Optocoupler as Optical Isolator for RS-232 Bus System

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INTRODUCTION

The RS-232 bus is a serial, single-ended bus system with a data transfer rate up to 115.2 kBd. The application areas are computer to computer or computer to peripheral devices communication, like a printer, mouse, and so on. As shown in Fig. 1, three lines are required for data transmission: the data transmitting line (TX), data receiving line (RX), and a common ground line (GND).

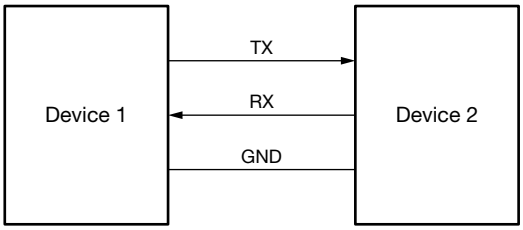

Fig. 1 - RS-232 Connection

OPTICAL ISOLATION

In case of electrical noise, coupling effects, or level shifting requirements, an optocoupler is a perfect solution for isolating two devices. Due to galvanic isolation, an optocoupler helps to break up ground loops and reduce the electrical noise due to optical light transmission across an isolation barrier. It can also restore the signal logic level and further be used for signal level transforming between different voltage domains, e.g. from 5 V to 3.3 V.

EXAMPLE CIRCUIT

Fig. 4 depicts an exemplary optical RS-232 isolator circuit. Vishay's 10 MBd high speed optocouplers are used: a single channel for OC_1 (TX (forward)) and for OC_2 (RX (backward)). This part is available in the DIP-8 package as the VOH260A [1], the SOIC-8 package as the VOIH060A [2], and the WDIP-8 package as the VOWH260A [3].

By assuming TX/IN (X_2) is at the logic "L" stage (the saturation voltage drop of the connected device at X_2 is neglected), the resistor R_1 sets the forward current (I_F) through the emitter LED of the optocoupler (OC_1) input, and can be calculated with Equation 1:

Notes

(1) www.vishay.com/ppg?80354
(2) www.vishay.com/ppg?80356
(3) www.vishay.com/ppg?84126

$$R_1 = \frac{V_{CC1} - V_F}{I_F} \quad (1)$$

By assuming RX/IN (X_4) is at the logic "L" stage (the saturation voltage drop of the connected device at X_4 is neglected), the resistor R_2 sets the forward current (I_F) through the emitter LED of the optocoupler (OC_2) input, and can be calculated with Equation 2:

$$R_2 = \frac{V_{CC2} - V_F}{I_F} \quad (2)$$

According to the datasheet figure "Voltage vs. Forward Current" (www.vishay.com/ppg?80354), a voltage drop (V_F) of 1.35 V is caused by a forward current (I_F) of 10 mA through the input LED, as shown in Fig. 2.

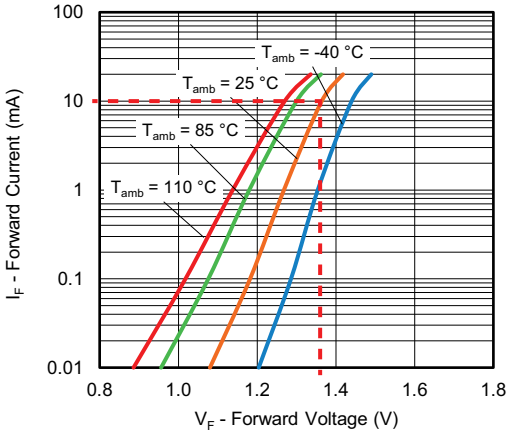

Fig. 2 - VOH260A Datasheet – V_F vs. I_F

By using 5 V as the supply voltage (V_{CC1} and V_{CC2}), values for the resistors R_1 and R_2 can be calculated using Equations 3 and 4:

$$R_1 = \frac{5\ V - 1.35\ V}{10\ mA} = 365\ \Omega \quad (3)$$

Note

- The closest value to an E series resistor can be chosen

APPLICATION NOTE

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$$R_2 = \frac{5\ V - 1.35\ V}{10\ mA} = 365\ \Omega \quad (4)$$

Note

- The closest value to an E series resistor can be chosen

When the data line (TX) is pulled down to the logic “L” stage, a voltage divider is formed by the pull-up resistor (R_P) and the internal NMOS drain source junction. The output voltage (V_O) is the voltage drop of the NMOS output (V_{OL}), as shown in Fig. 3.

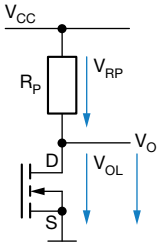

Fig. 3 - Voltage Divider

For the logic “H” stage, pull-up resistors (R_P, as shown in Fig. 3) are required and can be calculated for the required output current (I_O) with Equation 5 below:

$$R_P = \frac{V_{CC} - V_{OL}}{I_O} \quad (5)$$

The capacitors C_1 and C_2 stabilize the power supply, and should be placed as close as possible to the optocouplers OC_1 and OC_2.

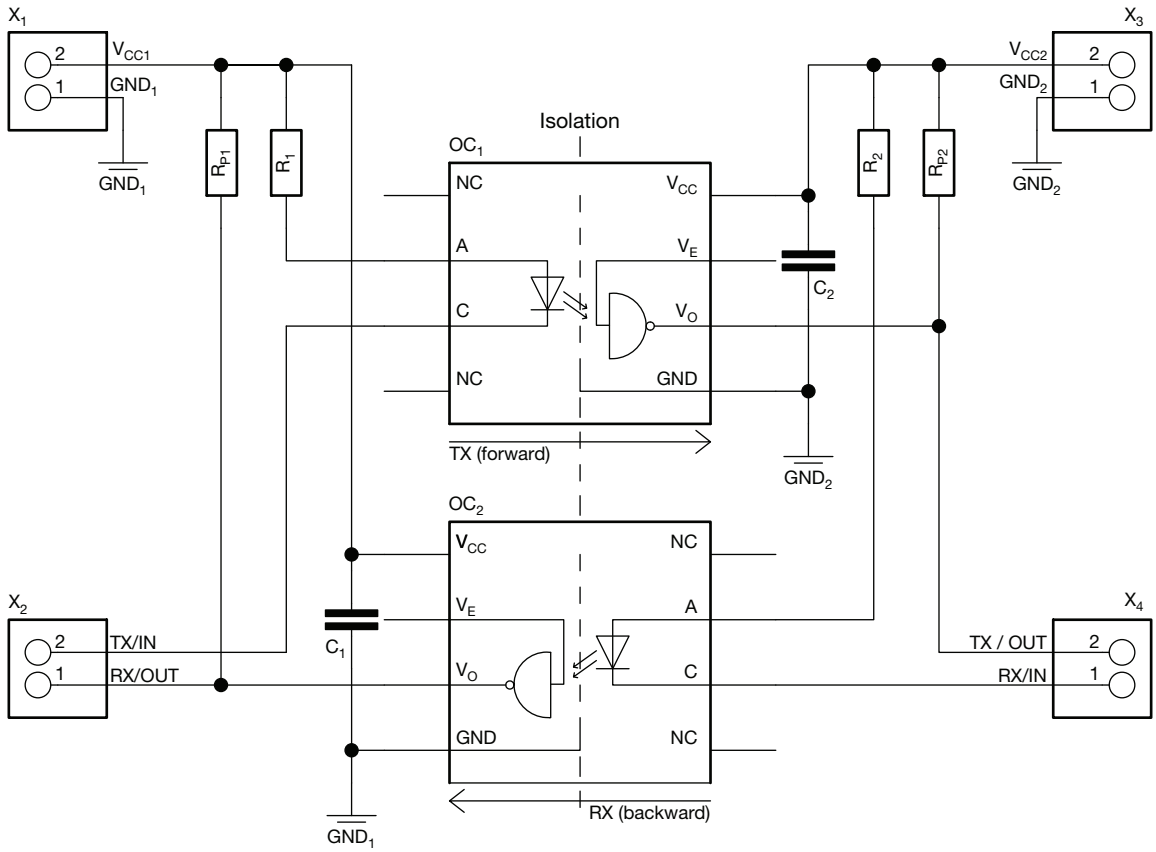

Fig. 4 - Example Schematic for an Optical RS-232 Isolator

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TRANSMISSION

When TX/IN (X_2) is at the logic “H” stage, no forward current (I_F) is flowing through the emitter LED (A/C) and the optocoupler OC_1 output V_O is also at the logic “H” stage. When TX/IN (X_2) is at the logic “L” stage, the forward current (I_F) is flowing through the emitter LED (A/C) and the optocoupler OC_1 output V_O is also at the logic “L” stage.

When RX/IN (X_4) is at the logic “H” stage, no forward current (I_F) is flowing through the emitter LED (A/C) and the optocoupler OC_2 output V_O is also at the logic “H” stage. When RX/IN (X_4) is at the logic “L” stage, forward current (I_F) is flowing through the emitter LED (A/C) and the optocoupler OC_2 output V_O is also at the logic “L” stage.

LOGIC LEVEL STANDARDS

Using standard TTL or CMOS 0/5 V logic levels, e.g. for communication between microcontrollers, the example circuit in Fig. 4 can be used.

According to the V.24 and V.28 recommendation, an RS-232 bus system has any standard logic levels. They are defined as -3 V to -15 V for logic 1 and +3 V to +15 V for logic 0. The area between -3 V and +3 V is not defined. For isolation of an RS-232 bus system, a MAX232 logic level converter is required. After converting the RS-232 signal to a TTL signal, it can be isolated with an optocoupler.

RECOMMENDED PARTS

TABLE1 - OPTICAL SPI ISOLATOR

IDENTIFIER	COMMENT
X_1	Pin header, 2 circuits
X_2	Pin header, 2 circuits
X_3	Pin header, 2 circuits
X_4	Pin header, 2 circuits
R_1	365 Ω resistance
R_2	365 Ω resistance
R_{P1}	350 Ω resistance (1)
R_{P2}	350 Ω resistance (1)
C_1	100 nF capacitance
C_2	100 nF capacitance
OC_1	10 MBd (single) high speed optocoupler VOH260A
OC_2	10 MBd (single) high speed optocoupler VOH260A

Note

(1) Recommended load resistance

CONCLUSION

It can be seen that by using Vishay’s 10 MBd high speed optocoupler series, it is easily possible to galvanically isolate RS-232 bus systems. Ground loops and electrical noise can be eliminated due to long term proven and robust optical isolation technology.

By choosing Vishay’s small and compact SOIC-8 package, board space can be saved. Higher isolation voltages up to 1414 V can be achieved by using parts with a WDIP package.

APPLICATION NOTE