

**Devices Connected/Referenced**

<a href="#">ADuM4160</a>	Full/Low Speed USB Digital Isolator
<a href="#">ADP3338</a>	High Accuracy, 1 A, Low Dropout Regulator (5 V Output Option)

## Universal Serial Bus (USB) Peripheral Isolator Circuit

### EVALUATION AND DESIGN SUPPORT

#### Circuit Evaluation Boards

[CN-0160 Circuit Evaluation Board](#)

#### Design and Integration Files

[Schematics, Layout Files, Bill of Materials](#)

### CIRCUIT FUNCTION AND BENEFITS

The universal serial bus (USB) is rapidly becoming the standard interface for most PC peripherals. It is displacing RS-232 and the parallel printer port because of superior speed, flexibility, and support of device hot swap. There has been a strong desire on the part of industrial and medical equipment manufacturers to use this bus as well, but adoption has been slow because there has not been a good way to provide the isolation required for connections to machines that control dangerous voltages or low leakage defibrillation proof connections in medical applications.

The [ADuM4160](#) provides an inexpensive and easy to implement isolation buffer for medical and industrial peripherals. The challenges that need to be met are

1. Isolate directly in the USB D+ and D– lines allowing the use of existing USB infrastructure in microprocessors.
2. Implement an automatic scheme for data flow of control that does not require external control lines.
3. Provide medical grade isolation.
4. Allow a complete peripheral to meet the USB-IF certification standards.
5. Support full speed (12 Mbps) and low speed (1.5 Mbps) signaling rates.
6. Support flexible power configurations.

The circuit shown in Figure 1 isolates a peripheral device that already supports a USB interface. Because the peripheral is not explicitly defined in this circuit, power to run the secondary side of the isolator has been provided as part of the solution. If the circuit is built onto the PCB of a peripheral

design, power could be sourced from the peripheral's off line supply, a battery, or the USB cable bus power, depending on the needs of the application.

The application circuit shown is typical of many medical and industrial applications.

### CIRCUIT DESCRIPTION

Power for the upstream USB connector is derived from the 5 V VBUS voltage available on the USB cable. The peripheral device must provide all of the signals and pull-up or pull-down resistors that would be required if the [ADuM4160](#) were not present. The downstream side power is provided by a wall wart and an [ADP3338](#) LDO regulator (5 V option). This LDO provides very low dropout voltage, thereby reducing the regulation requirements on the wall wart. Its small size (SOT-223) and 1 A current capability are ideal for this general-purpose circuit where the peripheral device may require cable power to operate.

The [ADuM4160](#) has several options for power, speed, and protection that must be determined. The first is the speed at which the peripheral runs. Peripheral devices run at one of three speeds: low (1.5 Mbps), full (12 Mbps), and high speed (480 Mbps). The [ADuM4160](#) does not support high speed operation and blocks handshaking signals that are used to negotiate that speed. High speed mode starts as a full speed configuration, and the peripheral requests high speed support through a process called a high speed chirp. The [ADuM4160](#) ignores the high speed chirp; therefore, the request for high speed operation is never passed on to the host, and the peripheral continues to work at full speed. The speed of the peripheral on the USB bus is either low speed or full speed. The particular peripheral determines the speed required, and the [ADuM4160](#) must be set to match this speed via the state of the SPU and SPD pins. In the current schematic, the SPU and SPD pins are tied to the internally regulated 3.3 V power supplies, VDD1 and VDD2, setting the part for full speed operation.

#### Rev. A

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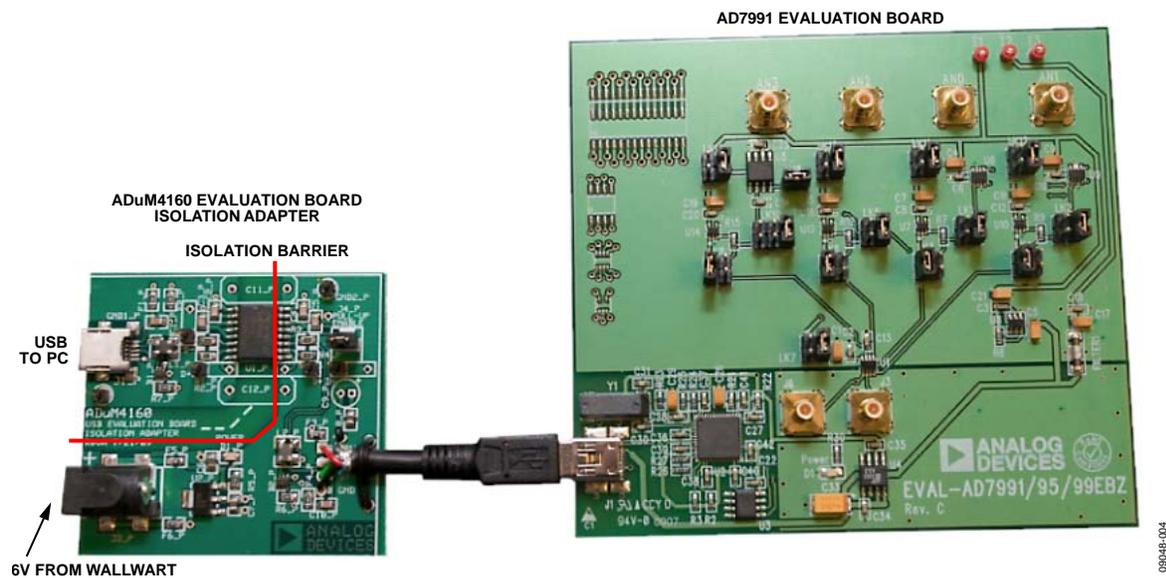


Figure 4. Photo of ADuM4160 USB Evaluation Board Connected to USB Port of AD7991 Evaluation Board

A photo of a typical application circuit is shown in Figure 4. The ADuM4160 evaluation board (left side of photo) is connected to the evaluation board for the AD7991 4-channel, 12-/10-/8-bit ADC with I<sup>2</sup>C compatible interface. The ADC evaluation board acts as a peripheral, which interfaces to a PC (for test and evaluation of the ADC) via the USB port. This provides total isolation between the ADuM4160 USB port and the ADC evaluation board.

Because of the fast edge speeds associated with this circuit, excellent layout, decoupling, and grounding techniques must be employed in order to pass system EMI/RFI tests. See Tutorial MT-031, Tutorial MT-101, and the AN-0971 Application Note for guidance. A complete design support package for this circuit note can be found at <http://www.analog.com/CN0160-DesignSupport>.

## COMMON VARIATIONS

Other linear regulators can be substituted depending on system requirements. See the ADIsimPower™ design tool for details.

## CIRCUIT EVALUATION AND TEST

The ADuM4160 evaluation board isolation adapter described in this note is used for evaluation and testing. A detailed schematic and a picture of the circuit boards used in the test setup are shown in Figure 1 and Figure 4.

## Equipment Needed

The following equipment is needed: a PC with Windows® XP or Vista, a USB data port connection, the ADuM4160 evaluation board isolation adapter, the EVAL-7991EBZ evaluation board and AD7991 evaluation software, two USB cables, and a high speed digital oscilloscope.

## Getting Started

In addition to the circuit and schematic of the test setup described in this Circuit Note, details regarding the ADuM4160 evaluation board isolation adapter, including schematics, Gerber's, and bill of materials, are available at <http://www.analog.com/CN0160-DesignSupport>.

## Functional Block Diagram

See Figure 1 for the schematic diagram and other information regarding the described test setup.

**LEARN MORE**

- CN0160 Design Support Package:  
<http://www.analog.com/CN0160-DesignSupport>
- ADIsimPower™ Design Tool, Analog Devices.
- Cantrell, Mark. Application Note AN-0971, *Recommendations for Control of Radiated Emissions with isoPower Devices*. Analog Devices.
- Chen, Baoxing, John Wynne, and Ronn Kliger. *High Speed Digital Isolators Using Microscale On-Chip Transformers*, Analog Devices, 2003.
- Chen, Baoxing. *iCoupler® Products with isoPower™ Technology: Signal and Power Transfer Across Isolation Barrier Using Microtransformers*, Analog Devices, 2006
- Chen, Baoxing. "Microtransformer Isolation Benefits Digital Control." *Power Electronics Technology*. October 2008.
- Krakauer, David. "Digital Isolation Offers Compact, Low-Cost Solutions to Challenging Design Problems." *Analog Dialogue*. Volume 40, December 2006.
- MT-031 Tutorial, *Grounding Data Converters and Solving the Mystery of "AGND" and "DGND,"* Analog Devices.
- MT-101 Tutorial, *Decoupling Techniques*, Analog Devices.
- USB 2.0 Specifications, USB Implementers Forum, Inc.
- Wayne, Scott. "iCoupler® Digital Isolators Protect RS-232, RS-485, and CAN Buses in Industrial, Instrumentation, and Computer Applications." *Analog Dialogue*. Volume 39, October 2005.

**Data Sheets and Evaluation Boards**

- [ADuM4160 Data Sheet](#)
- [ADP3338 Data Sheet](#)
- [ADuM4160 Evaluation Board](#)
- [AD7991 Data Sheet](#)
- [AD7991 Evaluation Board](#)
- [ADuM4160 Evaluation Board Isolation Adapter Layout Files](#)

**REVISION HISTORY****11/10—Rev. 0 to Rev. A**

Added Evaluation and Design Support Section.....	1
Changes to Circuit Description Section and Figure 4.....	4
Added Circuit Evaluation and Test Section.....	4
Changes to Learn More Section .....	5

**7/10—Revision 0: Initial Version**

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