

## Evaluating the ADuM3165/ADuM3166 3.75 kV RMS Digital Isolators for Isolated USB 2.0 High, Full, and Low Speed

### FEATURES

- ▶ Supports USB 2.0 data transfer
  - ▶ Low speed (1.5 Mbps)
  - ▶ Full speed (12 Mbps)
  - ▶ High speed (480 Mbps)
- ▶ USB Type C (upstream) and USB Type A (downstream) connectors
- ▶ Upstream 5 V power from cable or external supply
- ▶ Downstream power from external supply
- ▶ Accepts 3.3 V or 5 V external supplies
- ▶ PGOOD (power good) indicator on downstream side
- ▶ Option to connect test points
- ▶ 20-lead SSOP package option with 5.3 mm creepage

### EVALUATION KIT CONTENTS

- ▶ EVAL-ADuM3165EBZ or EVAL-ADuM3166EBZ

### DOCUMENTS NEEDED

- ▶ [ADuM3165/ADuM3166](#) data sheet

### EQUIPMENT NEEDED

- ▶ Signal generator or USB host (for example, laptop)
- ▶ USB peripheral (for example, mouse, headset, mass storage, or webcam)
- ▶ Oscilloscope
- ▶ Power supply (one or two outputs)

### GENERAL DESCRIPTION

The EVAL-ADuM3165EBZ and the EVAL-ADuM3166EBZ allow quick and easy evaluation of the ADuM3165 and ADuM3166 USB isolators, allowing direct connection to USB hosts and peripherals without the need for additional components. The ADuM3165/ADuM3166 employ Analog Devices, Inc., iCoupler® technology to combine isolator channels, USB transceivers, power and timing circuits, control logic and internal terminations, pull-ups, and pull-downs into a single, 20-lead, compact shrink small outline package (SSOP).

The evaluation boards have a separate ground and power plane for each side of the isolator. This separation enables the evaluation of the ADuM3165/ADuM3166 with galvanic isolation between both sides of these devices. However, the boards have not been certified for safety when using high voltages, and testing must be carried out by qualified personnel only.

Power can be provided on the upstream side from a connected USB host, while an external power supply is required for the downstream side.

For full details on the ADuM3165/ADuM3166, see the ADuM3165/ADuM3166 data sheet, which must be consulted in conjunction with this user guide when using the EVAL-ADuM3165EBZ or the EVAL-ADuM3166EBZ.

### EVALUATION BOARD PHOTOGRAPHS

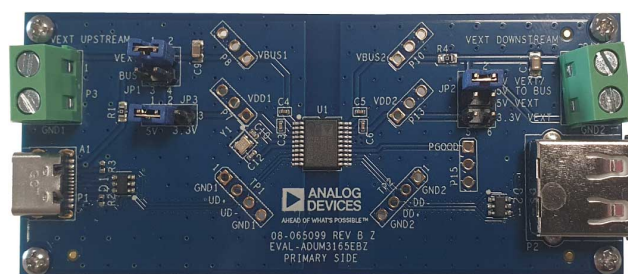


Figure 1. EVAL-ADuM3165EBZ Photograph



Figure 2. EVAL-ADuM3166EBZ Photograph

TABLE OF CONTENTS

Features.....	1	Upstream Side (Isolator Side 1).....	4
Evaluation Kit Contents.....	1	Downstream Side (Isolator Side 2).....	4
Documents Needed.....	1	Optional Test Points.....	5
Equipment Needed.....	1	Evaluation Board Schematics and Artwork.....	6
General Description.....	1	Ordering Information.....	10
Evaluation Board Photographs.....	1	Bill of Materials .....	10
USB Functionality.....	3	Notes.....	11
Power Supply Configuration.....	4		

REVISION HISTORY

5/2022—Revision 0: Initial Version

## USB FUNCTIONALITY

The EVAL-ADuM3165EBZ and the EVAL-ADuM3166EBZ include both an upstream facing port (USB Type C connector) and a downstream facing port (USB Type A connector) corresponding to the upstream Side 1 and downstream Side 2 of the [ADuM3165/ADuM3166](#) isolators (Pin 1 through Pin 10 for Side 1, and Pin 11 through Pin 20 for Side 2). The upstream facing USB Type C connector supports the flippable feature of USB Type C and can be used with either cable orientation. The isolators are designed to be transparent to USB data traffic other than adding between one and two hub plus cable delays.

Hosts or a hub downstream facing port can connect to the USB Type C connector (connecting to the ADuM3165/ADuM3166 UD+ and UD- pins), and peripherals or hub upstream facing ports can connect to the USB Type A connector (connecting to the ADuM3165/ADuM3166 DD+ and DD- pins). Low speed, full speed, or high speed devices can be connected to the EVAL-ADuM3165EBZ or the EVAL-ADuM3166EBZ, and the isolator automatically detects the speed and adjusts its internal pull-ups and termination.

## POWER SUPPLY CONFIGURATION

## UPSTREAM SIDE (ISOLATOR SIDE 1)

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. The 5 V supply on the cable can also be used to power functions in the peripheral at up to 500 mA.

The ADuM3165/ADuM3166 contain an internal low dropout (LDO) regulator on Side 1 that outputs 3.3 V on  $V_{DD1}$  for use by internal circuits when 5 V is applied to  $V_{BUS1}$ . Alternatively, this LDO regulator can be bypassed by shorting  $V_{BUS1}$  to  $V_{DD1}$  if an external 3.3 V supply is available. The EVAL-ADuM3165EBZ and the EVAL-ADuM3166EBZ allow both modes of operation to be selected, as well as optionally providing 5 V from the USB upstream connector (Type C connector) to  $V_{BUS1}$ , instead of from an external supply connected to the P3 connector block (VEXT UPSTREAM).

Jumper JP1 selects between power from the upstream USB connector or power from an external supply on P3, as shown in Table 1. When using power from the USB, the Side 1 supply voltage of the EVAL-ADuM3165EBZ or the EVAL-ADuM3166EBZ must be set up for 5 V using P4. When using an external supply, P4 allows configuration for 3.3 V (shorting  $V_{BUS1}$  and  $V_{DD1}$ , disabling the internal LDO regulator on Side 1 of the ADuM3165/ADuM3166) or 5 V (connected to  $V_{BUS1}$  only).

**Table 1. Upstream (Side 1) Power Supply Jumper Settings**

Power Source	JP1 Position	P4 Position
5 V from the USB	3 and 4	1 and 2
5 V (4.5 V to 5.5 V) External (P3)	1 and 2	1 and 2
3.3 V (3 V to 3.6 V) External (P3)	1 and 2	2 and 3

## DOWNSTREAM SIDE (ISOLATOR SIDE 2)

The USB 2.0 specification does not allow any power to be sourced from a peripheral connected to a downstream facing port such as the USB Type A connector on the EVAL-ADuM3165EBZ and the EVAL-ADuM3166EBZ. Power to run Side 2 of the ADuM3165/ADuM3166 cannot come from the downstream USB cable as it did on Side 1 from the upstream USB cable. 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 separate dc-to-dc converter.

As with Side 1, the ADuM3165/ADuM3166 contain an internal LDO regulator on Side 2 that outputs 3.3 V on  $V_{DD2}$  for use by internal circuits when 5 V is applied to  $V_{BUS2}$ . Alternatively, this LDO regulator can be bypassed by shorting  $V_{BUS2}$  to  $V_{DD2}$  if an external 3.3 V supply is available. The EVAL-ADuM3165EBZ and the EVAL-ADuM3166EBZ allow both modes of operation to be selected, as well as optionally providing 5 V to the USB downstream connector (Type A connector) in addition to  $V_{BUS2}$ .

An external 3.3 V or 5 V supply must be connected to the P16 terminal block for operation. Jumper JP2 must be configured for 3.3 V (shorting  $V_{BUS1}$  and  $V_{DD1}$ , disabling the internal LDO regulator on Side 1 of the ADuM3165/ADuM3166) or 5 V (connected to  $V_{BUS1}$  only). Additionally, when using a 5 V supply, JP2 allows connection of the supply on P16 to the USB downstream facing port. Refer to Table 2 for the correct position for the external power supply voltage and power supply configuration.

**Table 2. Downstream (Side 2) Power Supply Jumper Settings**

P16 Power Source	JP2 Position	Supply Connected To
5 V (4.5 V to 5.5 V)	1 and 2	$V_{BUS2}$ and USB port (downstream facing)
5 V (4.5 V to 5.5 V)	3 and 4	$V_{BUS2}$ only
3.3 V (3 V to 3.6 V)	5 and 6	$V_{BUS2}$ and $V_{DD2}$

OPTIONAL TEST POINTS

Positions for nine test points are included on both evaluation boards as listed in Table 3. 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 single inline package (SIP) header (as used for wire wrap) and removing the center pin. The signal pin can be trimmed to match the spacing

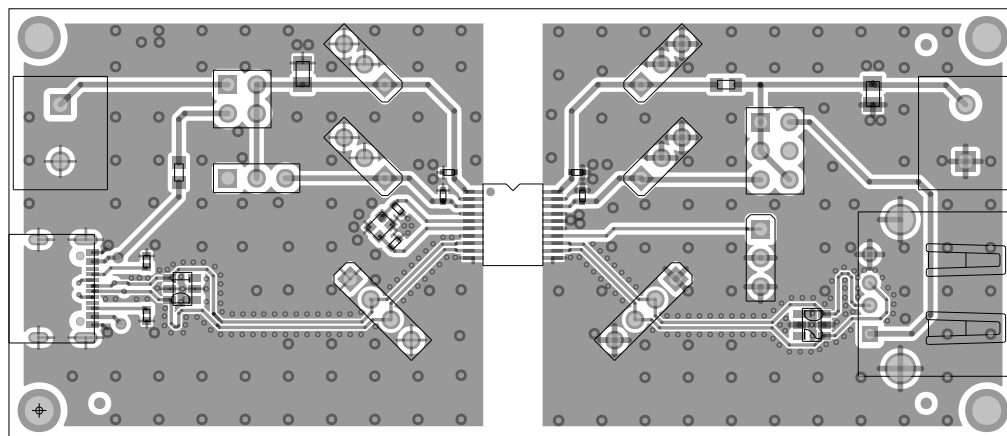
of the probe. If another type of connection is required, wires can be inserted into the holes provided for these connections.

The high speed, signal pin test points were designed to keep the proper impedance along the differential pairs. If the 200 mil scope probe scheme is used, only one of the pairs can be monitored, unless the second test point is installed from the other side of the PCB.

Table 3. Test Point Names and Description

Name	Type	Description
VBUS1	Power	Optional 5 V power supply (LDO regulator input for Side 1)
VBUS2	Power	Optional 5 V power supply (LDO regulator input for Side 2)
VDD1	Power	3.3 V power supply for Side 1
VDD2	Power	3.3 V power supply for Side 2
PGOOD	Output	Power-good indicator
UD+	Input and output	Upstream USB signal D+
UD-	Input and output	Upstream USB signal D-
DD+	Input and output	Downstream USB signal D+
DD-	Input and output	Downstream USB signal D-

003



004

## EVALUATION BOARD SCHEMATICS AND ARTWORK

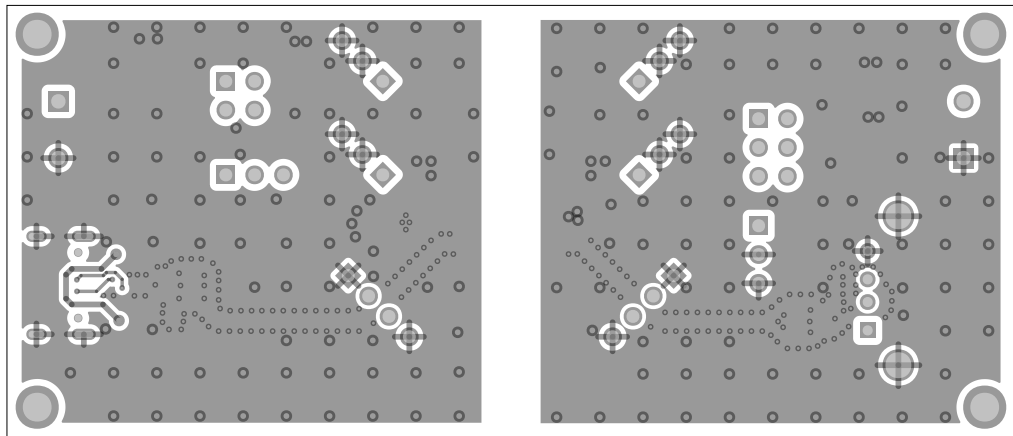


Figure 5. EVAL-ADuM3165EBZ Solder Side

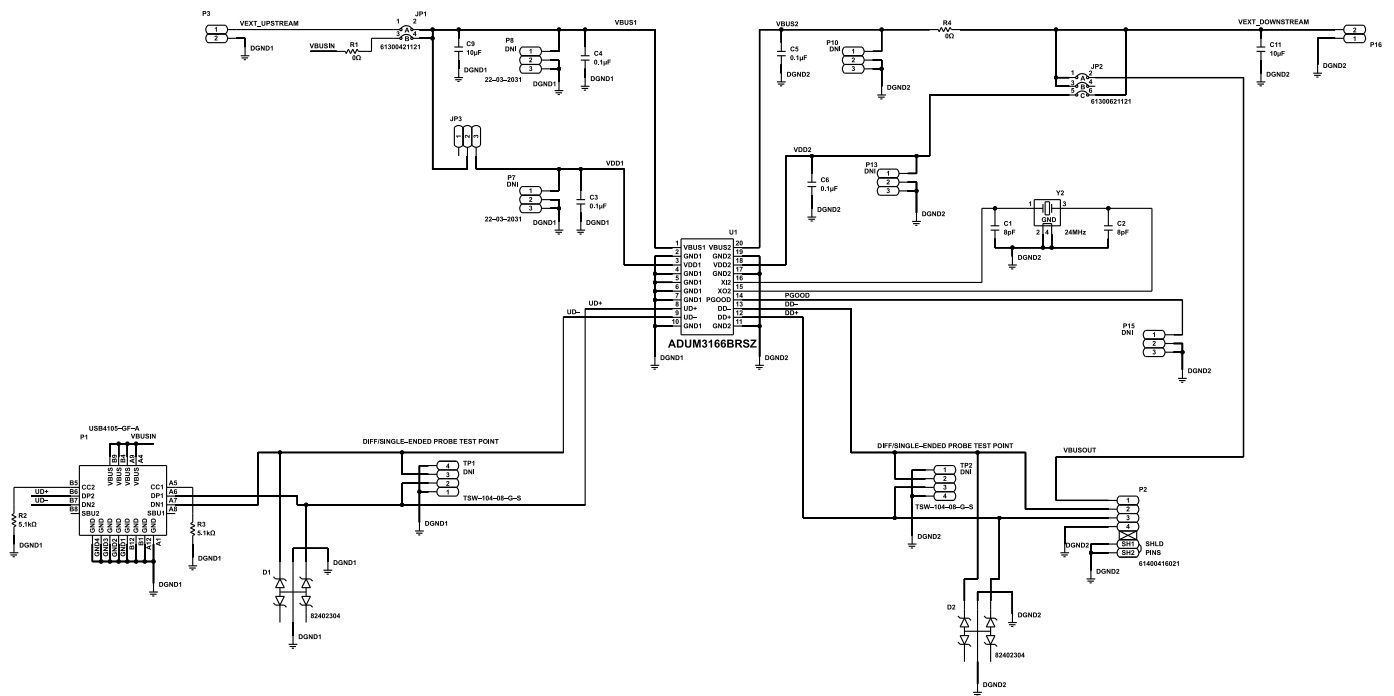


Figure 6. EVAL-ADuM3166EBZ Schematic

## EVALUATION BOARD SCHEMATICS AND ARTWORK

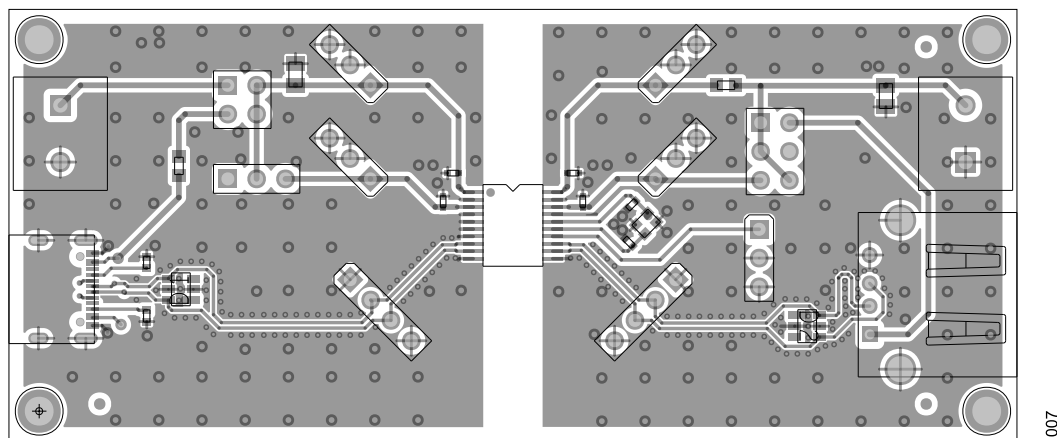


Figure 7. EVAL-ADuM3166EBZ Component Side

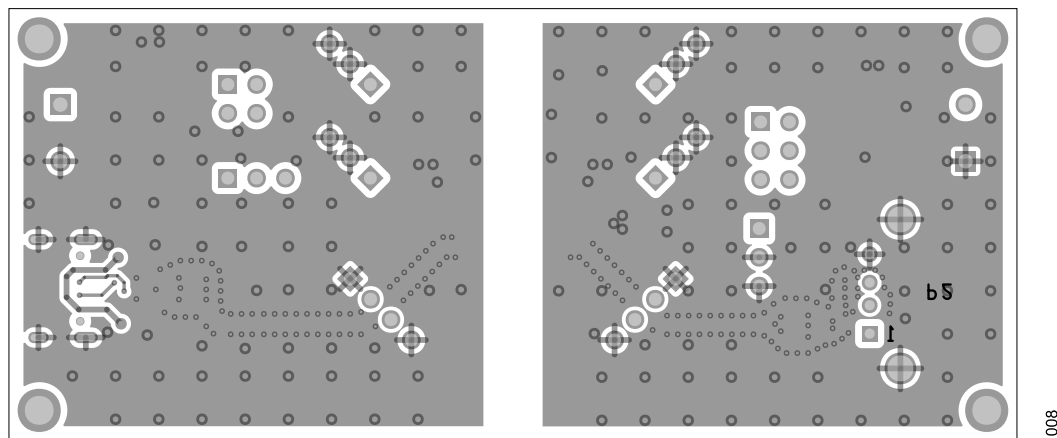


Figure 8. EVAL-ADuM3166EBZ Solder Side

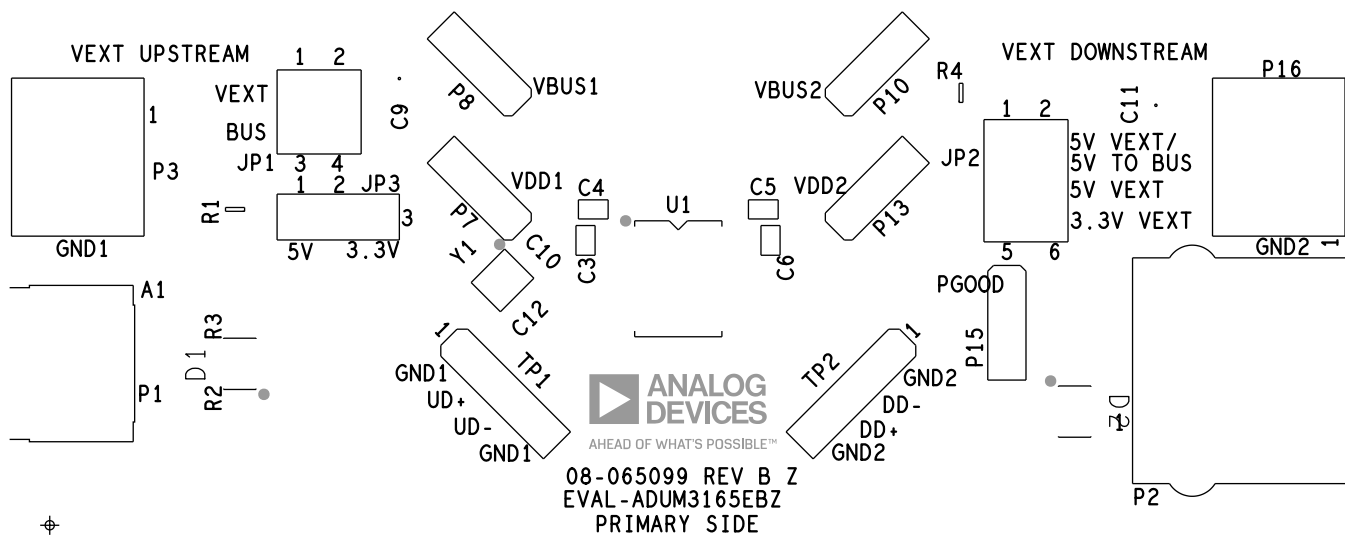
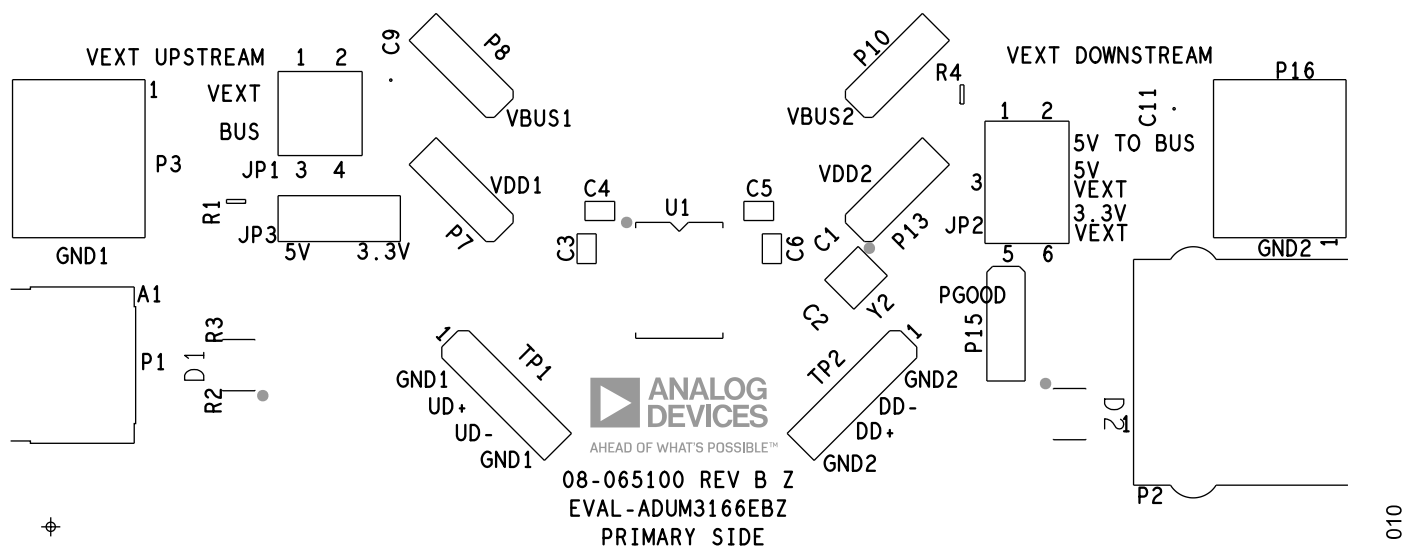


Figure 9. EVAL-ADuM3165EBZ Silkscreen



## EVALUATION BOARD SCHEMATICS AND ARTWORK



## ORDERING INFORMATION

## BILL OF MATERIALS

Table 4. EVAL-ADuM3165EBZ Bill of Materials

Quantity	Reference Designator	Description	Manufacturer	Part Number
4	C3, C4, C5, C6	Capacitors, 0.1 $\mu$ F, 0402	Würth Elektronik	885012205037
2	C9, C11	Capacitors, 10 $\mu$ F, 0805	Würth Elektronik	885012207026
2	C10, C12	Capacitors, 8 pF, 0402	AVX Corporation	0402YA8R0DAT2A
2	D1, D2	TVS diodes, 6.8 V, unidirectional	Würth Elektronik	82402304
1	JP1	Connector, pin header, 4 way, 2 row	Würth Elektronik	61300421121
1	JP2	Connector, pin header, 6 way, 2 row	Würth Elektronik	61300621121
1	P1	USB connector, Type C	GCT	USB4105-GF-A
1	P2	USB connector, Type A	Würth Elektronik	61400416021
2	P3, P16	Connectors, 2-pin terminal block	Würth Elektronik	691213710002
1	JP3	Connector, pin header, 3 way, 1 row	Würth Elektronik	61300311121
5	P7, P8, P10, P13, P15	Connectors, pin header, 3 way, 1 row	Not fitted	Not applicable
2	R1, R4	Resistors, 0 $\Omega$ , 0603	Panasonic	ERJ-3GEY0R00V
2	R2, R3	Resistors, 5.1 k $\Omega$ , 0402	Vishay	CRCW04025K10FKED
2	TP1, TP2	Test points, 4-pin header, 0.100", 2.54 mm	Not fitted	Not applicable
1	U1	Digital isolator for isolated USB 2.0 high speed	Analog Devices	<a href="#">ADuM3165BRSZ</a>
1	Y1	24 MHz $\pm$ 10 ppm crystal, 10 pF, 50 $\Omega$ , 4-SMD	IQD Frequency Products	LFXTAL071257REEL

Table 5. EVAL-ADuM3166EBZ Bill of Materials

Quantity	Reference Designator	Description	Manufacturer	Part Number
2	C1, C2	Capacitors, 8 pF, 0402	AVX Corporation	0402YA8R0DAT2A
4	C3, C4, C5, C6	Capacitors, 0.1 $\mu$ F, 0402	Würth Elektronik	885012205037
2	C9, C11	Capacitors, 10 $\mu$ F, 0805	Würth Elektronik	885012207026
2	D1, D2	TVS diodes, 6.8 V, unidirectional	Würth Elektronik	82402304
1	JP1	Connector, pin header, 4 way, 2 row	Würth Elektronik	61300421121
1	JP2	Connector, pin header, 6 way, 2 row	Würth Elektronik	61300621121
1	P1	USB connector, Type C	GCT	USB4105-GF-A
1	P2	USB connector, Type A	Würth Elektronik	61400416021
2	P3, P16	Connectors, 2-pin terminal block	Würth Elektronik	691213710002
1	JP3	Connector, pin header, 3 way, 1 row	Würth Elektronik	61300311121
5	P7, P8, P10, P13, P15	Connectors, pin header, 3 way, 1 row	Not fitted	Not applicable
2	R1, R4	Resistors, 0 $\Omega$ , 0603	Panasonic	ERJ-3GEY0R00V
2	R2, R3	Resistors, 5.1 k $\Omega$ , 0402	Vishay	CRCW04025K10FKED
2	TP1, TP2	Test points, 4-pin header, 0.100", 2.54 mm	Not fitted	Not applicable
1	U1	Digital isolator for isolated USB 2.0 high speed	Analog Devices	<a href="#">ADuM3166BRSZ</a>
1	Y2	24 MHz $\pm$ 10 ppm crystal, 10 pF, 50 $\Omega$ , 4-SMD	IQD Frequency Products	LFXTAL071257REEL

## ORDERING INFORMATION

## NOTES

**ESD Caution**

**ESD (electrostatic discharge) sensitive device.** Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

**Legal Terms and Conditions**

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS (\$100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

