N*App*kin Note: Isolating USB with SPI

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Currently, *i*Coupler® digital isolation technology is capable of transferring data at rates ranging from dc to about 150 Mbps, which is adequate for transferring serial data to support low (1.5 Mbps) and full (12 Mbps) speed modes of USB. Referring to Figure 1, there are three places where isolation could be introduced, in the differential transmission lines D+/D–, between the controller and the transceiver, and between the controller and the system controller. Unfortunately, the trend toward higher levels of integration incorporates the transceiver and controller interfaces into the system controller, leaving only D+/D– data lines available outside of the controller for isolation. This is an extremely challenging place to try isolation because there is no flow of control signals, and data is a combination of single ended and digital signaling. With current isolation technology, the most practical place to isolate is between the system controller and a stand-alone USB controller/transceiver where signals can be unidirectional and logic level. In many cases this means bypassing inboard controllers and adding a discrete USB controller.

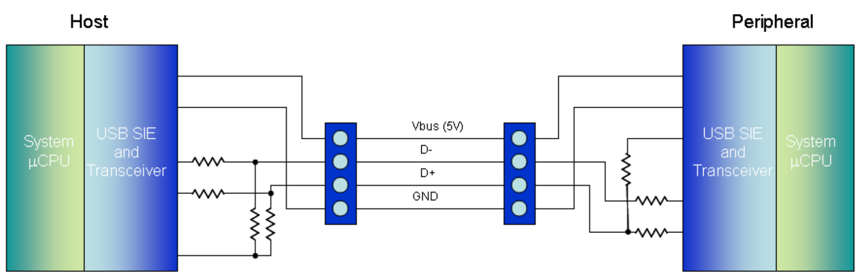

Figure 1.

Controller Isolation

The most practical place to insert an isolation barrier is between a system CPU and a stand-alone SIE/Controller with an embedded transceiver. Several manufacturers provide this type of device. The primary advantage in this approach is that the USB controller/SIE contains its own buffer memory, and can move data to and from the bus at speeds independent of the communication interface to the system CPU. This means that the USB interface could run at high speed, while the interface to the system runs as slowly as desired. If the SIE runs out of buffered data it will signal the host to try again later, when it will have buffered additional packets. In addition, there are no added delays in the USB data path to account for. This approach has no compromises for USB compatibility.

Stand-alone USB controllers can have a variety of interfaces. Among them are RS-232, RS-485, I^2C, SPI, or 8-16 bit parallel data. Each of these interfaces will operate at its characteristic speed, setting the average data rate through the USB. The USB interface itself will clock out packets to the bus at whatever speed is supported by the USB controller/SIE that is chosen. The best combination of speed and economy of implementation is provided by an SPI interface.

Protocol	Speed
RS-232	115kbps
RS-485	12Mbps
I^2C	400kbps
SPI	15Mbps
Parallel	480Mbps

Table 1. Isolated Interface Speed Comparison

SPI Interface

SPI is a full duplex bus standard originated by Motorola. It consists of a clock driven from a master and two unidirectional data lines. It can be expanded into a multi-component bus by adding chip selects from the master device to each of the slave devices. It can start to become cumbersome if more than a few SPI devices share a bus since each device requires a dedicated select line. The primary advantage of SPI over I^2C is data transfer speed. Even with an ADuM1401CRWZ *i*Coupler in the data path adding 32 ns of propagation delay in each direction, the SPI bus is capable of transferring serial data at 15 Mbps. This is fast enough to stream Full Speed data to the USB cable. SPI can be modified to operate at much higher speeds if a full 12Mbps interface ids required. Please review prior N*APP*kin Notes for more information on increasing the speed of an SPI interface.

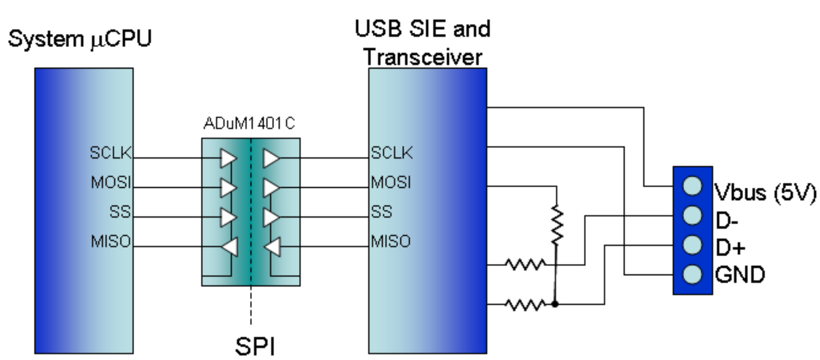

Figure 2. SPI Interface to Low/Full/High speed SIE and Transceiver

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