

## iCoupler ADuM4160/ADuM3160 USB Isolator Evaluation Board

### INTRODUCTION

USB use has displaced older communications standards, such as RS-232, as the default serial communications port in PC-based systems. When compared to these other standards, USB has many enhanced features, such as power for peripherals, automatic driver installation, and higher data rates. However, when using USB, it is difficult to provide isolation, which has limited its acceptance in medical and industrial applications.

Analog Devices, Inc., has introduced the [ADuM4160](#) and [ADuM3160](#) USB isolators to address the difficult task of isolating the bus. The EVAL-ADuM4160EBZ USB isolator evaluation board was constructed to allow an easy interface to existing applications by standard cabling or discrete wiring.

The USB evaluation board comes populated with an ADuM4160; however, because the ADuM4160 and ADuM3160 are electrically identical and pin compatible, any evaluation done with this board and component applies directly to the ADuM3160. If for some reason the user wants to substitute the ADuM3160 on the PCB, no other changes are required.

The design goals of this evaluation platform are to

- Connect to systems through standard USB Type A and Type B connectors.
- Draw power from the USB host or from an external 5.0 V or 3.3 V power supply.
- Support isolated power for the downstream interface through an [ADuM5000](#) *isoPower*® dc-to-dc converter.
- Support external downstream power from a 5 V or 3.3 V power supply.
- Provide test points for all power and signal paths.
- Support low and full speed communications.
- Support enumeration control.
- Support external ESD protection.
- Support common-mode chokes in the xD+/xD- lines.
- Support ferrite inductors in the V<sub>BUSx</sub> and GND<sub>x</sub> lines.

### FEATURES OF THE ADuM4160/ADuM3160

The ADuM4160 and ADuM3160 provide support for full speed and low speed data communications by interfacing directly with the USB xD+ and xD- lines. The parts are designed to be transparent to USB data traffic other than adding about as much delay as a hub and cable. Features of the isolator include the following:

- Built-in voltage regulators allow the ADuM4160 and ADuM3160 to draw power from either 5 V or 3.3 V sources.
- Application of the upstream pull-up resistor is under the control of a downstream pin, PIN (Pin 12).
- The operating speed of the isolator is set by pins on the upstream and downstream sides of the part, SPU and SPD (Pin 5 and Pin 13, respectively).

The upstream side of the isolator includes Pin 1 through Pin 8, is connected to the left side of the evaluation board, and interfaces through a Type B connector. The downstream facing side includes Pin 9 through Pin 16, is connected to the right side of the evaluation board, and interfaces through a Type A connector.

The evaluation board allows configuration of all of the features of the ADuM4160/ADuM3160 chip and provides support for a variety of possible power schemes. The board also allows common-mode voltages; however, it is not recommended for performing safety related testing, such as high voltage withstand testing. Perform this type of testing on the component level or on a production board.



Figure 1. USB Evaluation Board

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**REVISION HISTORY**

**9/10—Rev. 0 to Rev. A**

Added ADuM3160 .....	Throughout
Changes to Introduction.....	1

**2/10—Revision 0: Initial Version**

## POWER

### UPSTREAM SIDE

The USB standard requires that the upstream facing port of a peripheral device derive power for its pull-up from the 5 V present on the cable. Power can also be used to power functions in the peripheral at up to 500 mA.

The [ADuM4160](#) and [ADuM3160](#) contain an internal voltage regulator that can derive the 3.3 V from  $V_{BUSx}$  for use in the data transmission and pull-up power. The user can bypass this regulator if 3.3 V can be provided from an external supply. The evaluation board can source its power either from the cable at 5 V or from an external supply connected to terminal block J5, labeled EXT. Jumper JP1 selects between the two sources. When external power is chosen, the [ADuM3160](#) and [ADuM4160](#) can be configured to accept either 3.3 V or 5 V from that source. If 3.3 V is supplied, the internal regulator must be disabled by shorting Pin 1 and Pin 3 together. This is accomplished by placing a shunt across JP3, labeled 3.3EXT. This jumper should be open when the USB bus is the source of power.

**Table 1. Upstream Power Jumper Settings**

Power Source	Jumper Settings	
	IN SELU (JP1)	3.3EXT (JP3)
USB Bus	USB (2 and 3)	Open
EXT 5.0 V	EXT (1 and 2)	Open
EXT 3.3 V	EXT (1 and 2)	Short

### DOWNSTREAM SIDE

The USB standard does not allow any power to be sourced from a peripheral port. Power to run the downstream side of the [ADuM4160](#) or [ADuM3160](#) cannot come from the cable connection as it did on the upstream facing side. If the isolator is built into a peripheral device, it can receive power directly from the power supply of the peripheral. If the isolator is not built into the peripheral that it is protecting, power must be provided from an external source or derived from the upstream bus power through a dc-to-dc converter. All of these possible power configurations are addressed in the evaluation board.

Power for the downstream port can be provided from external power supply connections through Terminal Block J3 and Terminal Block J4 or from the upstream USB power bus through an [ADuM5000 isoPower](#) dc-to-dc module that can be ordered separately. To make the board design robust and as simple as possible, only one method of powering the board can be used. The evaluation board comes configured to accept an external 5 V supply. If the downstream port is powered from the peripheral or an external supply, an [ADuM5000](#) should not be installed.

The [ADuM5000](#) is only capable of providing 100 mA of power to the downstream side. Applications that require more power at the downstream port must use the external power option. The [ADuM5000](#) has been provided for the convenience of the user, and its use in final applications should be reviewed based on its data sheet precautions for power consumption and EMI mitigation.

Configuration of the downstream power is accomplished by installing or uninstalling the [ADuM5000](#) converter, applying power to J3 or J4, and setting the appropriate jumper.

As with the upstream side of the [ADuM4160](#) or [ADuM3160](#), there is an internal regulator that derives the 3.3 V supply for the xD+ and the xD- signal lines from a 5 V source applied to  $V_{BUS2}$ . In addition, if  $V_{BUS2}$  and  $V_{DD2}$  are connected together to a 3.3 V source, the regulator is bypassed, and the voltage is used directly by the chip. The IN SELD (JP2) jumper selects between deriving power from a 5 V source and a 3.3 V source. The 5 V source can either be an external voltage applied to J3 or an [ADuM5000](#). The only 3.3 V source is the J4 terminal block. If external power is used, the [ADuM5000](#) must not be installed on the board.

**Table 2. Downstream Power Jumper Settings**

Power Source	Jumper Settings/Components	
	IN SELD (JP3)	ADuM5000
USB bus	5 V/USB	Installed
5 V (J3)	5 V/USB	Not installed
3.3 V (J4)	3.3 V	Not installed

## GROUNDING SCHEME

The board consists of two separate ground and power systems. In addition, there is a floating capacitive structure on the bottom layer of the PCB that provides for EMI mitigation for the [ADuM5000](#) dc-to-dc converter. This structure consists of a floating plane on each side of the isolation boundary. To allow evaluation of different EMI mitigation schemes, the planes can be, for example,

- Left floating, which has a minimal effect on EMI.
- Connected by adding a strip of copper tape and soldering it to the exposed pads.
- Connected by safety capacitors installed in through-hole positions, C14 and C19.

In addition, the ground and power planes can be capacitively linked via C15 to C18 at the user's option. This can provide plane-to-plane noise bypassing through several paths to reduce radiated emissions from the ADuM5000 power supply.

There are two large screw holes along the top edge of the PCB that provide connection to the upstream ground plane and the downstream ground plane. These are provided to allow grounding of the PCB to the system in multiple configurations. The floating planes are designed with 0.4 mm of setback to all vias and other board planes. The PCB should not be used for high voltage testing if the floating structures are employed for noise reduction. If this type of structure is required in a final design, it should be built on an inner layer of the PCB to avoid creepage and clearance issues.

### SPEED SELECTION

The ADuM4160 and ADuM3160 work at a fixed USB transmission speed, either low speed or full speed. The speed is set by the SPU and SPD pins on the upstream and downstream sides of the part and must be set by jumpers on the evaluation board. Both speed jumpers must be set to the same speed setting for proper operation.

**Table 3. Speed Selection Jumpers**

SPU (JP4)	SPD (JP5)	Speed
Short SPU-Full	Short SPD-full	Full (12 Mbps)
Short SPU-Low	Short SPD-low	Low (1.5 Mbps)

### PULL-UP CONTROL

The PIN pin is provided to allow the control of enumeration and disconnect by the peripheral. When PIN is logic high, the pull-up on the upstream side of the ADuM4160 or ADuM3160 is applied to the data line appropriate for the USB speed mode. This allows enumeration and data transmission. When PIN is logic low, the upstream pull-up is disconnected, making the upstream port behave as though the port were not present.

This function is provided to allow the peripheral to delay communication with the host by delaying application of the upstream pull-up resistor until it is ready to be enumerated on the bus. If this functionality is not required, PIN can be tied to  $V_{DD2}$ , and the pull-up is applied to the upstream side when power is applied to both the downstream power supplies.

Control of PIN is provided through Jumper JP6. PIN input is pulled high by a 10 k $\Omega$  resistor. When a shunt is placed across JP6, it is pulled low. This provides a default state of high to PIN, allowing immediate enumeration.

**Table 4. PIN Pull-Up Control**

PIN (JP5)	Upstream Pull-Up State
Short	Disconnected
Open	Connected

### SERIES RESISTORS

The two USB speeds supported by the ADuM4160 and ADuM3160 require different series resistance values at the transceiver terminals.

For full speed operation, Resistor R1 to Resistor R4 should be populated with 24  $\Omega$ , 1% resistors. These are installed in the base configuration of the evaluation board and, if the board is operated at full speed, no changes are required.

For low speed operation, R1 to R4 should be replaced by 0  $\Omega$  shunts. If the board is operated at a low speed, it must be modified from the as-received configuration. The shunt can be an 805-size SMT device or a simple wire shorting the pads. The resistors do not significantly affect the low speed performance and can be left in place for both speed modes if impedance is not critical to the evaluation.

### TEST POINTS

Positions for eight test points are included on the evaluation board. No headers are provided in the default configuration. Mounting holes for a ground signal pair are provided. The holes fit a standard square-pin spaced at 100 mil or 200 mil on center. This configuration was chosen to match the dimensions of the Tektronix high frequency active probes or standard headers. An appropriate scope header can be obtained by using a 3-pin SIP wire wrap header and removing the center pin. The signal pin can be trimmed to match the spacing of the probe. If another type of connection is required, wires can be inserted into the holes provided for these connections.

### OPTIONAL COMPONENTS

Options for installing common-mode chokes and external ESD protection on the DD+/DD- and UD+/UD- data lines are also available. Positions for TDK ACM3225 chokes are provided at Position FL1 and Position FL2. Positions for ESD diode packs, NUP2202 from ON Semiconductor, are provided at Position D1 and Position D2. In addition, pads for surface-mount ferrite inductors are provided at Position R6 to Position R10. All of these component positions are either unpopulated or filled with 0  $\Omega$  resistors from Analog Devices. They are included on the PCB as a convenience to the end user.

EVALUATION BOARD SCHEMATIC AND ARTWORK

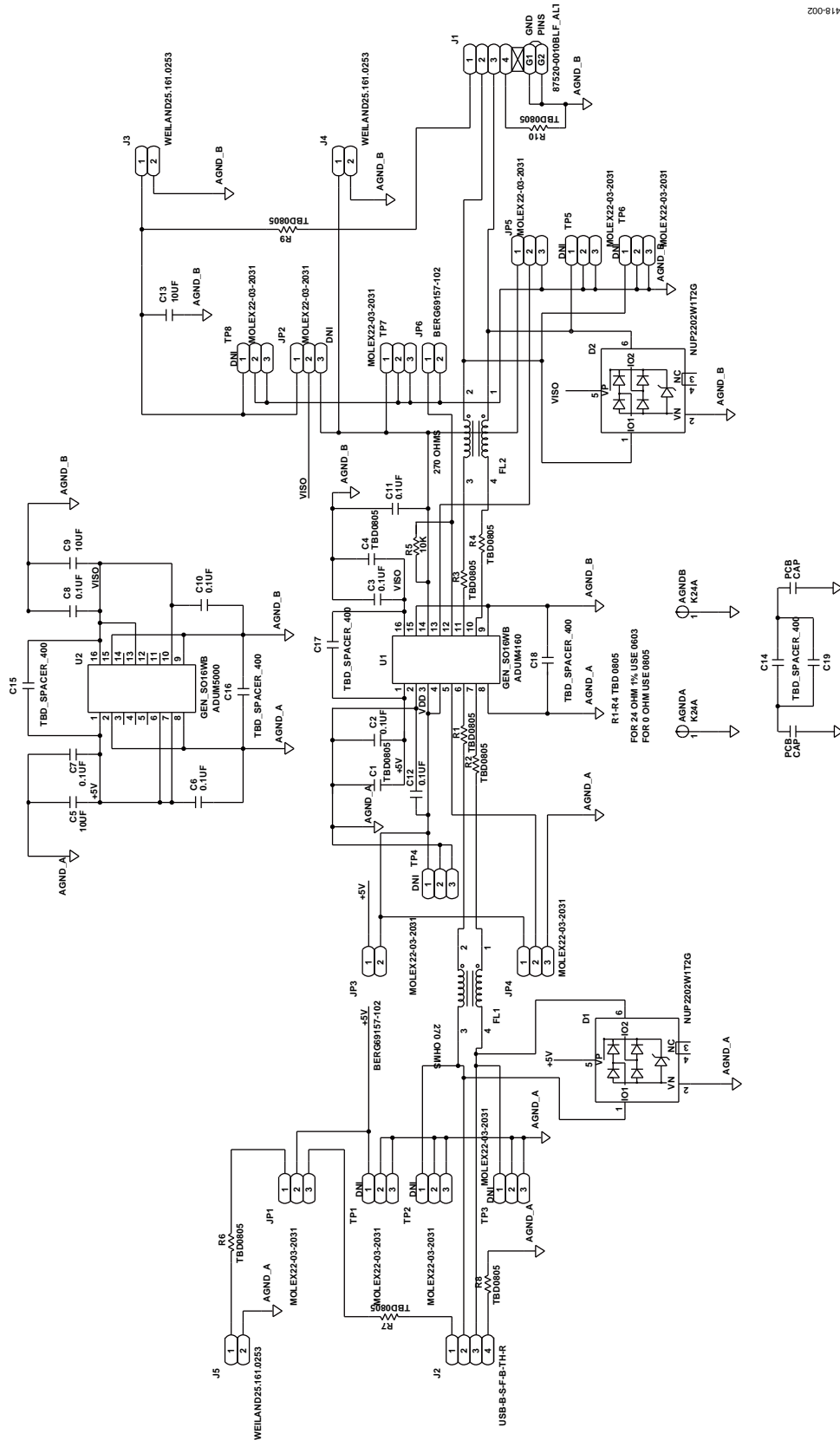


Figure 2. Evaluation Board Schematic

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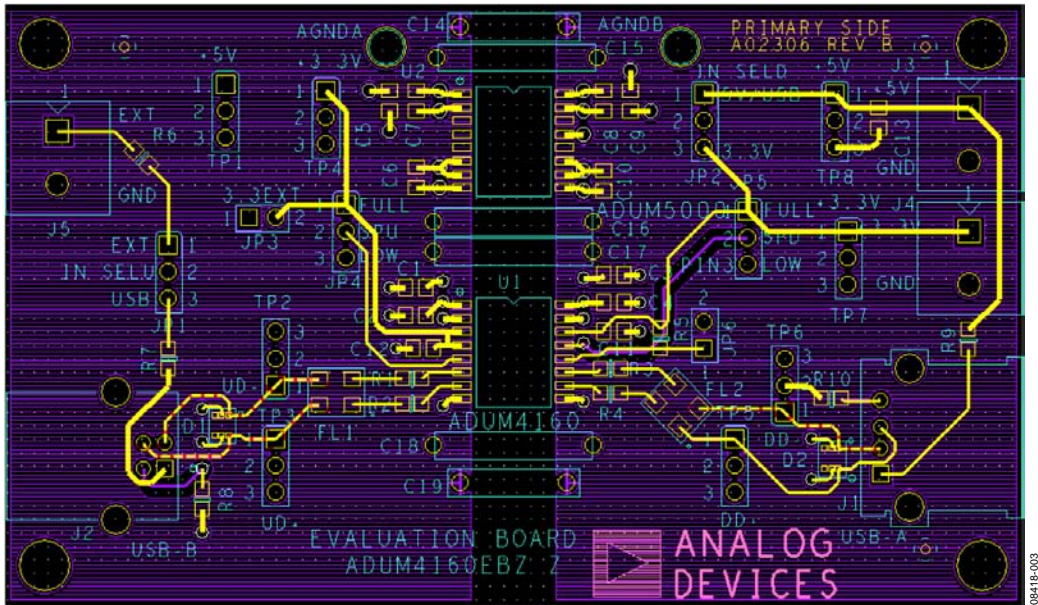


Figure 3. Evaluation Board Artwork

**NOTES**