The Basics of RS-232/422/485

RS-232—the most common and easy-to-use communication interface

The RS-232 serial interface was developed for connecting a computer to common peripherals such as modems, overhead projectors, and the sensors and actuators used for industrial automation applications. Despite its limited 15 m transmission distance, RS-232 is low cost and easy-to-wire, making it the first choice for many applications.

RS-232 establishes full-duplex (2-way) communication, with signals represented by voltage levels measured with respect to a system common ground (power or logic ground). The “idle” state (MARK) is negative with respect to the common ground, and the “active” state (SPACE) is positive with respect to the common ground.

**Start bit:** 1 bit  
**Data bits:** 5, 6, 7, or 8 bits  
**Parity:** None, Odd, Even, Space, Mark  
**Stop bits:** 1, 1.5 (if data bits = 5), or 2 bits

### RS-232 Specifications

<table>
<thead>
<tr>
<th>Standard</th>
<th>Connection Type</th>
<th>Operation Mode</th>
<th>Drivers per Line</th>
<th>Receivers per Line</th>
<th>Max. Cable Length</th>
<th>Max. Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIA RS-232</td>
<td>Point-to-point</td>
<td>Single-ended</td>
<td>1</td>
<td>1</td>
<td>50 ft (15 m)</td>
<td>921.6 Kbps</td>
</tr>
</tbody>
</table>

### RS-232 Signal Definition

The general relationship between the UART, TTL signal, transceiver, and RS-232 signal is illustrated in the following figure. UART is short for “universal asynchronous receiver transmitter,” and TTL stands for “transistor to transistor logic.” The UART, which is located on the serial board and stands between the computer’s CPU and the transceiver, transmits signals at 0 and 5 volts. The RS-232 transceiver converts the signal voltage to +3V to +15V, and -3V to -15V.

**Tx** Transmit Data  
**Rx** Receive Data  
**RTS** Request to Send  
**CTS** Clear to Send  
**DTR** Data Terminal Ready  
**DSR** Data Set Ready  
**DCD** Data Carrier Detect  
**GND** Ground

**RS-232 Data Format**

<table>
<thead>
<tr>
<th>Start</th>
<th>Data</th>
<th>Parity</th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5, 6, 7, 8</td>
<td>1</td>
<td>1, 1.5, 2</td>
</tr>
</tbody>
</table>

Unit: bit

**Standard Connection Type Operation Mode Drivers per Line Receivers per Line Max. Cable Length Max. Data Rate**

**EIA RS-232**  
**Point-to-point**  
**Single-ended**  
**1**  
**1**  
**50 ft (15 m)**  
**921.6 Kbps**
Flow Control

In RS-232 communications, one side of the connection sends a “flow control” signal to tell the other side to stop or start transmitting. Flow control signals are sent when the sender needs to take a break, such as when a data buffer is full.

H/W Flow Control

Hardware flow control uses RS-232’s RTS and CTS signals to indicate when data transmission should be paused or re-started. For example, as indicated in the figure, when PC1 is ready to receive, it raises the RTS signal to request data from PC2.

S/W Flow Control

Software flow control works by sending an XON/XOFF signal through the data channels. For example, as indicated in the following figure, PC2 sends an XON pattern when it is ready to receive, and then when its Rx buffer is almost full, it sends an XOFF pattern to request that PC1 stop transmitting.

Use Moxa PComm Library to Make Serial Programming Easy

Moxa PComm Lite provides software developers with a complete library of intuitive function calls for developing serial communication applications under Windows NT, 95, 98, 2000, ME, XP, 2003, 2008, and 7. PComm Lite requires fewer lines of code than Microsoft's more complex Win32 COMM API, allowing programmers to save time and reduce the number of bugs in their applications.

Performance Analyzer

Data Scope

PComm Diagnostic

Features of Moxa PComm Library

- 50 easy-to-use API functions
- Superior troubleshooting utilities
- Supports multiple interfaces: VB, C/C++, Delphi
- Supports X/Y/ZModem, Kermit, and ASCII protocols
- Compatible with Win32 Comm API
RS-422/485—tailor-made for industrial applications

Many of the devices used in today's industrial environments are designed for the RS-422 and RS-485 interfaces, both of which use “differential transmission” to “subtract out” external electronic and electromagnetic disturbances. For this reason, RS-422/485 can be used to transmit data up to 1.2 km. In addition to the need for long distance and multi-drop transmission, many industrial applications also require isolation, proper housing, heavy-duty wiring, a reliable power supply, and over-surge protection.

Differential Transmission

The RS-422 and RS-485 protocols use differential transmission to achieve high speed data transmission (up to 10 Mbps) over distances up to 4,000 feet (1.22 km). Differential transmission works by splitting each signal into two separate wires with opposite voltage states. The signals are subtracted at the receiving end, making this type of wiring configuration well-suited for noisy environments.

RS-422 Wiring

<table>
<thead>
<tr>
<th>Signal</th>
<th>Wiring</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>TxA</td>
<td></td>
<td>RoA</td>
</tr>
<tr>
<td>TxB</td>
<td>120 Ω</td>
<td>RoB</td>
</tr>
<tr>
<td>RxA</td>
<td></td>
<td>TxA</td>
</tr>
<tr>
<td>RxB</td>
<td></td>
<td>TxB</td>
</tr>
<tr>
<td>GND</td>
<td></td>
<td>GND</td>
</tr>
</tbody>
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RS-485 Wiring

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<tr>
<th>Signal</th>
<th>Wiring</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>DataA(-)</td>
<td>120 Ω</td>
<td>DataA(-)</td>
</tr>
<tr>
<td>DataB(+)</td>
<td></td>
<td>DataB(+)</td>
</tr>
<tr>
<td>GND</td>
<td></td>
<td>GND</td>
</tr>
</tbody>
</table>

RS-422 vs. RS-485

<table>
<thead>
<tr>
<th>Standard</th>
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<tbody>
<tr>
<td>EIA RS-422</td>
<td>Full-duplex, Point-to-point</td>
<td>Differential</td>
<td>1</td>
<td>10</td>
<td>4000 ft (1.22 km)</td>
<td>10 Mbps</td>
</tr>
<tr>
<td>EIA RS-485</td>
<td>Half-duplex, Multi-drop</td>
<td>Differential</td>
<td>32</td>
<td>31</td>
<td>4000 ft (1.22 km)</td>
<td>10 Mbps</td>
</tr>
</tbody>
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Multi-drop Networks

RS-485 was designed for applications that require connecting multiple devices to a single data line. An RS-485 multi-drop network uses a balanced transmission system that can accept up to 32 devices on the same data line. This is achieved with tri-state drivers that are controlled by a programmable handshake line to ensure that only one device acts as a driver at any given time.

Termination

In order to prevent signal reflection, termination resistors are used to match the impedance of the receiver and transmit nodes. The resistance needed to match the characteristic impedance is specified by the cable manufacturer. The most common value is 120 ohms.
RS-485 uses differential data transmission over two wires to transmit data from one station to another, and allows multiple transmitters and receivers to be used on the same data line. RS-485 uses half-duplex transmission, which means that transmission and reception share the same data channels. For this reason, only one transmitter can be active at any given time.

Moxa’s serial boards have a built-in circuitry to switch transmitters on and off automatically. We call this form of switching ADDC® (automatic data direction control). ADDC® is much easier to implement than the traditional “handshaking” method that uses the RTS signal.

A common problem in many industrial applications is the disturbance caused by ground loop currents that flow through the ground line when ground voltages differ between connected devices. To overcome this problem, Moxa’s industrial boards and full function converters use “optical isolation” to protect the boards against as much as 2000 volts.

Moxa provides an assortment of wiring peripherals that can be used to transform DB9 and DB25 connectors into terminal block connectors. The wiring peripherals shown below are DIN-Rail mountable.

Be sure to answer the following questions before ordering your RS-422/485 board from Moxa:

1. Does your system use RS-422, 2-wire RS-485, or 4-wire RS-485?
2. Does your application require “isolation protection” and/or “surge protection?”
3. What is the resistance of the termination resistors used by your application?
4. Is it easy to modify your application’s resistor setup?
5. What range of baudrates does your application support?