RS-422 vs RS-485

Similarities and Key Differences

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Rev.0.00
Dec 7, 2017

Abstract

The RS-422 and RS-485 standards specify the physical characteristics of driver and receiver components for differential data transmission interfaces in noisy environments. Although at a first glance the standards appear to be similar, subtle differences between them allow RS-485 bus components to be used in RS-422 applications, but do not allow RS-422 bus components to be used in RS-485 applications.

This application note describes some key parameters and bus topologies each standard supports and explains the reasons why RS-422 components should not be used in RS-485 networks.

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1. RS-422 Key Parameters and Topology

RS-422 is a unidirectional, multidrop network, allowing for the use of a single driver with an output signal that can be *dropped* at multiple (up to 10) receiver nodes (see Figure 1).

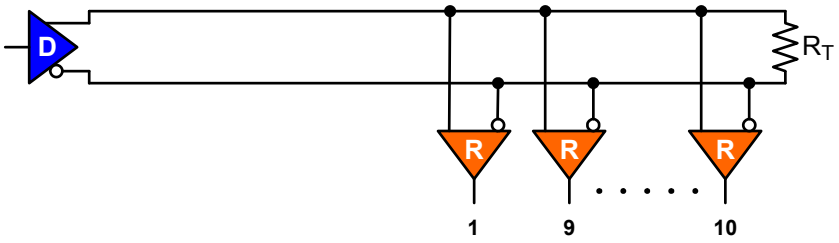

Figure 1. RS-422 Multidrop Bus: One Driver and up to 10 Receivers

The receiver common-mode input resistance, measured between each bus terminal and ground, is 4kΩ (Figure 2).

Up to 10 receivers can be connected to an RS-422 link. Because data traffic is unidirectional, only one termination resistor is required to eliminate signal reflections on the bus. Its value should match the characteristic cable impedance, typically in the range of 100Ω to 130Ω.

Note: if you want a bidirectional interface solely based on RS-422 components, add a second, separate data link in the opposite direction.

Although an RS-422 driver must be able to drive the common-mode load of 10 receivers, paralleled by a differential termination resistor, the standard specifies only a driver's output drive capability in the form of a minimum V_{OD} of ±2V across a differential load of 100Ω (Figure 3). The need for overcoming ground potential differences (GPDs) between driver and receivers is not explicitly mentioned.

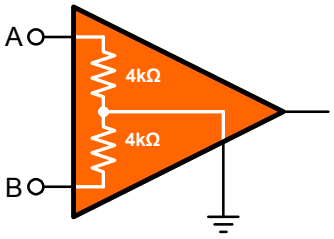

Figure 2. RS-422 Receiver Input Resistance

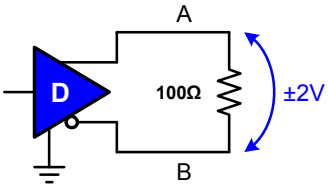

Figure 3. RS-422 Driver Output Voltage

2. RS-485 Key Parameters and Topology

RS-485 is a bidirectional multipoint interface, which allows for multiple drivers to be connected to the same bus (Figure 4). To avoid bus contention, bus access is controlled with driver enable pins. Only one driver can access the bus at a time.

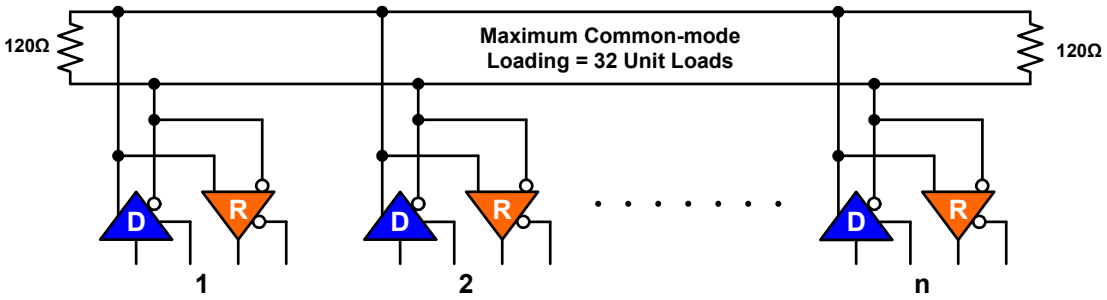

Figure 4. RS-485 Multipoint Bus: Multiple Drivers and Multiple Receivers

Unlike RS-422, RS-485 distinguishes between differential and common-mode bus loading. The maximum differential load is a 54Ω resistor across which a driver must produce a differential output voltage of ±1.5V minimum (Figure 7 on page 4). The maximum common-mode loading is specified with 32 unit loads (ULs) or 375Ω (Figure 8 on page 4). This resistor value is based on the relation of a single unit load (1UL) being equivalent to an input resistance of 12kΩ between each bus terminal and ground.

A unit load is defined as a 1mA current into a transceiver with disabled driver, or a receiver at a DC input voltage of 12V, measured at the bus terminals (A, B) with respect to ground.

To prevent a driver from being overloaded by exceeding the 32 ULs limit, transceivers are given a unit load rating (Figure 5). Legacy transceivers usually have a rating of 1UL, which is mainly due to their older process technologies. Modern transceivers, commonly based on CMOS and Bi-CMOS processes have higher input impedances and thus lower or fractional UL-ratings, such as 1/2UL, 1/4UL, and 1/8UL. These correspond to input resistances of 24kΩ, 48kΩ, and 96kΩ, respectively. The specified 32ULs therefore correspond to a different number of transceivers, depending on their UL-ratings (Figure 6).

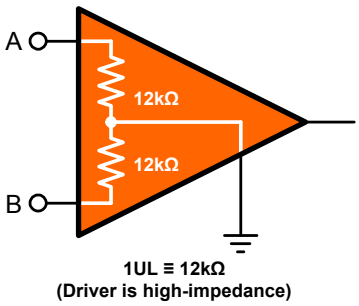

Figure 5. RS-422 Transceiver Input Resistance

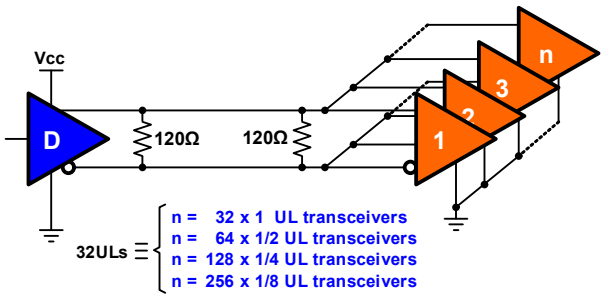

Figure 6. 32ULs Equivalents

A driver's total common-mode drive capability also requires it to overcome large common-mode voltages in the range of -7V to +12V and drive two termination resistors, one at each cable end, because the bus signal propagates bidirectionally. The value of these resistors should match the characteristic cable impedance of Z_0 = 120Ω to eliminate signal reflections.

Figure 8 shows the driver output test circuit under common-mode load conditions, in which the driver must produce a minimum V_{OD} of ±1.5V. Here the 60Ω resistor presents the parallel circuit of the termination resistors and the 375Ω resistors represent the total common-mode load of 32ULs.

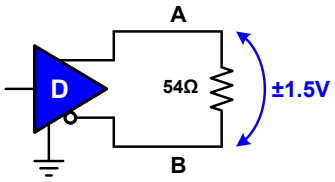

Figure 7. Differential Load Test Circuit

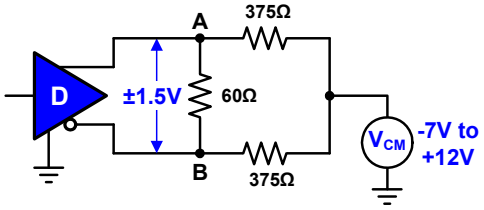

Figure 8. Common-Mode Load Test Circuit

3. Why RS-422 Components Fail in Multipoint Applications

There are three reasons not to use RS-422 drivers in multipoint applications:

- Limited common-mode range due to driver output stage design. For more information, refer to Common-Mode Range.
- Device-damaging bus currents due to bus contention. For more information, refer to Driver Contention.
- High operating drive currents due to parallel termination and high receiver count. For more information, refer to Driver Current.

3.1 Common-Mode Range

Figure 9 shows the typical bipolar output stage of an RS-422 driver. Associated with the classical totem pole structure is the parasitic diode formed between the EPI layer and the substrate. This diode limits the negative common mode range of the active driver's output by clamping the line voltage to a diode drop below driver ground.

Assume a typical multipoint application in which one driver (D1) is disabled and the other driver (D2) is active. If there is a ground potential difference (GPD), such that the ground potential of D1 is 2V higher than that of D2, and D2's V_{OL} = 0.5V, the parasitic diode in D1 is forward biased by -1.5V. In this case, the line at D1 is clamped to -0.7V instead of the driven level and data flow is not guaranteed.

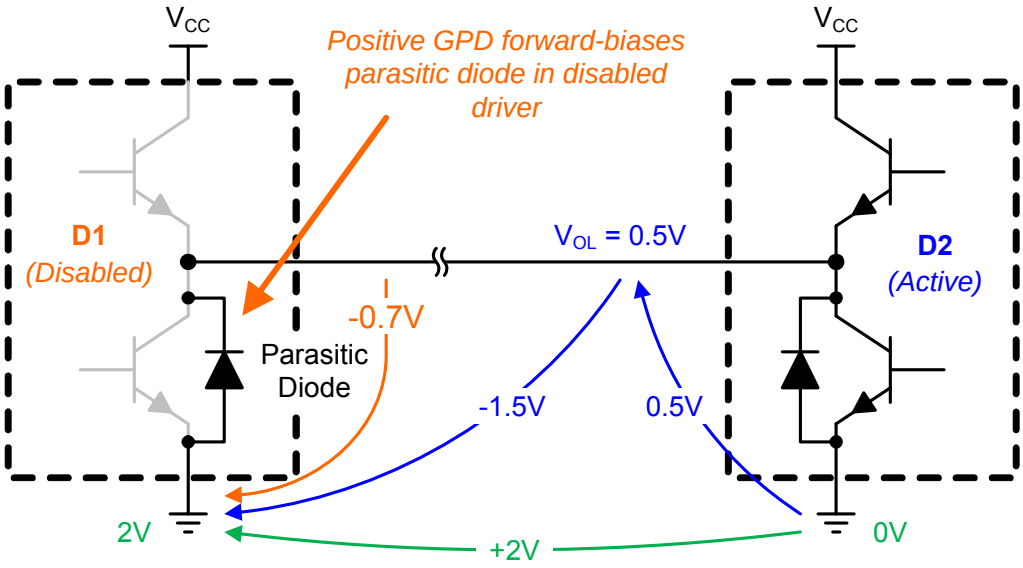

Figure 9. RS-422 Driver Output Structure with Forward-Biased Substrate Diode

RS-485 drivers include Schottky diodes in their output structures. These diodes isolate the EPI/SUB diodes from the output terminals and eliminate the possibility of the parasitic diodes from conducting and clamping the data line. This increases the common mode range from −7V to +12V, or 7V from either supply rail.

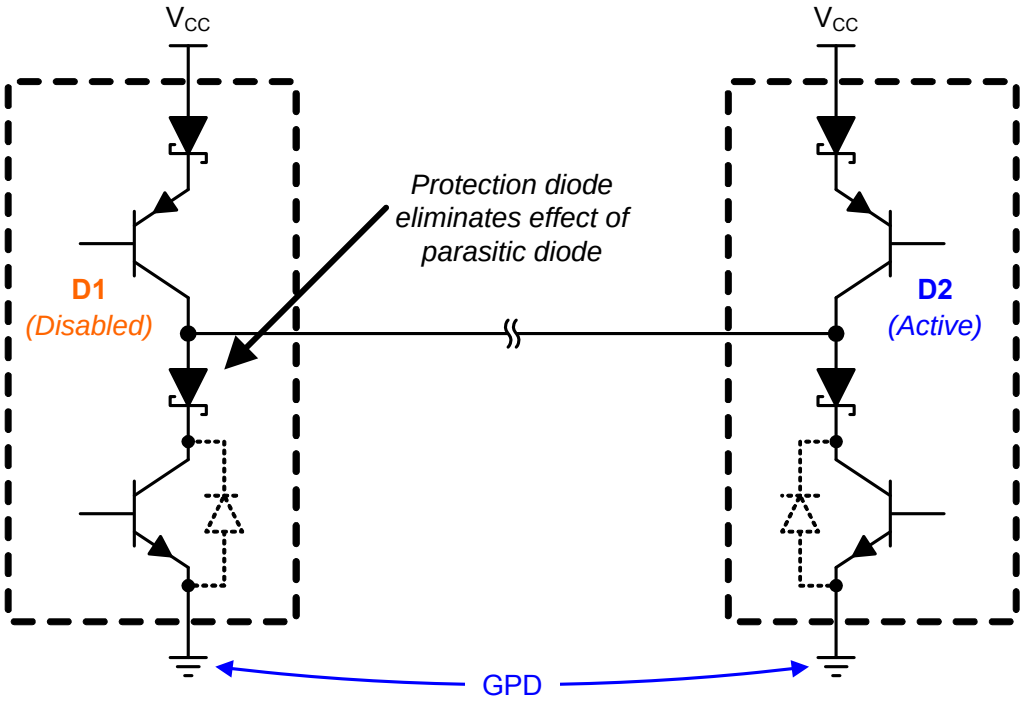

Figure 10. RS-485 Driver Output Structure

The adverse effects of the Schottky diodes are minimal. The driver's V_{OH} and V_{OL} are simply one Schottky diode drop lower and higher. However, the outputs of disabled drivers remain high impedance across the entire common-mode range.

3.2 Driver Contention

If two drivers access the bus at the same time due to hardware or software errors, a large current will flow between the drivers if their outputs are in opposite states. This current will be further amplified in the presence of a large ground potential difference. In this case, the maximum package power dissipation rating will be exceeded. Because RS-422 drivers are intended for use in single-driver/multiple-receiver applications, they do not have contention protection circuits built in and are often damaged when this fault occurs.

However, RS-485 drivers are protected against bus contention effects through the use of short circuit current limiting over a wide common-mode range. They also possess a thermal shutdown feature in case the fault condition continues to exist for a prolonged time. For example, if a short circuit condition occurs, the driver output will be limited to 250mA. If the fault condition remains, the driver will heat up and trigger a thermal shutdown circuit that disables the driver output from the bus. The sudden lack of current flow allows the driver to cool down to a certain degree before it is re-enabled. If the fault is still present, the device will cycle into and out of thermal shutdown until the fault is removed.

3.3 Driver Current

RS-422 drivers have a much lower current rating than RS-485 transceivers. RS-422's single termination, low receiver count, and small common-mode range allow the driver to have a low current rating of ±20mA minimum. In strong contrast, the multipoint applications of RS-485 require a driver to drive parallel terminations, high receiver count, and a wide common-mode range. RS-485 drivers therefore have a minimum drive capability of ±55mA, which is three times that of RS-422. Consequently, RS-422 drivers have insufficient drive capability to support multipoint RS-485 applications.

4. Conclusion

RS-422 components are not RS-485 compatible and therefore should not be used in multipoint applications. Conversely, RS-485 components are RS-422 compatible, which is why Intersil's portfolio of differential transceivers are RS485/RS-422 compatible.

5. Revision History

Rev.	Date	Description
0.00	Dec 7, 2017	Initial release

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(Rev.4.0-1 November 2017)

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