EVAL-ADuM4160EBZ User Guide

UG-043

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

*i*Coupler 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 *i*Coupler® USB isolators to address the difficult task of isolating the bus. The EVAL-ADuM4160EBZ USB isolator evaluation board allows for an easy interface to existing applications by standard cabling or discrete wiring.

This 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 also applies directly to the ADuM3160. If the user wants to substitute the ADuM3160 on the printed circuit board (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 electrostatic discharge (ESD) protection.
- Support common-mode chokes in the xD+/xD– lines.
- Support ferrite inductors in the VBUSx and GNDx lines.

For full details, see the ADuM4160 and the ADuM3160 data sheets, which must be used in conjunction with this user guide when using the EVAL-ADuM4160EBZ evaluation board.

EVAL-ADuM4160EBZ EVALUATION BOARD

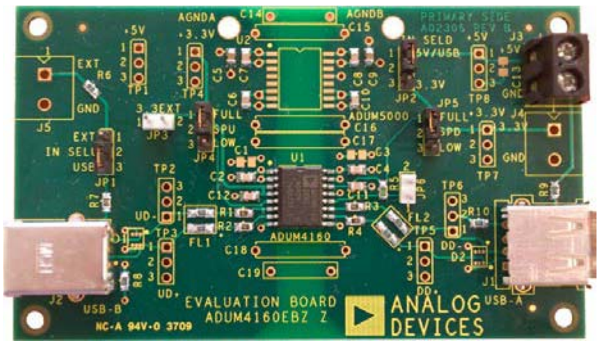

Figure 1.

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 devices 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 that allow the ADuM4160 and the ADuM3160 to draw power from either 5 V or 3.3 V sources.
- Application of an upstream pull-up resistor is under the control of the downstream pin, PIN (Pin 12).
- Pins on the upstream and downstream sides of the device, SPU and SPD (Pin 5 and Pin 13, respectively), can set the operating speed of the isolator.

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 the features of the ADuM4160/ADuM3160 chip and provides support for a variety of possible power schemes. The evaluation 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.

TABLE OF CONTENTS

Introduction ... 1
EVAL-ADuM4160EBZ Evaluation Board ... 1
Features of the ADuM4160/ADuM3160 ... 1
Revision History ... 2
Power ... 3
  Upstream Side ... 3
  Downstream Side ... 3
  Grounding Scheme ... 3
  Speed Selection ... 4
  Pull-Up Control ... 4
  Series Resistors ... 4
  Test Points ... 4
  Optional Components ... 4
Evaluation Board Schematic and Artwork ... 5
Ordering Information ... 8
  Bill of Materials ... 8

REVISION HISTORY

7/2017—Rev. A to Rev. B

Changed from EVAL-ADuM4160EBZ/ADuM3160EBZ User Guide to EVAL-ADuM4160EBZ User Guide ... Throughout
Changes to Features of the ADuM4160/ADuM3160 Section ... 1
Changed Evaluation Board Section to EVAL-ADuM4160EBZ Evaluation Board Section ... 1
Changes to Upstream Side Section and Downstream Side Section ... 3
Changes to Table 4, Series Resistors Section, Test Points Section, and Optional Components Section ... 4
Changes to Figure 3 ... 6
Added Figure 4 ... 6
Added Figure 5 and Figure 6 ... 7
Added Ordering Information Section, Bill of Materials Section, and Table 5 ... 8

9/2010—Rev. 0 to Rev. A

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

2/2010—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 is 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 J5 terminal block, 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. Shorting Pin 1 and Pin 3 is accomplished by placing a shunt across JP3, 3.3EXT. This jumper must be open when the USB bus is the source of power.

Table 1. Upstream Power Jumper Settings

	Jumper Settings	
Power Source	**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 an external 5 V power supply through Terminal Block J3 or from the upstream USB power bus through an ADuM5000 *iso*Power isolated dc-to-dc converter. The ADuM5000 is shipped loose with the evaluation board and must be soldered to the evaluation board in the U2 position if isolated power is provided by the upstream USB power bus. Only one method of powering the downstream port can be used.

The ADuM5000 can provide a maximum 500 mW of power to the downstream side. Applications that require more power at the downstream port must use the external 5 V power supply option. The ADuM5000 is provided for the convenience of the user, and its use in final applications must be reviewed based on its data sheet precautions for power consumption and electromagnetic interference (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 the 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 (JP3) 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

	Jumper Settings/Components	
Power Source	**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 evaluation 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 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 option of the user. This linking can provide plane-to-plane noise bypassing through several paths to reduce radiated emissions from the ADuM5000 power supply.

Two large screw holes along the top edge of the PCB provide connection to the upstream ground plane and the downstream ground plane. These holes 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. If the floating structures are employed for noise reduction, the PCB must not be used for high voltage testing. When this type of structure is required in the final design, build it 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 SPU pin and the SPD pin on the upstream and downstream sides of the device set the speed and must be set by jumpers on the evaluation board. For proper operation, set both speed jumpers to the same speed setting.

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 allows control of enumeration and disconnect by the peripheral. When PIN is logic high, the pull-up on the upstream side of the ADuM4160 or the ADuM3160 is applied to the data line appropriate for the USB speed mode, which 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 allows the peripheral to delay communication with the host by delaying application of the upstream pull-up resistor until it is ready to enumerate on the bus. If this functionality is not required, tie PIN to V_{DD2}, and when power is applied to both the downstream power supplies, the pull-up is applied to the upstream side.

Jumper JP6 provides control of PIN. A 10 kΩ resistor pulls the PIN input high. When a shunt is placed across JP6, it is pulled low, which provides a default state of high to PIN, allowing immediate enumeration.

Table 4. PIN Pull-Up Control

PIN (JP6)	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, the R1, R2, R3, and R4 resistors must be populated with 24 Ω, 1% resistors. These 24 Ω resistors are installed in the base configuration of the evaluation board and, if the evaluation board is operating at full speed, no changes are required.

When the ADuM4160 operates at low speeds, it is recommended to modify the evaluation board from the as received configuration. For low speed operation, replace the R1, R2, R3, and R4 resistors with 0 Ω, 0805 sized, SMT shunts. If impedance is not critical, the 24 Ω resistors do not significantly affect the low speed performance, and they can be left in place for both speed modes.

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. To obtain an appropriate scope header use a 3-pin SIP (2.54 mm spacing) wire wrap header and remove the center pin. The signal pin can be trimmed to match the spacing of the probe. If another type of connection is required, insert wires 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 available on the EVAL-ADUM4160EBZ evaluation board. Positions for 1206-sized Wurth WE-CNSW 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. These positions are included on the PCB as a convenience to the end user and are not necessary for operation. To make use of common-mode chokes, remove the R11, R12, R13, and R14 shunts.

EVALUATION BOARD SCHEMATIC AND ARTWORK

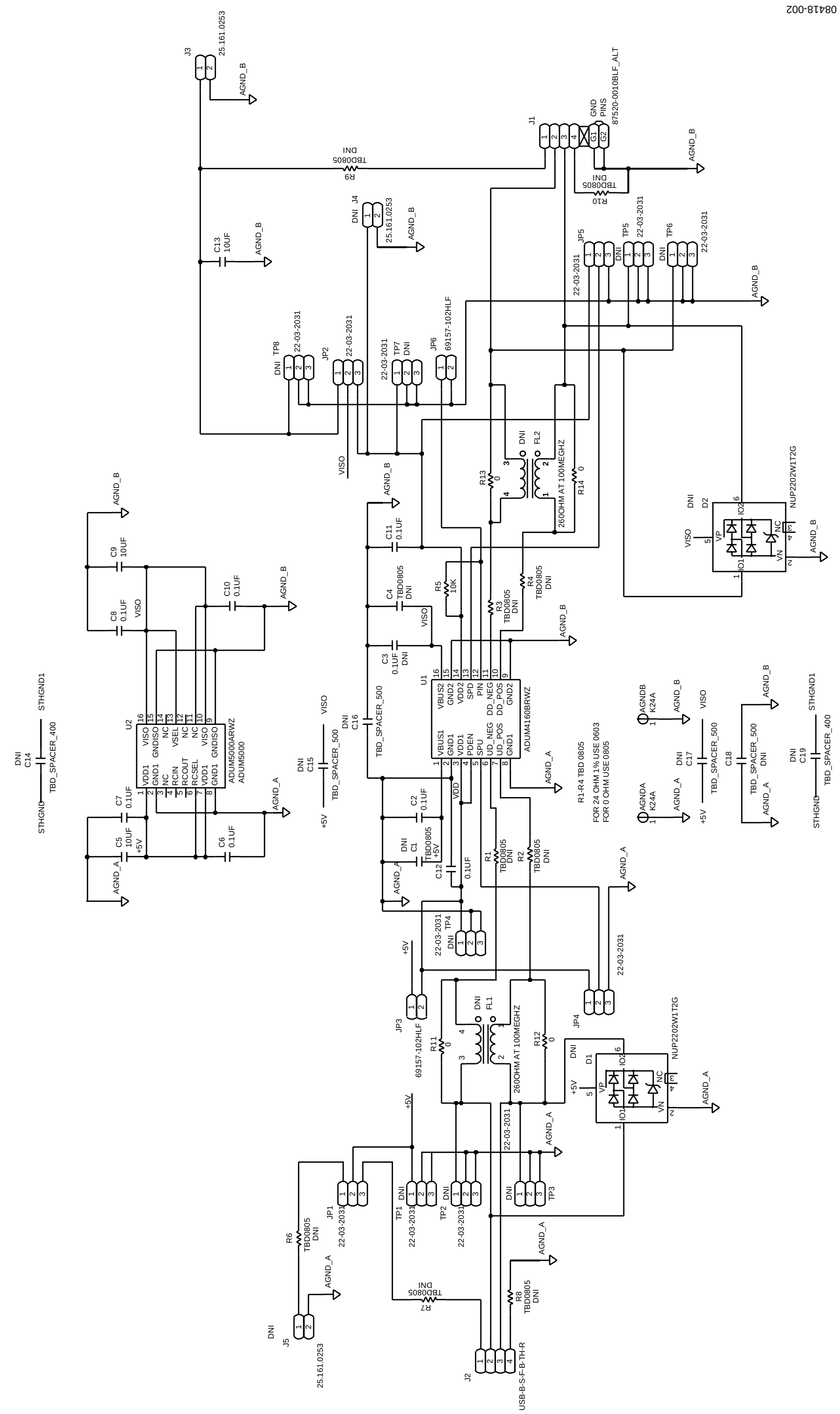

Figure 2. EVAL-ADUM4160EBZ Evaluation Board Schematic

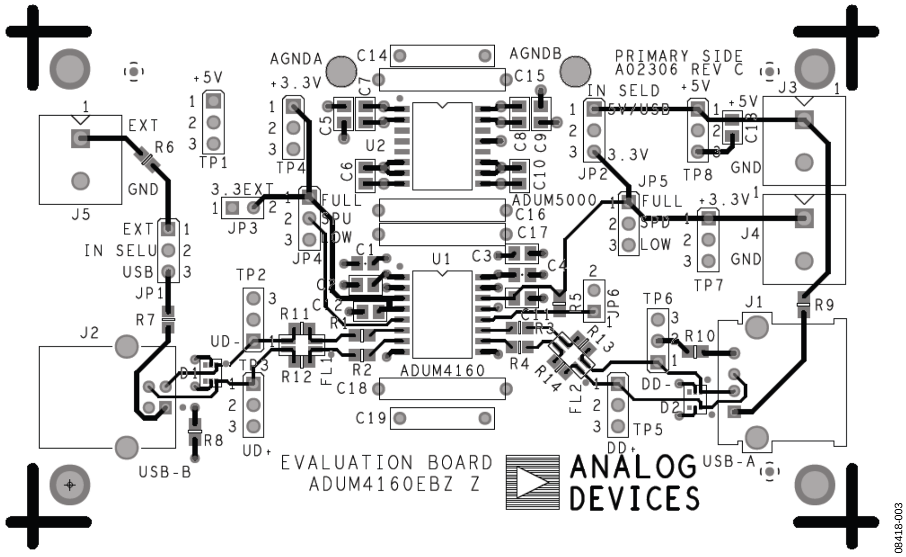

Figure 3. EVAL-ADUM4160EBZ Evaluation Board Layer 1 and Silkscreen

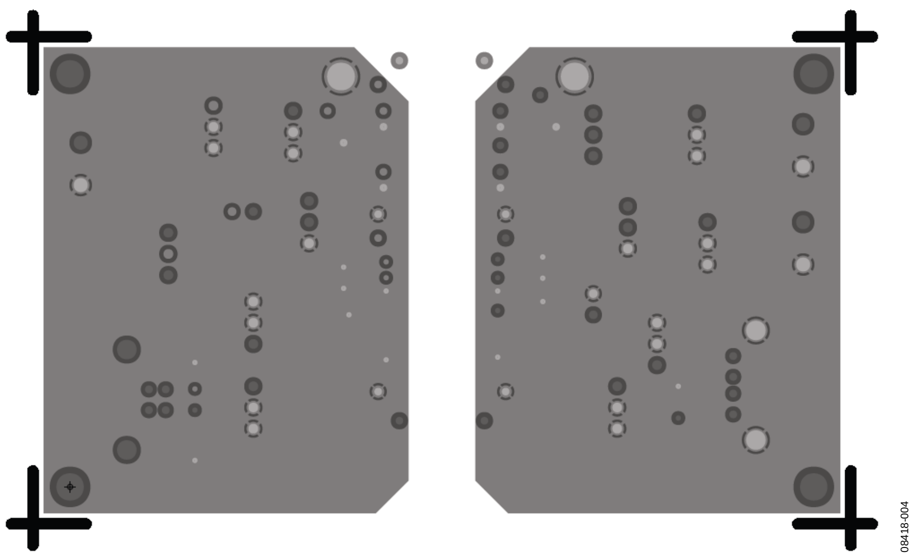

Figure 4. EVAL-ADUM4160EBZ Evaluation Board Layer 2

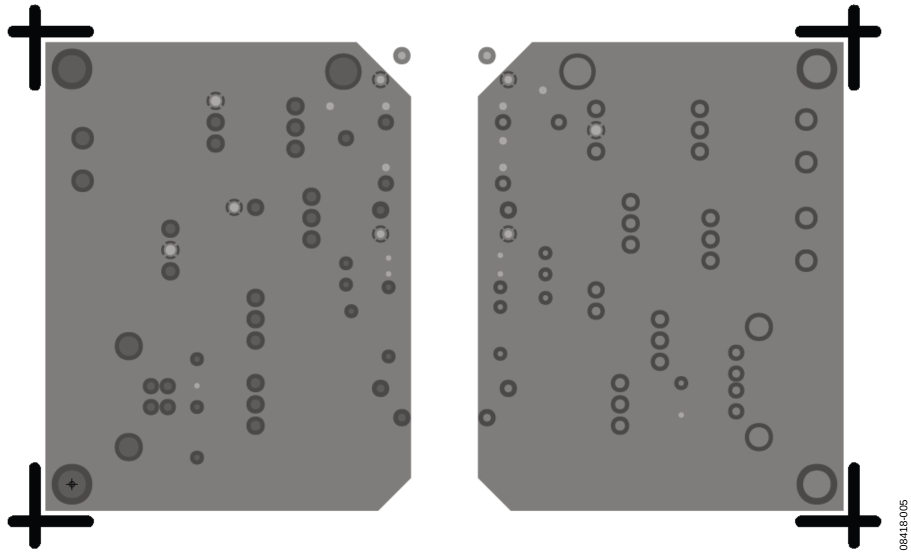

Figure 5. EVAL-ADUM4160EBZ Evaluation Board Layer 3

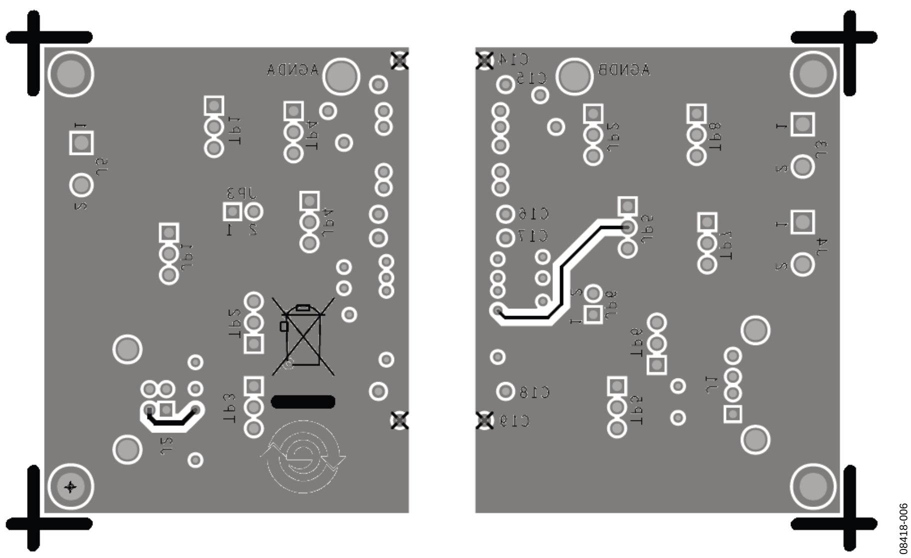

Figure 6. EVAL-ADUM4160EBZ Evaluation Board Layer 4 and Silkscreen

ORDERING INFORMATION

BILL OF MATERIALS

Table 5.

Qty	Reference Designator	Description	Manufacturer/Part Number
1	U1	Device under test (DUT)	Analog Devices/ADuM4160BRWZ
1	U2	DUT (shipped with evaluation board; not installed)	Analog Devices/ADuM5000ARWZ
7	C2, C6, C7, C8, C10, C11, C12	X7R, 0805, capacitors	Murata/GRM21BR71H104KA01L
3	C5, C9, C13	X5R, 0805, capacitors	Murata/GRM21BR61C106KE15L
1	J1	USB, Type A, PCB connector	FCI/87520-0010BLF_ALT
1	J2	USB, Type B, PCB connector	SAMTEC/USB-B-S-F-B-TH-R
1	J3	2-position screw terminal	Wieland/25.161.0253
4	JP1, JP2, JP4, JP5	100 mil (2.54 mm) 3-position headers	Molex/22-03-2031
2	JP3, JP6	100 mil (2.54 mm) 2-position headers	Amphenol FCI/69157-102HLF
4	R11, R12, R13, R14	0805, 0 Ω, resistors	Panasonic/ERJ-6GEY0R00V
1	R5	0805, 10 kΩ, resistor	Panasonic/ERJ-6ENF1002V
5	Not applicable	100 mil (2.54 mm) jumpers	FCI/68786-302LF
9	R1, R2, R3, R4, R6, R7, R8, R9, R10	0805, resistors, not installed	Not applicable
2	C1, C3, C4	0805, capacitors, not installed	Not applicable
6	C14, C15, C16, C17, C18, C19	Leaded capacitor position, not installed	Not applicable
2	D1, D2	Transient voltage suppressor (TVS) arrays, not installed	ON Semiconductor/NUP2202W1T2G
2	FL1, FL2	SMD, common-mode chokes, not installed	Wurth Elektronik/744232261
2	J4, J5	2-position screw terminals, not installed	Wieland/25.161.0253
8	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8	100 mil, 3-position headers, not installed	Molex/22-03-2031