RS-485 Interfaces

3.3V High-Speed Opto-Isolated RS-485 Interface with RV1S9160A and ISL3178E

Abstract

This application note discusses the design of opto-isolated RS-485 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:

- ISL3178E, 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 Half-Duplex RS-485 Interface

The interface in Figure 1 operates the RS-485 transceiver in half-duplex mode; the transceiver either transmits or receives data. If the direction terminal DIR = H, the ISL3178E transmits data, if DIR = L, it receives data. See Figure 2 for the corresponding timing diagrams.

The ISL3178E is a 3.3V, 20Mbps half-duplex transceiver, available in a 3mm x 3mm 8-pin MSOP package. Combined with the RV1S9160A opto-couplers, they allow for a small footprint design, ideal for space constrained applications.

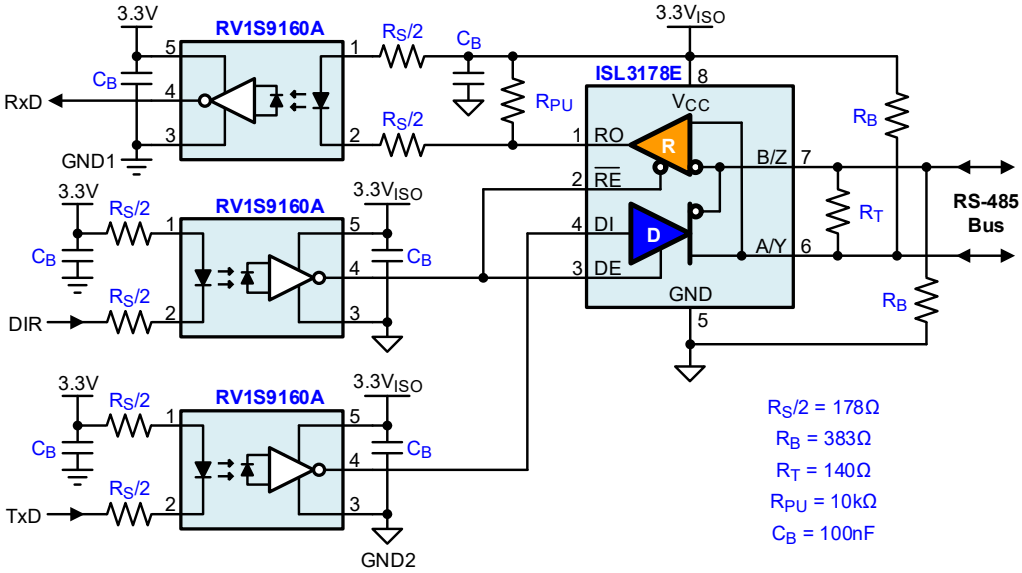

Figure 1. 3.75kV Isolated 20Mbps Half-Duplex RS-485 Interface

Note: The receiver output has a pull-up resistor, which ensures the opto-coupler input is properly biased when RO is high-impedance. The R_B-R_T resistor network provides failsafe biasing to ensure the correct receiver output state (High) if the bus is not actively driven. For more information on failsafe biasing and on the calculation of the resistor values, see TB509, *Detecting Bus Signals Correctly with Failsafe Biased RS-485 Receivers*.

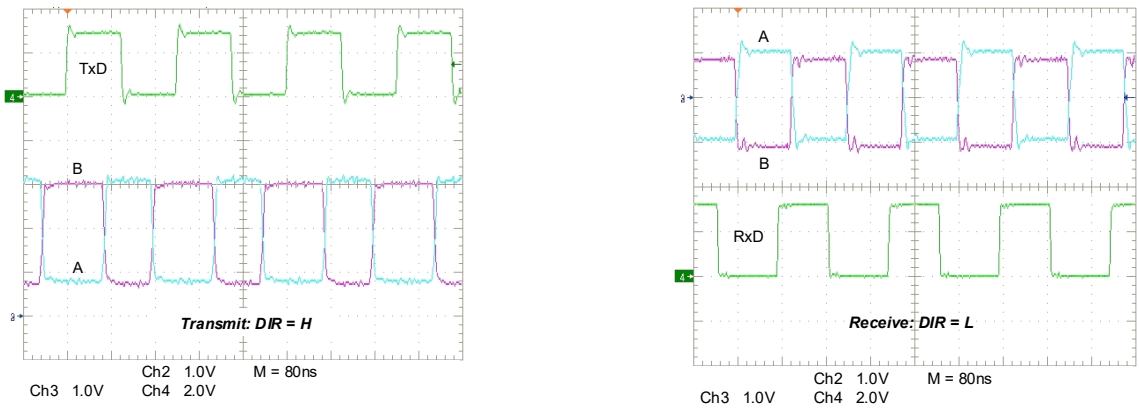

Figure 2. Transmit and Receive Signal Waveforms of the Circuit in Figure 1

4. Revision History

Rev.	Date	Description
1.00	Oct.29.19	Initial release

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