RS-232 Interfaces

3.3V High-Speed Opto-Isolated RS-232 Interface with RV1S9160A and ISL3232E

Abstract

This application note discusses the design of opto-isolated RS-232 interfaces for space constraint applications using the RV1S9160A opto-coupler, the smallest included in the latest Renesas family of digital high-speed optocouplers. For detailed information on the construction of opto-couplers, see AN1991, *Isolating RS-485 Interfaces with High-Speed Digital Optocouplers*.

Related Literature

For a full list of related documents, visit our website:

- ISL3232E, RV1S9160A device pages

1. Opto-Coupler Features

Table 1 lists the features for the RV1S9x60A family of high-speed opto-couplers.

Table 1. Opto-Coupler Features

Parameter	RV1S9060A	RV1S9160A	RV1S9960A
Creepage Distance (minimum)	8mm	4.2mm	14.5mm
Supply Range	2.7V – 5.5V	2.7V – 5.5V	2.7V – 5.5V
Data Rate (minimum)	15Mbps	15Mbps	15Mbps
Pulse Width Distortion (typical/maximum)	2/20ns	2/20ns	2/20ns
Common-mode Transient Immunity (minimum/ typical)	50/60kV/µs	50/60kV/µs	50/60kV/µs
Forward Current – I_{FHL} (minimum)	2.2mA	2.0mA	3.8mA
Working Voltage (V_{IORM})	$799V_{RMS}$	$502V_{RMS}$	$1131V_{RMS}$
Isolation Voltage (V_{ISO})	$5000V_{RMS}$	$3750V_{RMS}$	$7500V_{RMS}$
Transient Overvoltage (V_{IOTM})	$8000V_{PK}$	$6000V_{PK}$	$12000V_{PK}$
Temperature Range	-40°C to +125°C	-40°C to +125°C	-40°C to +110°C
Insulation Classification	Reinforced	Basic	Reinforced

2. LED Drive Circuit for Best Common-Mode Rejection

The opto-coupler LED is driven with a setting resistor, R_S, in series. The value of R_S is calculated using Equation 1:

$$R_S = \frac{V_{CC1} - V_F - V_{OL}}{I_F} \quad \text{(EQ. 1)}$$

where V_F and I_F are the typical forward voltage and current of the LED, and V_{CC1} and V_{OL} the nominal supply voltage and typical output low-voltage of the driving source, which can be a logic gate or the general-purpose output of a local controller.

The RV1S9x90A datasheet specifies the minimum (3mA) and maximum (6mA) LED forward currents. The arithmetic means of these two currents define the typical value with $I_{F\text{-}TYP}$ = 4.5mA. The I_F-versus-V_F characteristic in the opto-coupler datasheet depicts a typical forward voltage of V_F = 1.49V at this current. Therefore, for a nominal supply of V_{CC} = 3.3V and a typical V_{OL} of 0.25V for a standard logic output, the value for R_S is:

$$R_S = \frac{3.3V - 1.49V - 0.25V}{4.5mA} = 347\Omega$$

To improve the common-mode rejection and reducing the risk of output glitches, the common-mode impedance at the LED anode and cathode is balanced by splitting R_S into two resistors of equal value; in this case with $R_S/2 = 173\Omega$.

The next higher 5% standard value is 178Ω. Therefore, all current setting resistors in the following schematics use $R_S/2 = 178\Omega$. Because the output of the RV1S9160 opto-coupler turns low when the LED is on, and high when the LED is off, each coupler is driven from its cathode side.

3. Isolated RS-232 Interface

The interface in Figure 1 operates the RS-232 transceiver in full-duplex mode; the transceiver transmits and receives data at the same time. If the direction terminal DIR = H, the ISL3178E transmits data, if DIR = L, it receives data. See Figure 2 for corresponding waveforms. The ISL3232E is a 3.3V, 500kbps dual-channel driver and receiver circuit, available in a 4mmx5mm 16 Ld TSSOP package. Combined with the RV1S9160A opto-couplers they allow for a small footprint design, which is ideal for space constrained applications.

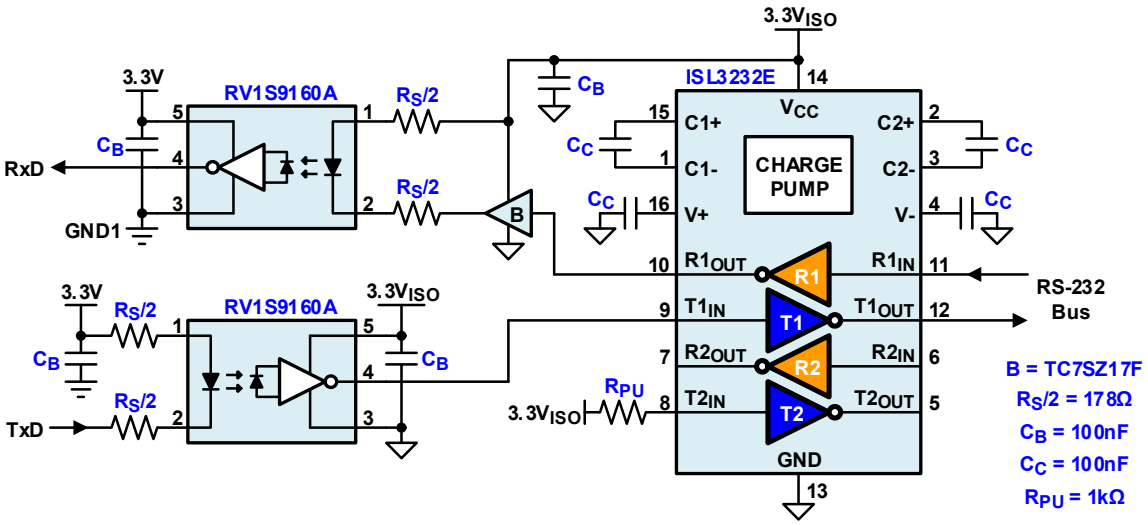

Figure 1. 3.75kV Isolated 500kbps RS-232 Interface

Note: The the RS-232 receiver output needs an external buffer to drive the opto-coupler. Also, unused transmitter inputs require an external pull-up or pull-down resistor, while unused receiver inputs can be left open as they are pulled down internally using a 5kΩ resistor.

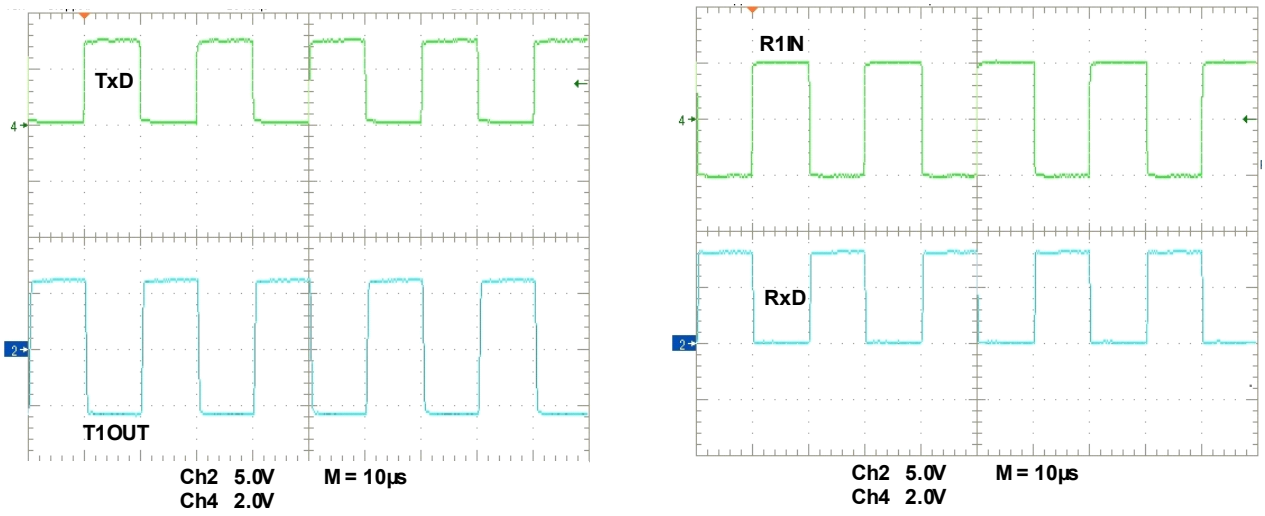

Figure 2. Signal Waveforms of the Circuit in Figure 1

4. Revision History

Rev.	Date	Description
1.00	Oct.29.19	Initial release

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.

(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.4.0-1 November 2017)

Corporate Headquarters

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

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/

Trademarks

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