Isolate, Convert, Extend & Connect

Exploit the benefits of USB while eliminating its weaknesses

USB was a great leap forward. Its convenience, flexibility, and interoperability have simplified everything from cabling to device installation. You can connect up to 127 devices using a single port. You can connect new peripherals without opening your computer to insert an expansion card. Devices are hot swappable. Cables are interchangeable. USB will even supply power to a downstream device.

But as good as it is, USB was designed with safe office and IT environments in mind. When it moves out into the real world, as it is currently doing in industries ranging from manufacturing to health care, USB reveals a number of inherent weaknesses. USB has an effective range limitation of only 30 meters, even when using hubs. It is highly susceptible to ground loops, electromagnetic interference (EMI), and electrostatic discharges (ESD). It can provide 500 mA power to downstream devices, but that same capability can lead to arcing and fire when cables come loose. And it's not designed to communicate with older protocols. When you take USB off the desktop you'll need to consider each of those issues

USB's Range Limitation: Conversion and Extension

In a straight line, USB's 30 meter range is roughly the height of a nine-story building. At first glance, that sounds pretty good. But data communications cables rarely get to travel in a straight line. They're normally laid above, below and around working spaces, so it can easily require 30 meters of cable to connect two pieces of equipment that are only 10 meters apart. Thirty meters may be adequate for home/office environments, but for industry it isn't enough.

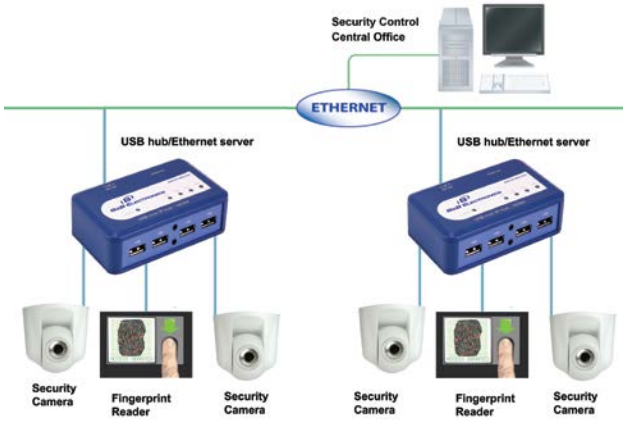

Figure 1

You can address the USB range limitation through extension and conversion. For example, in situations where installing a local PC would be impractical, as in kiosks or security applications, a USB-over-Ethernet server would let you connect multiple USB devices at a remote location, convert the data stream for TCP/IP transmission over Ethernet, and then control the devices from a central office. The intervening Ethernet connection can be Cat 5 cable, fiber optics, or radio. In each case the data stream will be converted to a different protocol, but the data itself will move smoothly. (See Fig. 1)

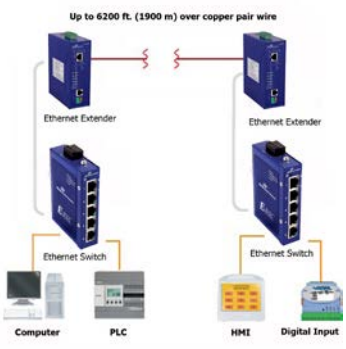

Figure 2

In some situations there's another conversion option. If, as often happens, there is already a legacy coax or telephone cable system in place you can eliminate the labor and material costs of a Cat5 cable installation by deploying a pair of Ethernet extenders. Ethernet extenders use DSL technology to convert your data for transmission over the legacy copper cable, and to convert it back again at the other end. The savings can be quite substantial. (See Fig. 2)

And although serial communications protocols pre-date USB by decades, there's no need to leave your legacy serial devices out of the loop. You can acquire USB-to-serial converters for virtually any application, from heavy duty, multi-port, DIN rail mounted converters to simple inline converters that USB-enable just a single device. (See Fig. 3)

Spikes, Surges and Ground Loops: The Need for Isolation

USB cables behave well enough in the home office, but in industrial environments they're the weakest link in the USB specification. For example, a powerful magnetic field like those found around industrial motors can induce current on the USB cable and burn out expensive components in connected PLCs and machinery. Ordinary surge suppressors won't protect you. Surge suppression tries to limit spikes between the signal and ground line. But if the ground line rises, as it does in ground loop situations, then surge suppression is powerless to intervene. The answer is USB isolation.

USB cable contains four wires; two are for data and two carry 5 VDC power for downstream devices. Isolation works by changing the nature of the signal on the two USB data lines and transforming the 5 VDC power on the other pair. The isolator protects the data lines by converting the signal to either pulses of light or an electrical field, then back to an electrical signal again. It allows data to pass through, but it stops power surges and ESDs at the isolation zone. The isolator controls surges and ESD on the power line by transforming the 5 VDC USB power to AC, then back to DC. (See Fig.4)

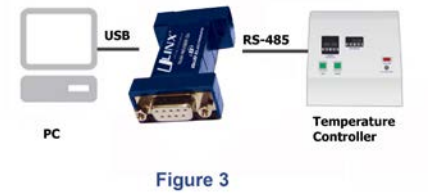

Figure 3


Figure 4

Note that isolators will limit the USB data rate to "Full Speed", or 12 Mbps. This happens because USB devices default to Full Speed until they are able to negotiate a higher connection rate with the USB hub. The negotiation is initiated by the device, which drives 17.78mA into the D- data line for at least a millisecond, creating what is called a K-chirp. If the hub is "Hi Speed" (480 Mbps) capable it will respond by alternately injecting 17.78 mA into the D- and the D+ lines. When the device has detected at least 3 of these chirp pairs it will decide that the hub is Hi Speed capable, and it will establish the connection at the higher data rate. Unfortunately, isolators interfere with this negotiation when they convert the DC signal to AC at the isolation zone. So the negotiation for a higher data rate fails, and the connected devices default to Full Speed. That's more than ample for most industrial applications, but it does mean that unprotected, non-isolated Hi Speed USB connections will normally be faster.

The Right Way to Connect.

Older cables were connected with exposed pins that could be bent or broken. USB cables protect their pins inside the connector housing. You may connect and disconnect them over and over again without doing any harm. The design has proven to be quite reliable in desktop applications.


Figure 5

But industrial environments are less benign. Vibration can cause USB cables to work themselves loose, and minor tugging will do the same thing. When that happens in a home office a typical result might be that the printer seems to have stopped working. It's an easy fix. But in industrial applications it can mean serious data loss and downtime. And if flammable substances are present, USB's 5 VDC power is enough to pose a risk for fire and explosion. It would be impractical to abandon USB, so some manufacturers are addressing the problem by developing high retention USB ports. They closely resemble the ports you see in office-grade equipment, and plugging in a USB cable feels almost as effortless, but the difference in industrial safety is enormous. A typical high retention port can grip a cable firmly enough to resist 3.4 lbs of force. (See Fig. 5)

USB may have been designed for the office environment, but it doesn't have to stay there. Just isolate, convert, extend and connect. If you do it correctly you can take USB all the way out to the network edge.