Industrial USB Basics – Bridging the Connectivity Gap

It's getting very hard to find a new computer that ships with a built-in serial port these days. In the home/office environment the older serial protocols have been largely supplanted by the newer, high-speed Universal Serial Bus (USB). So PC manufacturers have stopped providing serial ports as standard hardware. They have been replaced by USB ports.

That's a problem in the industrial world, where so much equipment still needs RS-232 and RS-422/485 interfaces to communicate. Consequently, a major connectivity gap has emerged between industrial electronics and today's computers.

Why USB?

USB was officially introduced to the world in 1995, the brainchild of a consortium of seven companies that combined their resources to advance the ways computers connect to peripherals and other components. Called the USB Implementers Forum, Inc. (USB-IF), the group has grown to include over 1000 members that help steer the promotion and development of USB technologies. Leading participants within the USB-IF include industry players such as Intel, Hewlett Packard, Microsoft, NEC and Phillips.

Before USB came along, adding peripherals to computer systems and networks typically involved powering down the system, installing an expansion card, rebooting the system and then installing the necessary drivers.

USB has radically streamlined this process. Users can add and subtract peripherals such as printers, cameras, scanners, and a wide range of Human Interface Devices (HIDs) without rebooting. Devices are "hot swappable". Device drivers are still needed, but they only need to be installed once. And specialized internal cards are unnecessary when a device connects via the USB port.

USB also has excellent expansion capacity. When combined with USB hubs, adequate PC resources, and proper wiring, a single USB port can manage as many as 127 devices. (By comparison, a standard DB9 connection controls just one piece of equipment.)

So there's no denying that USB has proven to be very useful, or that it's here to stay. But to get the most out of equipment that uses older protocols, and to keep that equipment operating with full functionality throughout its useful life, those older devices must be able to communicate with systems using USB. That can be done with quite easily with USB-to-serial converters – provided that you select the correct converter. Let's talk about that.

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Three generations of USB

USB has gone through several revisions. When specifying equipment you will need to be able to tell them apart, and to understand how each revision has affected USB.

For example, USB's naming conventions can be confusing. USB 1.1 referred to "Low Speed" and "Full Speed". USB 2.0 added "High Speed", which is faster than "Full Speed." USB 3.0 adds "SuperSpeed" to the mix. This chart will show you the actual data rates:

USB Speed	USB Protocol	Rate	Bi-Directional Data Transfer	Charging Capability	Smart Charging
Low Speed	USB 1.1, 2.0, 3.0	1.5 Mbps	Half Duplex	100 mA	X
Full Speed	USB 1.1, 2.0, 3.0	12 Mbps	Half Duplex	100 mA	X
High Speed	USB 2.0, 3.0	480 Mbps	Half Duplex	100 mA	X
SuperSpeed	USB 3.0	4.8 Gbps	Full Duplex	900 mA	Yes

It's important to note that while each version of USB is backwards compatible with its predecessors, it can't make devices designed for earlier versions of USB go any faster. Thus, a USB 3.0 port is quite capable of communicating with a USB 1.1 or USB 2.0 device, but only at the speeds supported by the device itself. The reverse is also true. A USB 3.0 device attached to a USB 2.0 port can only operate at USB 2.0 speeds. To get full USB 3.0 speed, both the host USB port and the connected device would have to be USB 3.0 capable.

Also note that USB 3.0 adds more than raw speed to the specification. It provides more power to downstream devices, along with "Smart Charging" functionality. Earlier versions of USB could not tell whether a device was connected to a USB port or not, or whether a connected device was active. So power was supplied at all times. USB 3.0 reduces power to a port if no device is connected, or if a connected device is idle.

You may see one of several USB logos on your equipment. The logo can help you determine your device's capabilities.

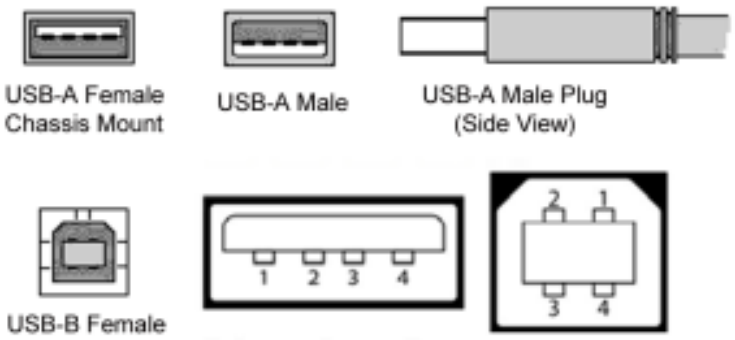
	**Standard USB Logo** – Designates the existence of a USB connection. Can be USB 1.0, 1.1, or USB 2.0. Data transfer rates can vary from 1.5 Mbps to 12 Mbps.
	**High-Speed USB Logo** – Indicates the presence of USB 2.0 with transfer capacities of up to 480 Mbps.
	**USB 3.0 SuperSpeed Logo** – Data rate of 4.8 Gbit/s. USB 3.0 ports come in low-power and high-power variants, providing 150 mA and 900 mA respectively while transmitting data at SuperSpeed rates. A Battery Charging Specification increases the power handling capability to 1.5 A, but does not allow concurrent data transmission. Communication is full-duplex during SuperSpeed. (In USB 1.0 and 2.0 communication is half-duplex, with direction controlled by the host.)

USB Cables and Connections

Standard USB 3.0 hardware can co-exist with older USB cables and ports. Standard USB 1.1/USB2.0 Type A and B cables will fit into their corresponding 3.0 ports, allowing USB 1.1/USB 2.0 equipment to communicate with USB 3.0 equipment.

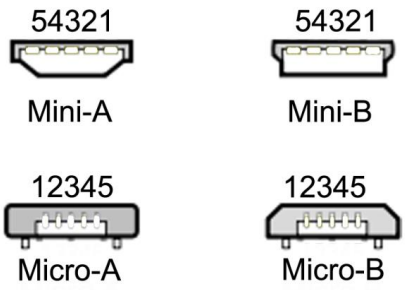
But that's not true of USB 3.0 Micro connectors, which are designed only for SuperSpeed devices.

USB 1.0/2.0 Standard Connectors and Pinouts



Pin	Name	Description
1	VBUS	+4.75-5.25 V
2	D–	Data –
3	D+	Data +
4	GND	Ground

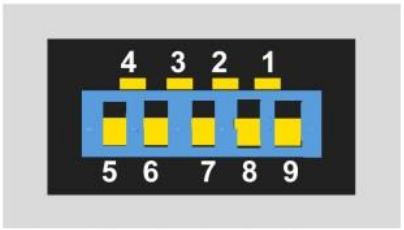
USB 1.0/USB 2.0 Mini/Micro Connectors and Pinouts



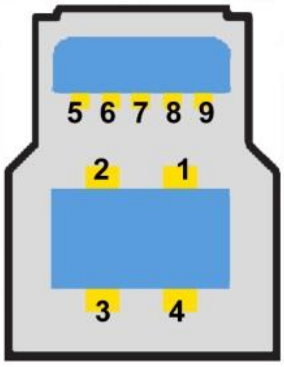
Pin	Name	Description
1	VBUS	+5 V
2	D−	Data −
3	D+	Data +
4	ID	Permits distinction of host connection from slave connection Host: connected to Signal ground Slave: not connected
5	GND	Signal ground

USB 3.0 Standard Connectors and Pinouts

SuperSpeed Standard A plug pinout

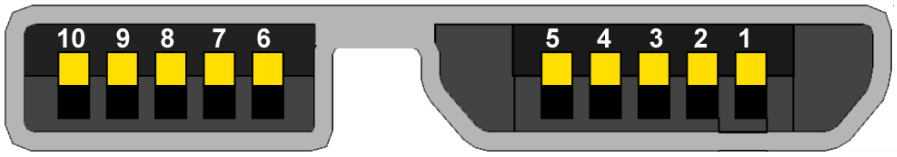


SuperSpeed Standard B plug pinout



Pin	Signal name ('A' connector)
1	VBUS
2	D−
3	D+
4	GND
5	StdA_SSRX−
6	StdA_SSRX+
7	GND_DRAIN
8	StdA_SSTX−
9	StdA_SSTX+

USB 3.0 Micro Connectors and Pinouts



Pin	Pin Name	Description
1	VBUS	+5V
2	USB D-	USB 2.0 differential pair
3	USB D+	USB 2.0 differential pair
4	OTG ID	USB OTG ID for identifying lines
5	GND	Ground
6	USB3 SSTX-	USB 3.0 signal transmission line
7	USB3 SSTX+	USB 3.0 signal transmission line
8	GND	Ground
9	USB3 SSRX-	USB 3.0 signal receiving line
10	USB3 SSRX+	USB 3.0 signal receiving line

Connecting Serial to USB

Serial equipment can always be connected to computers, even if those computers lack the appropriate ports. The USB-to-Serial converter acts much like a serial port expansion card, except it uses the USB interface instead of a PCI or PCI express slot. When the converter is plugged into the USB port, the driver sets up a serial COM port in Device Manager that can be accessed by your software applications.

Your legacy peripherals and equipment remain fully operational, but they can now connect via USB.

USB-to-serial converters come in a wide variety of shapes and sizes. So it's important to make sure that you are getting the right one. Just because a connector seems to have the correct pin configuration doesn't guarantee that the converter can make the necessary conversions or meet the required baud rates.

For example, a USB-to-serial converter connecting to a 9-pin DB9 port will typically have the capacity to connect to RS-232 devices. However, supported operating systems, baud rates, cable types, buffer rates, duplexing capabilities and a number of other factors can vary greatly.

The same type of variables hold true for USB to RS-422 and RS-485 converters.

Because of these differences, it is important to understand the exact specifications needed for the conversion process. Here are some essential elements to consider:

1. Is the serial protocol RS-232, RS-422, RS-485 or do you need a device that can handle them all? The answer to this question will greatly affect the price of the converter you select.

2. What transfer rates are required?

3. If you are using RS-485, is it full-duplex or half duplex?

4. Are you dealing with DB9 or DB25 connectors? Male or female?

5. Are you operating in an electrically noisy environment? If so, isolation is almost always required to prevent damage to your PC.

6. Does the converter provide sufficient voltage on the serial lines? We always recommend using a device based on the FTDI chipset for best results.

7. Does the converter need to be shared between multiple computers? In this case you should use one that locks in the COM port assignment. Our "LS" versions with a "locked serial number" provide this functionality and are great for field service technicians.

8. Chipsets and drivers are important. Make sure you select a stable platform.

Bridging the gap between serial and USB is easy when you've got the right converter. Simply attach the converter to a USB port on the computer and connect your peripheral to the other end. You'll have to install drivers the first time, but after that you'll be able to hot swap elements and components as necessary**.**

A word on isolation…

Adding isolation limits bandwidth on the USB connection to "Full Speed" or 12 Mbps. While this is still technically USB 2.0, the host controller will not pass data at "High Speed" or 480 Mbps. It will automatically ratchet down to 12 Mbps. Therefore, if you require 480 Mbps "High Speed," you should not use isolation. Luckily, most industrial applications will work fine at 12 Mbps. And if you are using a USB-to-Serial Converter, the speed is limited by the serial connection anyway.

For almost all industrial field service applications, we strongly recommend an isolated converter. Even a purely USB connection should be isolated in these situations. We have a full line of isolators and isolated USB hubs to fit any application.

B&B Electronics USB-to-Serial Converters

Communicating with your legacy serial devices in the field is simple when you have the right conversion device. You CAN take advantage of the latest computing power while continuing to use perfectly good equipment throughout its useful lifecycle. B&B Electronics offers a variety of USB-to-Serial conversion devices that are designed and built at our Ottawa, IL, USA facility. To ensure maximum reliability we use the best components available, as well as stable drivers and the FTDI chipset.

B&B ELECTRONICS

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