ENVISIONING • EMPOWERING • EXCELLING

Advantages of Designing with Multi-Protocol Transceivers

Application Note

Revision History

Document No.	Release Date	Change Description
295ANR00	September 1, 2023	Initial release.

Table of Contents

List of Figures

List of Tables

Introduction

Many industrial communications and networking products require support for multiple interfaces. The RS-232, RS-485, and RS-422 protocols are the most commonly used interfaces in industrial applications. MaxLinear's RS-232/RS-422/RS-485 multi-protocol transceivers simplify product development and provide flexibility over dedicated RS-485 and RS-232 transceivers by adding the ability to switch between these interfaces, using a single, small form factor integrated circuit (IC). MaxLinear also provides multi-protocol transceivers that support other protocols such as RS-449, EIA-530, and EIA-530A. For more information, see Table 2.

Table 1: MaxLinear's Dual-Protocol Transceivers

Device	Power Input	RS-232 Tx/Rx	RS-485 Tx/Rx	Product Page Link
XR34350	3.3V or 5V	3/5	1/1	www.maxlinear.com/XR34350
XR3160	3.3V or 5V	2/2	1/1	www.maxlinear.com/XR3160
SP339B	3.3V or 5V	3/5	1/1	www.maxlinear.com/SP339B
SP339	3.3V or 5V	3/5	1/1	www.maxlinear.com/SP339
SP338	3.3V or 5V	3/5	2/4	www.maxlinear.com/SP338
SP337	3.3V or 5V	3/5	2/2	www.maxlinear.com/SP337
SP336	3.3V or 5V	4/4	2/2	www.maxlinear.com/SP336
SP335	3.3V or 5V	2/2	1/1	www.maxlinear.com/SP335
SP334	5V	3/5	2/2	www.maxlinear.com/SP334
SP332	5V	4/4	2/2	www.maxlinear.com/SP332
SP331	5V	4/4	2/2	www.maxlinear.com/SP331
SP330	3.3V or 5V	2/2	1/1	www.maxlinear.com/SP330

Table 2: MaxLinear's Multi-Protocol Transceivers

Device	Power Input	Supported Protocols	Product Page Link
SP510E	5V	RS-232, RS-449, EIA-530, EIA-530A, V.10, V.11, V.28, V.35, V.36, X.21	www.maxlinear.com/SP510E
SP508E	5V		www.maxlinear.com/SP508E
SP3508	3.3V		www.maxlinear.com/SP3508

Standard versus Multi-Protocol Transceivers

You can design a multi-protocol system in two ways, that is:

- By using standard transceivers.
- By using multi-protocol transceivers.

MaxLinear recommends that you choose the second option, because it solves the main problems that arise when using standard transceivers (described in “Disconnection of RS-485 Termination Resistor, Driver, and Receiver” on page 3) without having to install additional components.

Design of a Multi-Protocol System with Standard Transceivers

When designing a multi-protocol system with standard transceivers, many jumpers or additional components such as buffer gate or signal switch are required to achieve dynamic mode switching.

The following figure shows an example of a block diagram that uses standard transceivers to support a multi-protocol system (RS-232 and RS-485/RS-422). The additional parts used increase both PCB size and bill of materials (BOM) costs.

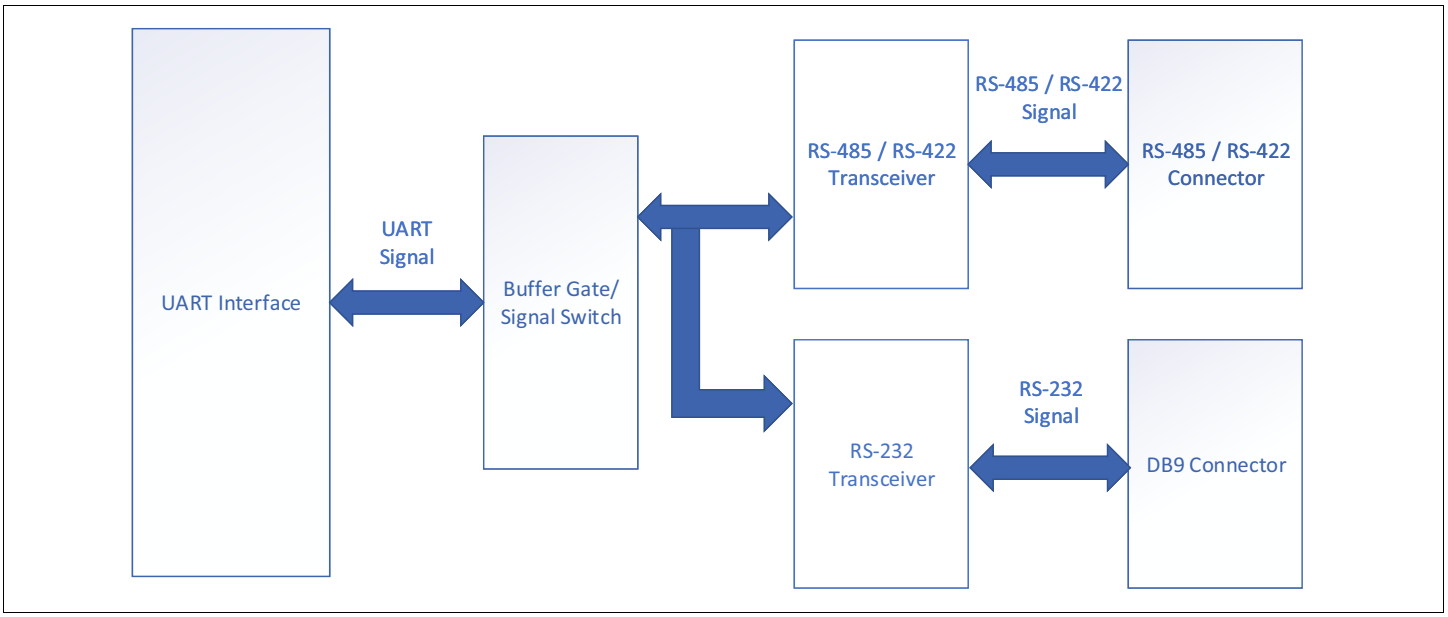

Figure 1: Multi-Protocol Design Block Diagram using Standard Transceivers

When designing a multi-protocol system over shared data lines, two main issues must be addressed, related to:

- RS-485 termination (number 1 in Figure 2). For more information, see "Disconnection of RS-485 Termination Resistor, Driver, and Receiver".
- The fact that the driver and the receiver must be disconnected when switching from RS-485 to RS-232 (number 2 in Figure 2). For more information, see "Disconnection of RS-485 Termination Resistor, Driver, and Receiver".

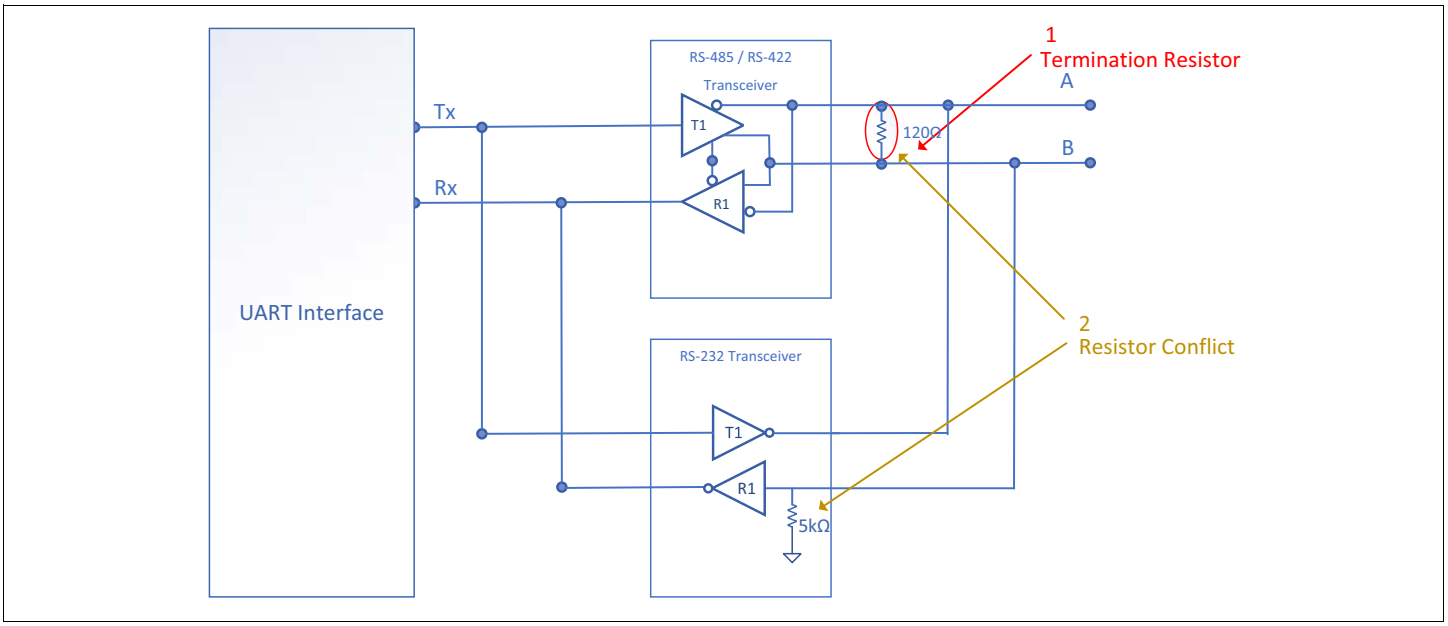

Figure 2: Multi-Protocol Design Block Diagram using Standard Transceivers over Shared Data Bus

Disconnection of RS-485 Termination Resistor, Driver, and Receiver

The RS-485 termination resistor, driver, and receiver must be disconnected when switching from RS-485 to RS-232.

Most RS-485 applications require termination resistors due to impedance matching and reduced reflection. When switching between RS-485 and RS-232 interfaces in a multi-protocol design over a shared data line, the termination resistor must be installed and uninstalled after each interface swap to prevent the RS-232 driver and receiver data from being affected by the termination resistor.

Design of a Multi-Protocol System with Multi-Protocol Transceivers

To simplify the design of RS-485 and RS-232 multi-protocol systems, MaxLinear provides multi-protocol transceiver solutions that combine both types of transceivers in a single device to support a wide variety of applications. Additionally, these multi-protocol transceivers include features that make them flexible and robust.

This section describes some of the main advantages of designing a multi-protocol system with multi-protocol transceivers such as the SP335 with shared RS-485 and RS-232 interface pins (see “Flexible Hardware Design” on page 5, “Use of RS-232 and RS-485 with a Shared Pinout” on page 6, and "Integrated Termination Resistor Feature" and “Slew Limiting Feature” on page 7) and how it solves the problems that arise when simply combining standalone RS-485 and RS-232 transceivers (see “Enhanced Fail-Safe Feature” on page 8 and “Internal Termination Feature” on page 8).

The SP335 can change between the RS-232 signals and RS-485 signals via control of the RS-485/RS-232 pin during normal operation, as shown in the following figure.

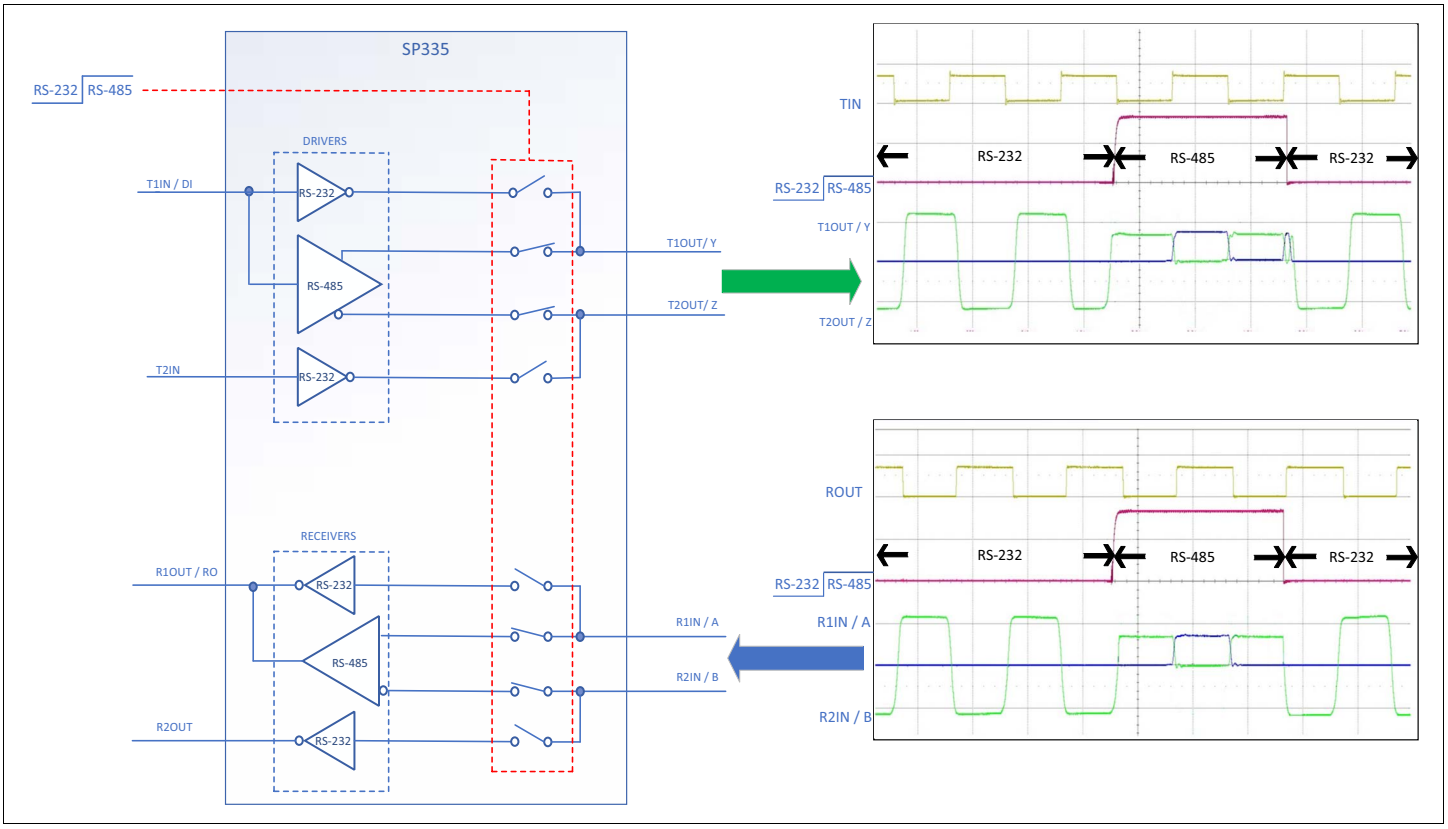

Figure 3: SP335 Signal Switching via RS-485/RS-232 Pin Control

Note: The oscilloscope waveform shows the driver outputs toggling data during the mode switch.

Flexible Hardware Design

By combining the function of both transceivers in a single device, complex switching through external components is not required, thus reducing the overall footprint on a circuit board.

The signaling pins on Maxlinear multi-protocol transceivers are shared between the RS-485 and the RS-232 transceivers, with one transceiver active at any time.

For example, the SP335 can switch modes between the RS-232 and RS-485 transceivers via the 485/232 control pin, configure the mode between the RS-485 and RS-422 via the HALF/FULL control pin, and seamlessly switch between termination schemes via the TERM control pin as needed. These pins can be controlled by the GPIO pin from the UART bridge IC or microprocessor.

The following figure shows the connection for RS-232 (a), RS-485 half-duplex (b) and RS-485 full-duplex (c) protocol communications and mode configurations, using the SP335 as an example.

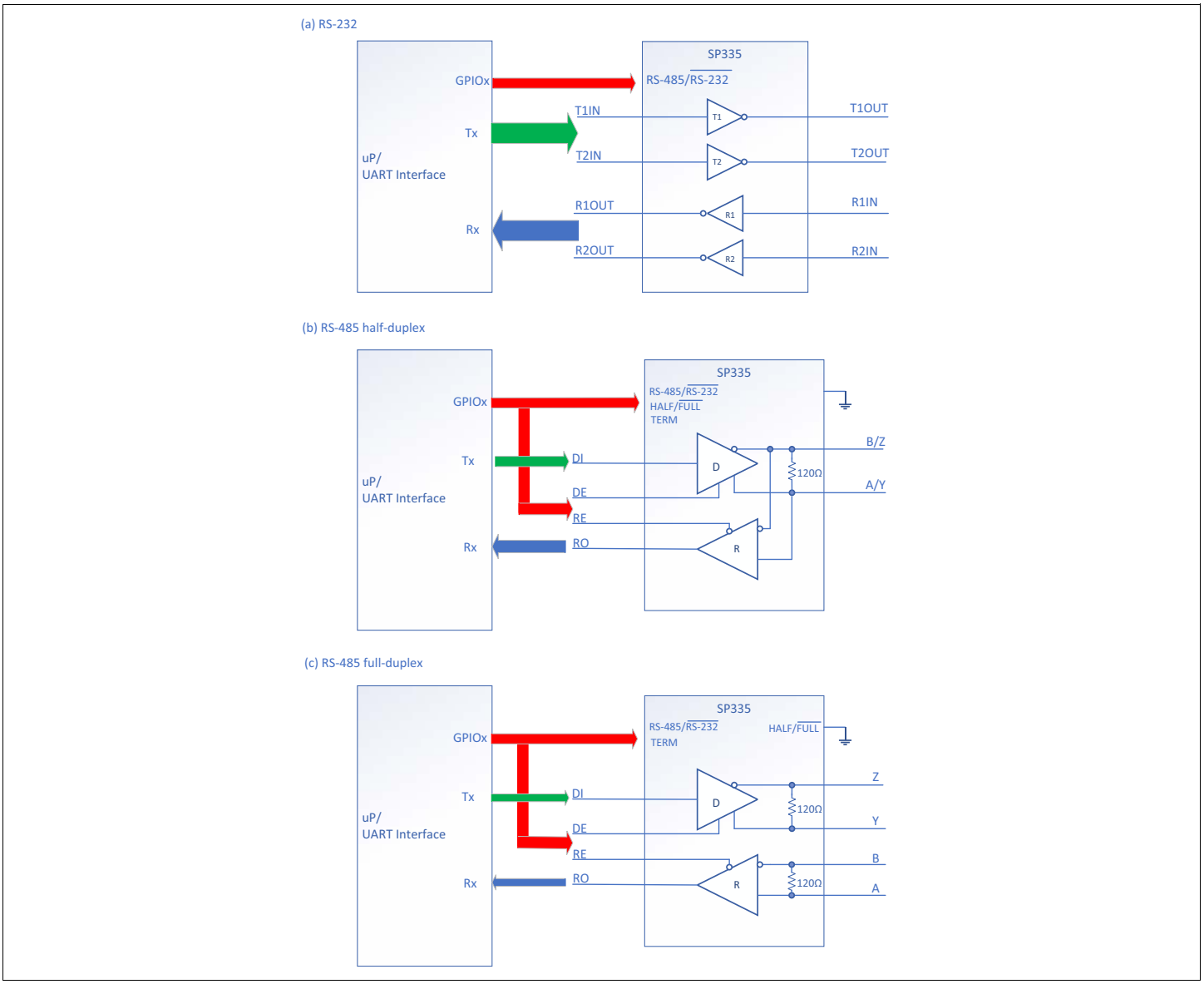

Figure 4: Multi-Protocol Design Block Diagram using Multi-Protocol Transceivers

Note: Due to the difference in design, the pin name and feature can differ for different multi-protocol devices. For more information about pin configuration, refer to the corresponding data sheets.

Use of RS-232 and RS-485 with a Shared Pinout

This section explains how to use both RS-232 and RS-485 half-duplex in the same pinout and sharing the same DB9 connector.

For convenience of use, as well as to save PCB space and cost, you can make the connection of Tx/Rx, Z/B, Y/A, and the DB9 connector compatible with the RS-232 and RS-485 half-duplex mode.

To do this, you can use the features of the multi-protocol transceiver and work on the pins in a floating state under a specific mode. For this purpose you can use RxIN in RS-232 mode, which is a floating pin in RS-485 half-duplex mode. Adding the external FET switch allows you to connect the RxIN pin and the TxOUT pin together under RS-485 mode.

- When the RS-485/RS-232 mode select pin is *0*, it is configured in RS-232 mode. The FET switch is turned off, so the RxIN pin is disconnected from the TxOUT pin.
- When the RS-485/RS-232 mode select pin is *1*, it is configured in RS-485 mode. The FET switch is turned on, causing the RxIN pin to connect to the TxOUT pin.

By adding this switch design, you ensure that the RS-232 and RS-485 half-duplex connection works properly with the same connector and pinout.

The following figure shows an example of a shared connector design for RS-232 and RS-485.

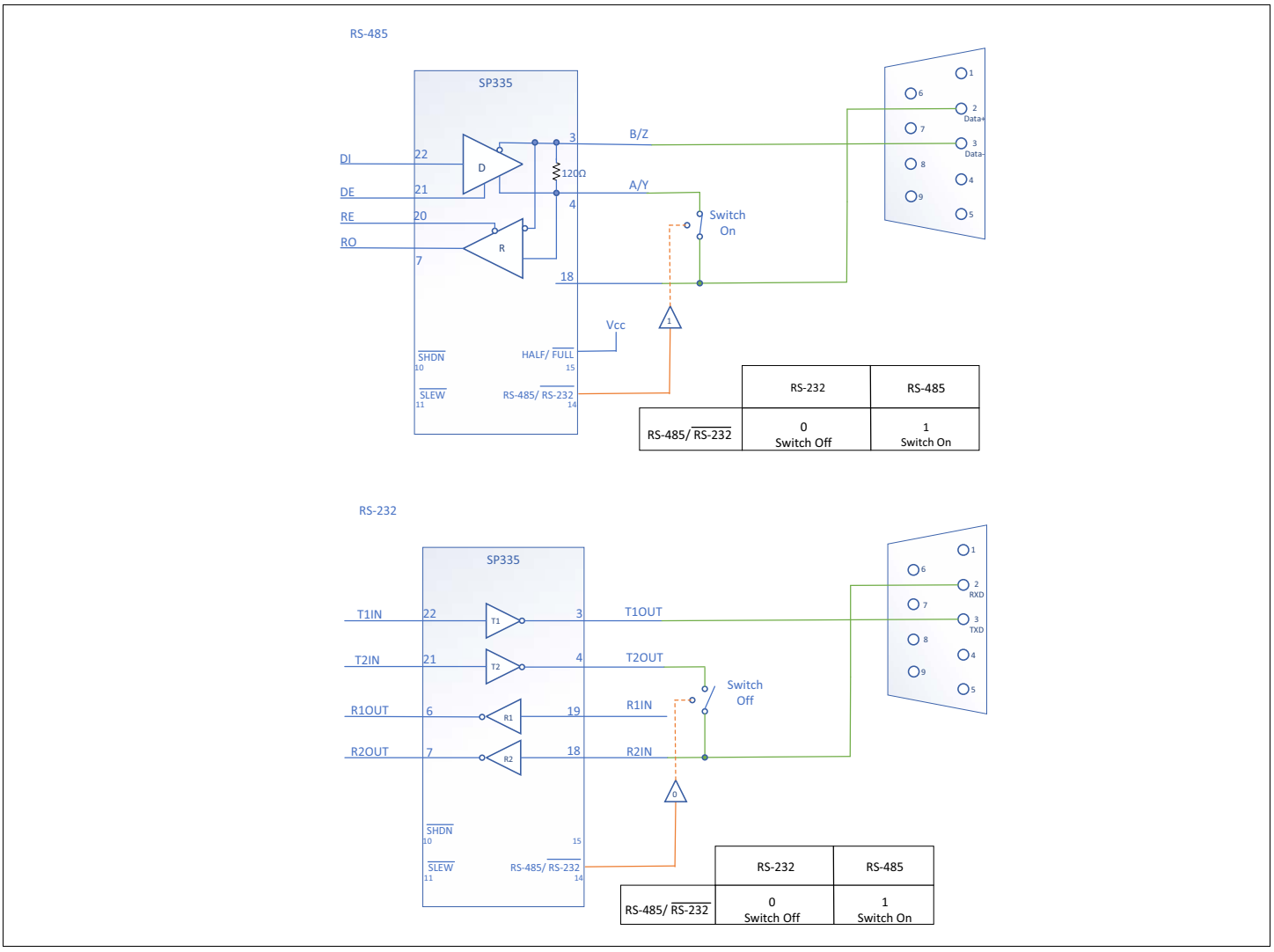

Figure 5: Multi-Protocol Shared Connector Design for RS-232 and RS-485

Integrated Termination Resistor Feature

RS-485 communicates differentially over a bus with one or more twisted wire pairs. If the impedance is discontinuous, meaning that the signal suddenly encounters a cable with little or no impedance at the end of the transmission line, or if the impedance between the data transceiver and the transmission cable does not match, it causes signal reflection.

The purpose of the termination resistor (RT) is to adjust the input impedance of the bus node circuit to match the characteristic cable impedance in order to absorb the reflected wave on the network and effectively enhance the signal strength.

Enabling and disabling the RS-485/RS-422 termination resistor is one of the biggest challenges that system designers face when sharing a single connector or pair of lines across multiple serial protocols. A termination resistor may be necessary for accurate RS-485/RS-422 communication, but must be removed when the lines are used for RS-232. For example, the SP335 solves this problem by integrating the termination resistor and switching control, and allowing it to be switched in and out of the circuit with a single pin. No external switching components are required. Termination on the receiver inputs is enabled if both TERM and RS-485/RS-232 are high as shown in the following figure.

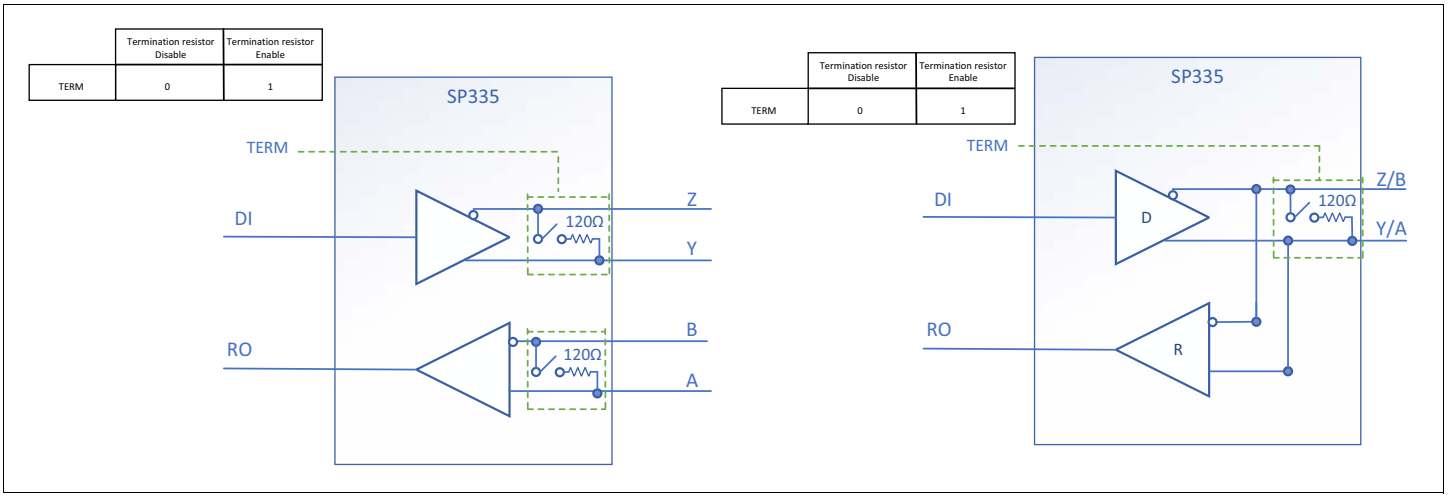

Figure 6: Integrated Termination Resistor Feature

Slew Limiting Feature

The multi-protocol system supports the slew limiting feature. Enabling this feature limits the slew rate of the driver output. This helps reduce electromagnetic interference (EMI) and minimize reflections in unterminated or poorly terminated networks.

For more information, refer to the data sheets corresponding to the different pins.

Enhanced Fail-Safe Feature

MaxLinear provides enhanced fail-safe multi-protocol transceivers that ensure a logic-high receiver output.

When the receiver inputs are open, shorted, or terminated but undriven or idle, the differential voltage of 0V at the receiver input produces a logic high at the receiver output. No additional external biasing resistor is required.

For more information, refer to the *RS-485 Advanced Fail-Safe Feature Application Note* (291AN).

The enhanced fail-safe multi-protocol transceivers are:

- XR34350
- XR3160
- SP339B
- SP339
- SP338
- SP337
- SP336
- SP335

Internal Termination Feature

MaxLinear provides multi-protocol transceivers with internal termination to facilitate the design of different applications for RS-485 and RS-422 interfaces. You can choose to enable or disable this feature during the interface switching process according to your needs. The internal termination feature eliminates the need to disconnect the driver and receiver when switching from RS-485 to RS-232.

MaxLinear's internal termination multi-protocol transceivers are:

- XR34350
- SP339B
- SP339
- SP338
- SP335
- SP510E
- SP508E
- SP3508

Conclusion

MaxLinear provides flexible multi-protocol transceivers that communicate using RS-232, RS-485, and RS-422 signaling on shared I/O pins within a single-chip solution for multi-protocol design.

MaxLinear's multi-protocol transceivers offer features such as integrated mode selection, half-duplex RS-485, full-duplex RS-485, internal termination resistor, slew limiting feature, and advanced fail-safe to allow you to design with minimal external components, lower cost, and simpler hardware.

MaxLinear, Inc.
5966 La Place Court, Suite 100
Carlsbad, CA 92008
Tel.: +1 (760) 692-0711
Fax: +1 (760) 444-8598

www.maxlinear.com