

Evaluating the ADuM4165/ADuM4166 5.7 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)
- ▶ Standard USB Type A and Type B 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
- ▶ Optional connection of external clock
- ▶ Option to connect test points
- ▶ 20-lead SOIC_IC package option with 8.3 mm creepage

EVALUATION KIT CONTENTS

- ▶ EVAL-ADuM4165EBZ or EVAL-ADuM4166EBZ

DOCUMENTS NEEDED

- ▶ [ADuM4165/ADuM4166 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)

INTRODUCTION

The EVAL-ADuM4165EBZ and the EVAL-ADuM4166EBZ allow quick and easy evaluation of the ADuM4165 and ADuM4166 USB isolators, allowing direct connection to USB hosts and peripherals without the need for additional components. The ADuM4165/ADuM4166 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, wide-body, increased creepage SOIC_IC package.

The evaluation boards have a separate ground and power plane for each side of the isolator. This separation enables the evaluation of the ADuM4165/ADuM4166 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 ADuM4165/ADuM4166, see the ADuM4165/ADuM4166 data sheet, which must be consulted in conjunction with this user guide when using the EVAL-ADuM4165EBZ or the EVAL-ADuM4166EBZ.

EVALUATION BOARD PHOTOGRAPHS

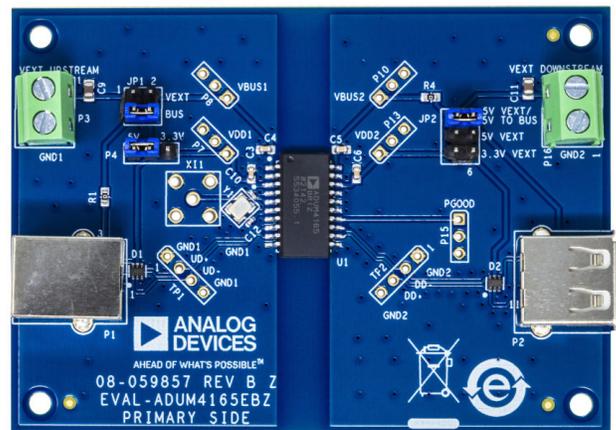


Figure 1. EVAL-ADuM4165EBZ Photograph

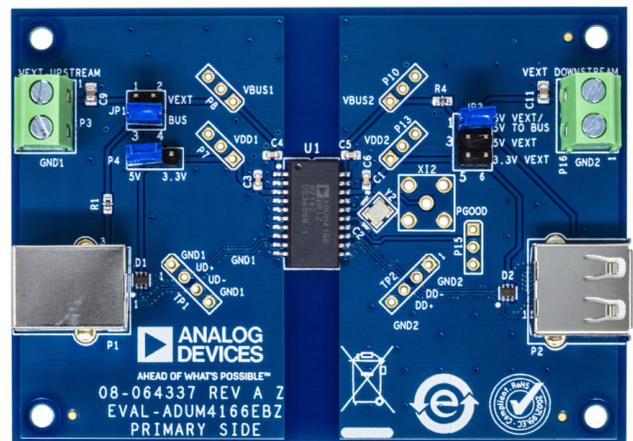


Figure 2. EVAL-ADuM4166EBZ Photograph

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REVISION HISTORY**2/2022—Revision 0: Initial Version**

USB FUNCTIONALITY

The EVAL-ADuM4165EBZ and the EVAL-ADuM4166EBZ include both an upstream facing port (USB Type B connector) and a downstream facing port (USB Type A connector) corresponding to the upstream Side 1 and downstream Side 2 of the ADuM4165/ADuM4166 isolators (Pin 1 through Pin 10 for Side 1, and Pin 11 through Pin 20 for Side 2). 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 B connector (connecting to the ADuM4165/ADuM4166 UD+ and UD- pins), and peripherals or hub upstream facing ports can connect to the USB Type A connector (connecting to the ADuM4165/ADuM4166 DD+ and DD- pins). Low speed, full speed, or high speed devices can be connected to the EVAL-ADuM4165EBZ or the EVAL-ADuM4166EBZ, 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 ADuM4165/ADuM4166 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-ADuM4165EBZ and the EVAL-ADuM4166EBZ allow both modes of operation to be selected, as well as optionally providing 5 V from the USB upstream connector (Type B 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-ADuM4165EBZ or the EVAL-ADuM4166EBZ 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 ADuM4165/ADuM4166) 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-ADuM4165EBZ and the EVAL-ADuM4166EBZ. Power to run Side 2 of the ADuM4165/ADuM4166 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 ADuM4165/ADuM4166 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-ADuM4165EBZ and the EVAL-ADuM4166EBZ 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 ADuM4165/ADuM4166) 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}

CLOCK INPUT OPTIONS

The crystal on the board connected to ADuM4165/ADuM4166 provides a clock source for the internal circuits to retime high speed data and clean up any jitter on the input signal for an open output eye on the other side. The EVAL-ADuM4165EBZ and the EVAL-ADuM4166EBZ allow a clock input to be used instead of the on-board crystal to assist in prototyping. To use an external clock input with the EVAL-ADuM4165EBZ, the crystal fitted to Y1 on the printed circuit board (PCB) must be removed and a Subminiature A (SMA) straight PCB connector added at X11 instead (Y2 and X12 for EVAL-ADuM4166EBZ). The external clock source must be 24 MHz at 3.3 V levels. Refer to the [ADuM4165/ADuM4166](#) data sheet for the clock and power supply sequencing and expected PGOOD and isolator behavior.

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-

EVALUATION BOARD SCHEMATICS AND ARTWORK

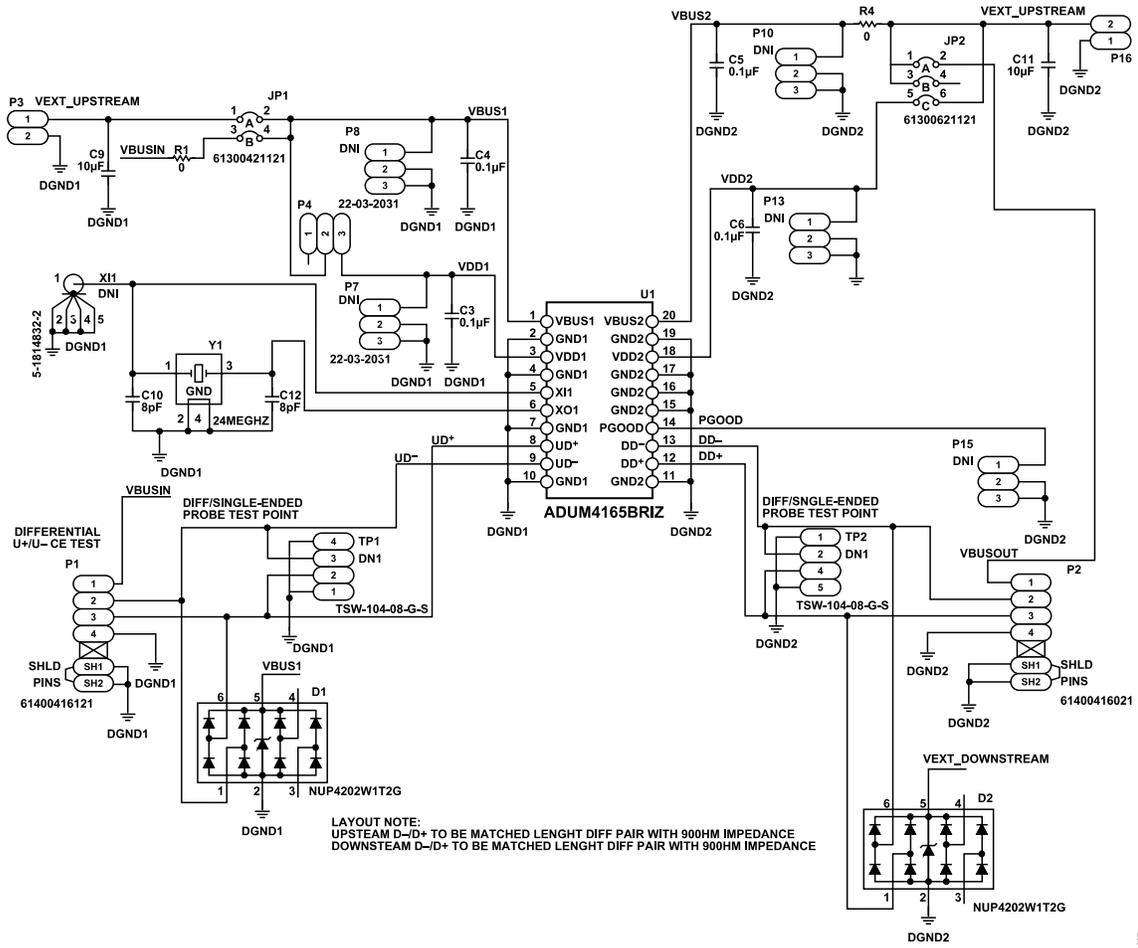


Figure 3. EVAL-ADuM4165EBZ Schematic

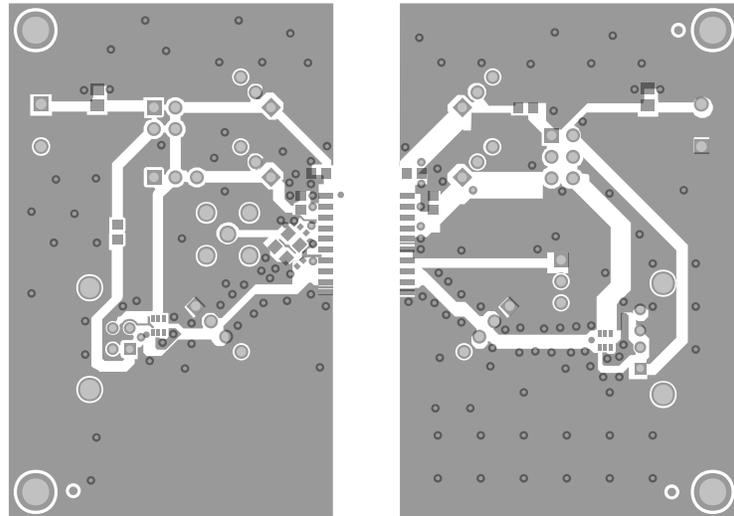


Figure 4. EVAL-ADuM4165EBZ Component Side

EVALUATION BOARD SCHEMATICS AND ARTWORK

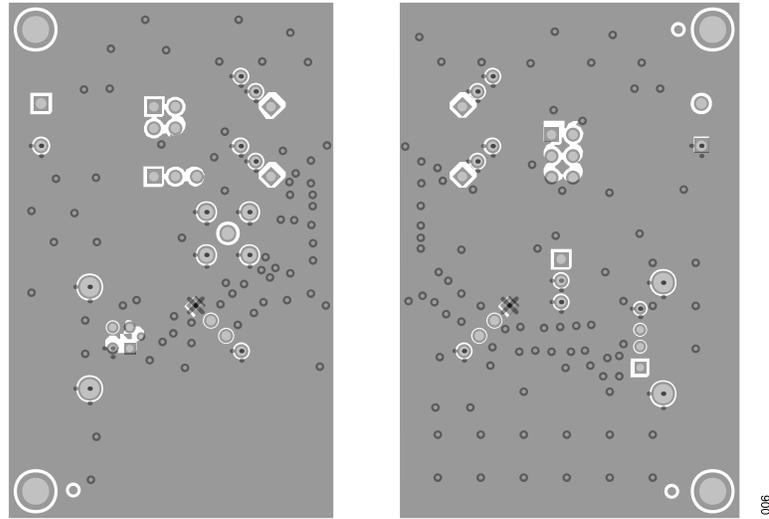


Figure 5. EVAL-ADuM4165EBZ Solder Side

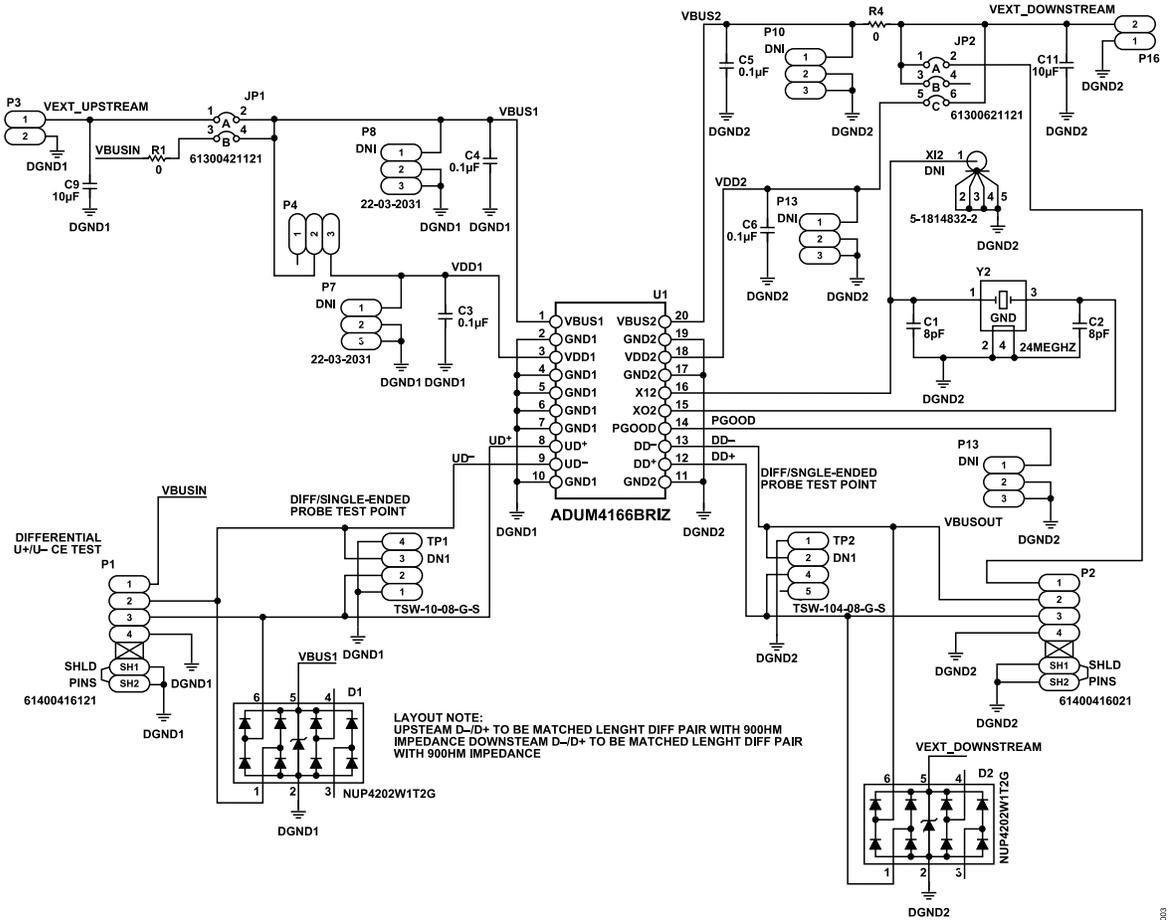


Figure 6. EVAL-ADuM4166EBZ Schematic

EVALUATION BOARD SCHEMATICS AND ARTWORK

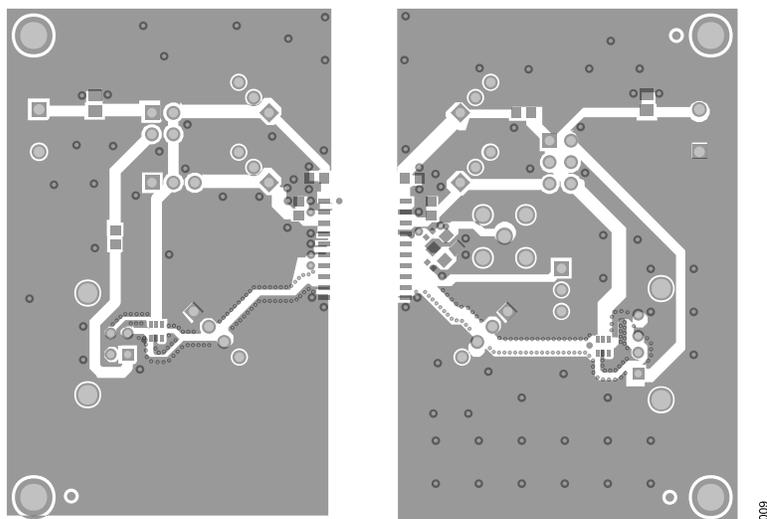


Figure 7. EVAL-ADuM4166EBZ Component Side

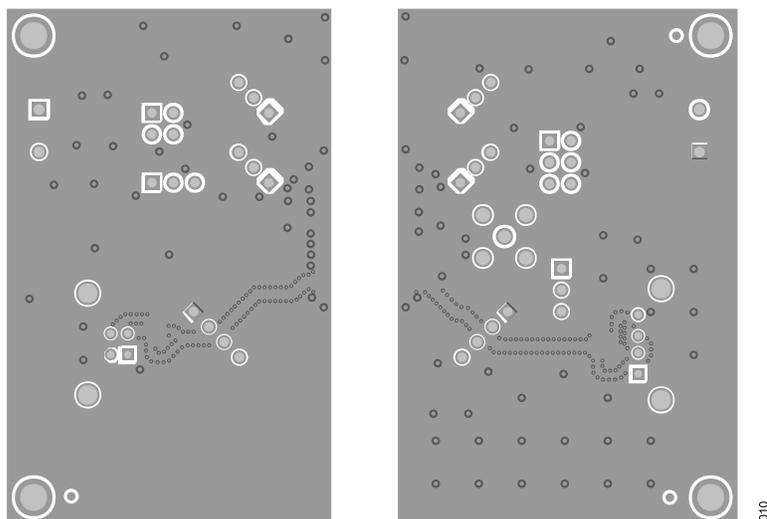


Figure 8. EVAL-ADuM4166EBZ Solder Side

ORDERING INFORMATION

BILL OF MATERIALS

Table 4. EVAL-ADuM4165EBZ Bill of Materials

Quantity	Reference Designator	Description	Manufacturer	Part Number
4	C3, C4, C5, C6	Capacitors, 0.1 μ F, 0603	Würth Elektronik	885012206046
2	C9, C11	Capacitors, 10 μ F, 0805	Würth Elektronik	885012207026
2	C10, C12	Capacitors, 8 pF, 0402	AVX Corporation	0402YA8R0DAT2A
2	D1, D2	TVS diodes, 5 V, 500 W, unidirectional	ON Semi	NUP4202W1T2G
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 B	Würth Elektronik	61400416121
1	P2	USB connector, Type A	Würth Elektronik	61400416021
2	P3, P16	connectors, 2-pin terminal block	Würth Elektronik	691213710002
1	P4	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 Ω , 0603	Panasonic	ERJ-3GEY0R00V
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	ADuM4165BRIZ
1	XI1	Connectors, SMA, 50 Ω female straight PCB	Not fitted	Not applicable
1	Y1	24 MHz \pm 50 ppm crystal, 8 pF, 50 Ω , 4-SMD	IQD Frequency Products	LFXTAL056140REEL

Table 5. EVAL-ADuM4166EBZ 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 μ F, 0603	Würth Elektronik	885012206046
2	C9, C11	Capacitors, 10 μ F, 0805	Würth Elektronik	885012207026
2	D1, D2	TVS diodes, 5 V, 500 W, unidirectional	ON Semi	NUP4202W1T2G
1	JP1	Connector, pin header, 4 way, 2 row	Würth Elektronik	61300421121
1	JP2	Connector, pin headers, 6 way, 2 row	Würth Elektronik	61300621121
1	P1	USB connector, Type B	Würth Elektronik	61400416121
1	P2	USB connector, Type A	Würth Elektronik	61400416021
2	P3, P16	Connectors, 2-pin terminal block	Würth Elektronik	691213710002
1	P4	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 Ω , 0603	Panasonic	ERJ-3GEY0R00V
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	ADuM4166BRIZ
1	XI2	Connector, SMA, 50 Ω female straight PCB	Not fitted	Not applicable
1	Y2	24 MHz \pm 50 ppm crystal, 8 pF, 50 Ω , 4-SMD	IQD Frequency Products	LFXTAL056140REEL

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.

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