Simple Rules in Building USB Devices and Cable Assemblies

As most of our readers know, USB promises end users the ability to hot-attach peripherals and adapters … an evolutionary next step in plug-and-play expansion without opening the box. To deliver on this promise, device and interconnect providers need to adhere to a few simple rules. It's like designing with Lego blocks. The pieces need to follow a common set of rules so that they plug together consistently.

The USB "lego" pieces consist of hubs, cables and devices. The topology has a PC system at the root of a hierarchical tree connected by cable assemblies and intermediate hubs to end devices. The hub itself could be a standalone package or be built into another package such as a monitor. In fact, the PC system includes a root hub.

The specification declares two kinds of hubs, self-powered and bus-powered. Self-powered hubs need to provide a full budget of 500 mA on each downstream connector. This is an important USB capability that eliminates the need to provide wall power to each device. In contrast, a bus-powered hub merely redistributes power from its upstream cable while providing fanout. Consequently, each downstream connection is only provided 100 mA.

Cable assemblies are uniquely identified by a rectangular A-type receptacle for the upstream connection and a more square B-type receptacle for the downstream connection. Hubs have one B-type receptacle and one or more A-type receptacles. Devices may either incorporate a B-type receptacle or directly embed the cable end within the device assembly.

From an interconnect reliability viewpoint, cable assemblies need to follow three rules:

1. The length must not exceed 5 metres. At 12 Mbit per second transmission, this enables the reflected signal to settle within the bit window using specified cable construction.
2. The power conductor must be rated at full gauge, so that the resistive IR drop at 500 mA max current is within spec.
3. The cable must be adequately shielded to ensure electromagnetic reliability.

For devices that use low-speed signaling, the cable should be no more than 3 metres and the device end must be embedded, i.e., no B-type receptacle. Additionally, embedded cables can be built with reduced gauge power conductors that are matched to the power design of the device. The benefits of reduced emissions from low-speed signaling and reduced power requirements may be leveraged into a lower cost cable construction. However, standalone cable assemblies need to be able to handle full speed and full current ratings so that they can be used with any off-the-shelf USB device.

While it may seem obvious, building compliant sub-subsystems is critical to ensuring that the pieces come together in a consistent and reliable manner.

- Cable assemblies should not be chainable without going through a hub. In particular, cables should use plugs, and devices should use sockets, never the other way around. It is important to ensure that only legal topologies are constructed. USB is not as forgiving as communication or telephone interconnect and exceeding the specifications will cause unreliable behavior.
- Hubs must meet full functionality per chapter 11 of the spec. Mere signal repeaters do not constitute hubs! Hubs should be fully SW configurable and support all upstream and downstream signaling modes.
- Hub power supplies should be rated to support simultaneous use of all A-type receptacles after budgeting for internal requirements. In particular, the entire power circuit should be designed to be stiff enough to meet Drop and Droop compliance at the A-type receptacle.

Remember, the goal is to enable easy assembly without having to trace wires or read a manual. Those who follow these simple rules will be able to build reliable USB building blocks that deliver on the promise.