



NAppkin Note: Building an Isolated USB Cable

By Mark Cantrell, Applications Engineer

Building an isolated USB cable requires both isolated D+ and D– lines, as well as an isolated dc-dc converter to supply power to the downstream port and cable. As can be seen in the example schematic in Figure 1, the combination of the ADuM4160 isolator and ADuM5000 *isoPower*® device provide an extremely simple and effective solution for specific applications. This circuit will operate at Full speed, 12 Mbps, and provide isolated +5 V to the downstream USB cable. The only additional circuit elements are bypass capacitors for the various power input and output pins, as well as external series resistors for the D+ and D– lines. The ADuM4160 was developed primarily as a device to isolate peripherals; however, it can also meet the electrical requirements of USB 2.0 as an embedded host, thereby making it possible to design an isolated USB cable. There are some considerations in using the ADuM4160 in an isolated USB cable, and these are reviewed in this note. These considerations relate to isolated power, speed mode configuration, and propagation delay.

A non-isolated USB cable affects the data and power only as a distributed capacitive and inductive load. In contrast, an isolated cable is an active device that consumes power. To satisfy USB specification requirements, the upstream side of the cable must behave as a peripheral and the downstream side must behave as a host for both power and data. The downstream segment of the cable must provide +5 V power to the pull-up of the peripheral device at all times. The ADuM5000 provides this, as well as providing sufficient power for devices with low power requirements. However, the ADuM5000 draws about 6 mA of quiescent current. This is very low for a DC/DC converter, but it is still above the limit allowed for USB standby mode which is 2.5 mA from V_{BUS} . To meet the 2.5 mA standby limit, power to the ADuM5000 can be turned off so that +5 V is no longer maintained on the downstream port. This disconnects the peripheral so the isolated cable will not meet the USB specification requirements.

Another consideration is speed mode configuration. To comply with USB 2.0, downstream facing ports must accept Low or Full speed devices and automatically configure their buffers to the proper logic conventions and slew rates. The ADuM4160 speed is set by fixed values at the SPU and SPD. This means that the cable will work at a fixed speed, requiring that speed rating of devices plugged into the downstream port be matched to the cable. This is completely acceptable under the embedded host specification, but does not meet the general host requirements. In this application, configuring speed modes can be accomplished by simple mechanical switches or more elaborate circuits depending on the end users requirements.

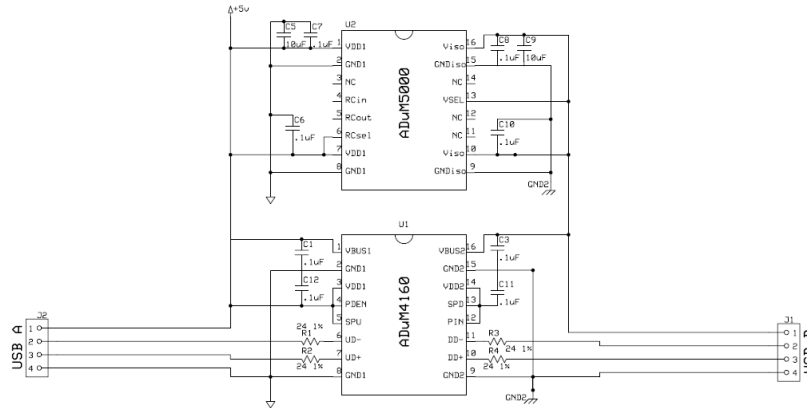


Figure 1 Isolated cable interface including *isoPower*

The last consideration is propagation delay. USB 2.0 does not allow repeaters because added cable and prop delays associated with them do not fit into the standard USB rules for hub and spoke bus architecture. In this application the ADuM4160 acts as a repeater but can be made to meet the propagation delay specification consistent with a single hub, as long as the total cable length is controlled to the 5 m limit and extension cables are not added.

By paying close attention to these considerations, an isolated USB cable can be created that works extremely well for specific applications.

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