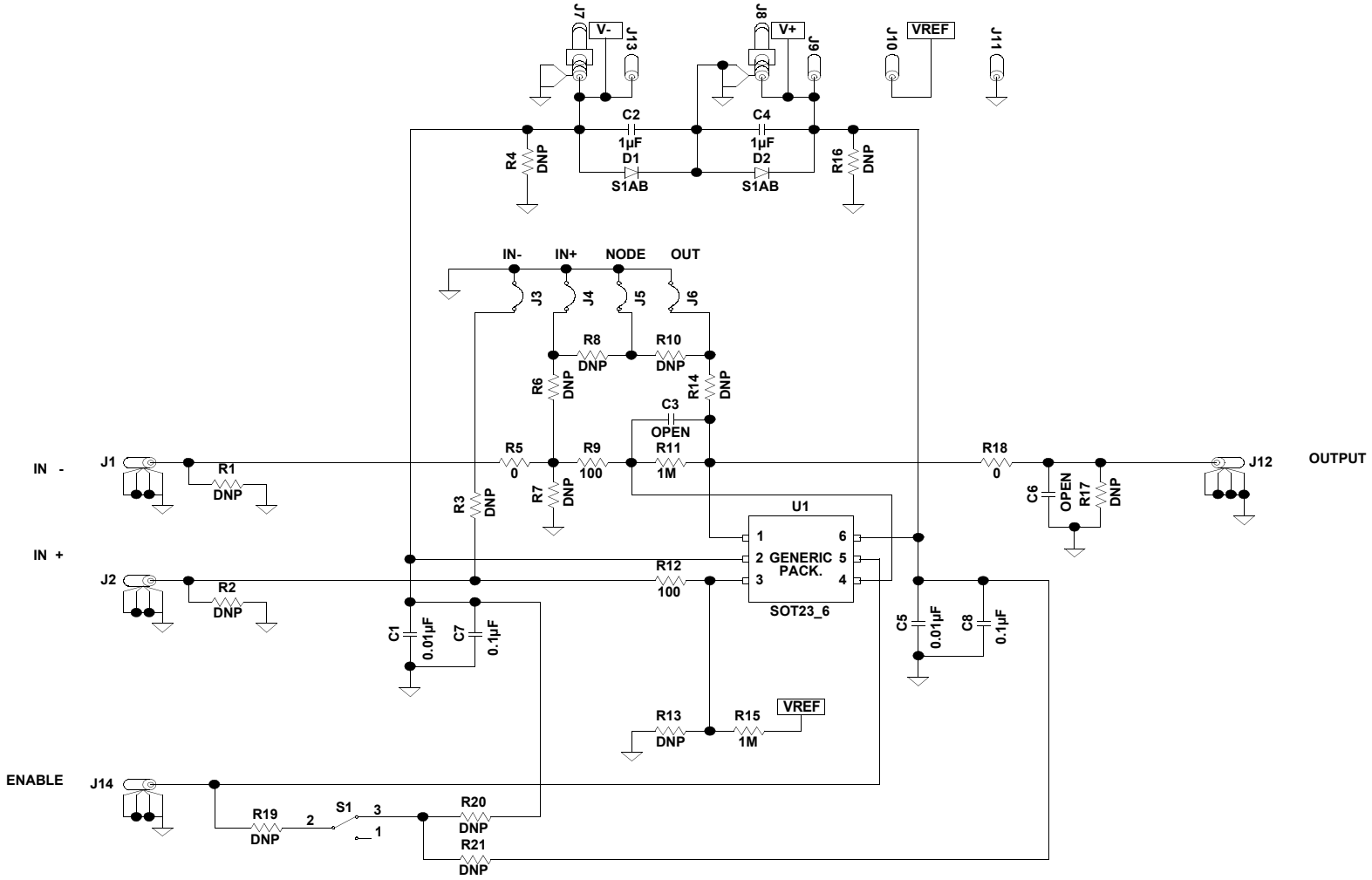
TABLE 1. ISL28133EVAL1Z COMPONENTS PARTS LIST

DEVICE #	DESCRIPTION	COMMENTS
C2, C4	CAP, SMD, 0603, 1μF, 25V, 10%, X7R, ROHS	Power Supply Decoupling
C1, C5	CAP, SMD, 0603, 0.1μF, 25V, 10%, X7R, ROHS	Power Supply Decoupling
C7, C8	CAP, SMD, 0603, 0.01μF, 25V, 10%, X7R, ROHS	Power Supply Decoupling
C3, C6	CAP, SMD, 0603, DNP-PLACE HOLDER, ROHS	User selectable capacitors - not populated
D1, D2	DIODE-RECTIFIER, SMD, SOD-123, 2P, 40V, 0.5A, ROHS	Reverse Power Protection
U1 (ISL28133EVAL1Z)	ISL28133FHZ-T7, IC-RAIL-TO-RAIL OP AMP, SOT-23, ROHS	
R1-R4, R6-R8, R10, R13, R14, R16, R17, R19, R21	RESISTOR, SMD, 0603, 0.1%, MF, DNP-PLACE HOLDER	User selectable resistors - not populated
R5, R18	RES, SMD, 0603, 0Ω, 1/10W, TF, ROHS	0Ω user selectable resistors
R9, R12	RES, SMD, 0603, 100, 1/10W, 1%, TF, ROHS	Gain resistors
R11, R15	RES, SMD, 0603, 1M, 1/10W, 1%, TF, ROHS	Gain resistors

ISL28133EVAL1Z Top View



ISL28133EVAL1Z Schematic Diagram



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 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 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.
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 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 Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K.
Tel: +44-1628-651-700, Fax: +44-1628-651-804

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, 200333 P. R. 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 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 2nd Stage, Indiranagar, Bangalore 560 038, India
Tel: +91-80-67208700, Fax: +91-80-67208777

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