

# TUSB1146-Q1 USB Type-C® Evaluation Module



## Description

The TUSB1146-Q1 USB Type-C® Alternate Mode redriving switch supports data rates up to 10Gbps for a downstream facing port (host). The TUSB1146Q1-EVM uses the TPS65987 PD controller for CC pin control and to configure the device in pin-strap mode.

## Get Started

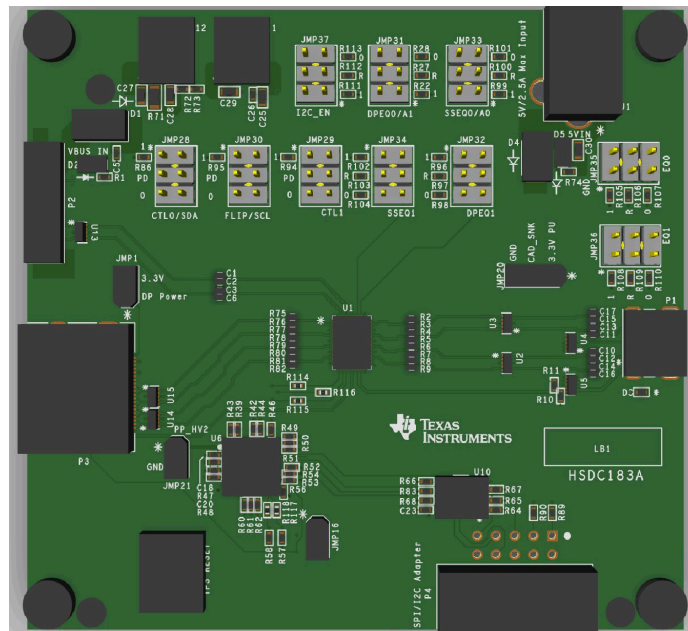
1. Order the EVM
2. Configure the board headers to fit your application.
3. Use the EVM and associated design files to evaluate the TUSB1146-Q1.
4. For issues, reach out to us directly on the TI E2E forum.

## Features

- USB Type-C® crosspoint switch supporting
  - USB 3.1 Gen 2+ 2 DP 1.4 lanes
  - 4 DP 1.4 lanes
- USB 3.1 Gen 2 up to 10Gbps
- DisplayPort™ 1.4 up to 8.1Gbps
- VESA® DisplayPort™ alt mode DFP redriving crosspoint switch supporting pin assignments C, D, and E
- Choice between adaptive or fixed equalization for USB DFP receivers
- Configuration through GPIO or I<sup>2</sup>C

## Applications

- [PC and notebooks](#)
- [TV](#)
- [Gaming](#)
- [Home theater and entertainment](#)
- [Smart phones](#)
- [Tablets](#)
- [Automotive infotainment](#)



# 1 Evaluation Module Overview

## 1.1 Introduction

The TUSB1146-Q1 device is a USB Type-C/VESA DisplayPort, alternate mode, redriving switch which supports data rates up to 10Gbps for a downstream facing port (host).

This EVM user's guide describes how to bring up the EVM, and includes schematics that can be used as a reference design for alternate mode implementations of the system with the TUSB1146-Q1 device.

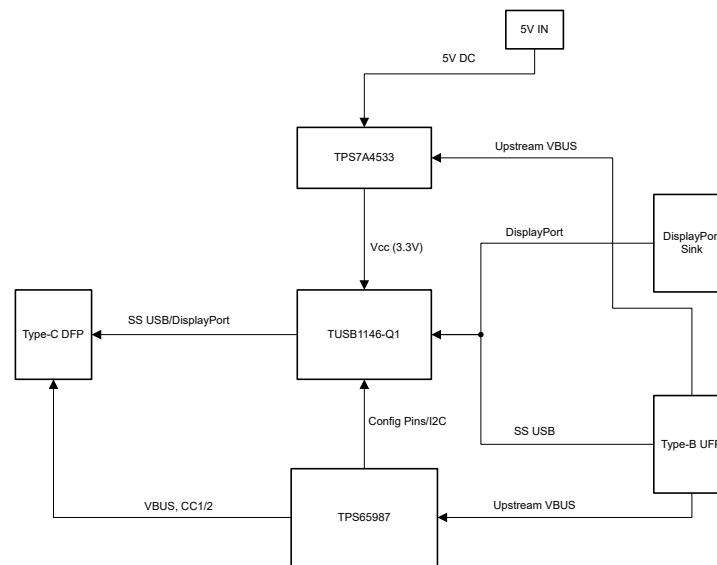
## 1.2 Kit Contents

The TUSB1146Q1-EVM includes:

- The TUSB1146-Q1 device
- (1) USB-B receptacle that connects to a USB host
- (1) DisplayPort receptacle that connects to a DisplayPort-capable source
- (1) Standard 5V barrel jack receptacle
- Headers for configuring various TUSB1146-Q1 features

## 1.3 Specification

Figure 1-1 shows the power and data path of the TUSB1146Q1-EVM.



**Figure 1-1. Block Diagram**

## 1.4 Device Information

The TUSB1146-Q1 is a VESA USB Type-C alt mode redriving switch supporting USB 3.1 data rates up to 10Gbps and DisplayPort 1.4 up to 8.1Gbps for a downstream facing port (source). The device is used for D\_DFP pin assignments C, D, and E from the VESA DisplayPort alt mode on USB Type-C standard.

## 2 Hardware

### 2.1 Setup

[Table 2-1](#) lists the headers provided for the configuration of the TUSB1146-Q1 by default. The configuration settings must be optimized depending on the amount of loss of each channel in the system. The EVM is configured to GPIO mode by default. If I<sup>2</sup>C configuration is desired, then the JMP37 (I2C\_EN) shunt must be changed.

**Table 2-1. TUSB1146-Q1 EVM Configuration Pins**

Designator	Jumper Control	Default Configuration
JMP1	DP Power	No Shunt
JMP37	I2C_EN	Shunt on pin 5 - 6 (0)
JMP35	EQ0	Shunt on pin 3 - 4 (R)
JMP36	EQ1	Shunt on pin 3 - 4 (R)
JMP33	SSEQ0	Shunt on pin 3 - 4 (R)
JMP34	SSEQ1	Shunt on pin 3 - 4 (R)
JMP31	DPEQ0	Shunt on pin 3 - 4 (R)
JMP32	DPEQ1	Shunt on pin 3 - 4 (R)
JMP16	HPDIN	No Shunt
JMP20	CAD_SNK	No Shunt
JMP28	CTL0	Shunt on pin 3 - 4 (PD)
JMP29	CTL1	Shunt on pin 3 - 4 (PD)
JMP30	FLIP	Shunt on pin 3 - 4 (PD)

#### 2.1.1 Power

The TUSB1146-Q1 EVM is designed to draw power from the upstream USB connection. If DisplayPort-only operation is desired, a 5V power source must be attached to J1.

### 2.2 TUSB1146-Q1 Equalization Control

Equalization (EQ) can be controlled using I<sup>2</sup>C or pin-strapping. Each of the TUSB1146-Q1 receiver lanes has individual controls for receiver equalization (see [Table 2-2](#)). For a list of the gain values of each available combination of downstream, upstream, and DisplayPort configurations, refer to the [TUSB1146-Q1 data sheet](#).

**Table 2-2. Configuration Pin-Level Definitions**

Level	Settings
0	Option 1: Tie 1kΩ 5% to GND
	Option 2: Tie directly to GND
R	Tie 20kΩ 5% to GND
F	Float (leave pin open)
1	Option 1: Tie 1kΩ 5% to VCC
	Option 2: Tie directly to VCC

## 3 Software

### 3.1 Firmware Description

The TUSB1146-Q1 EVM uses the TPS65987 power delivery (PD) controller to manage the Type-C VBUS, handle configuration channel negotiation, and to set the CTL0/CTL1/FLIP pins on the TUSB1146-Q1. The TPS65987 can be configured by loading firmware through the SPI programming header located on the side of the EVM. This evaluation module comes with pre-loaded firmware, but if a certain behavior is desired, custom firmware can be loaded to the PD controller as well. For details on creating a custom firmware file, see the [TPS6598X-CONFIG page](#) on TI.com.



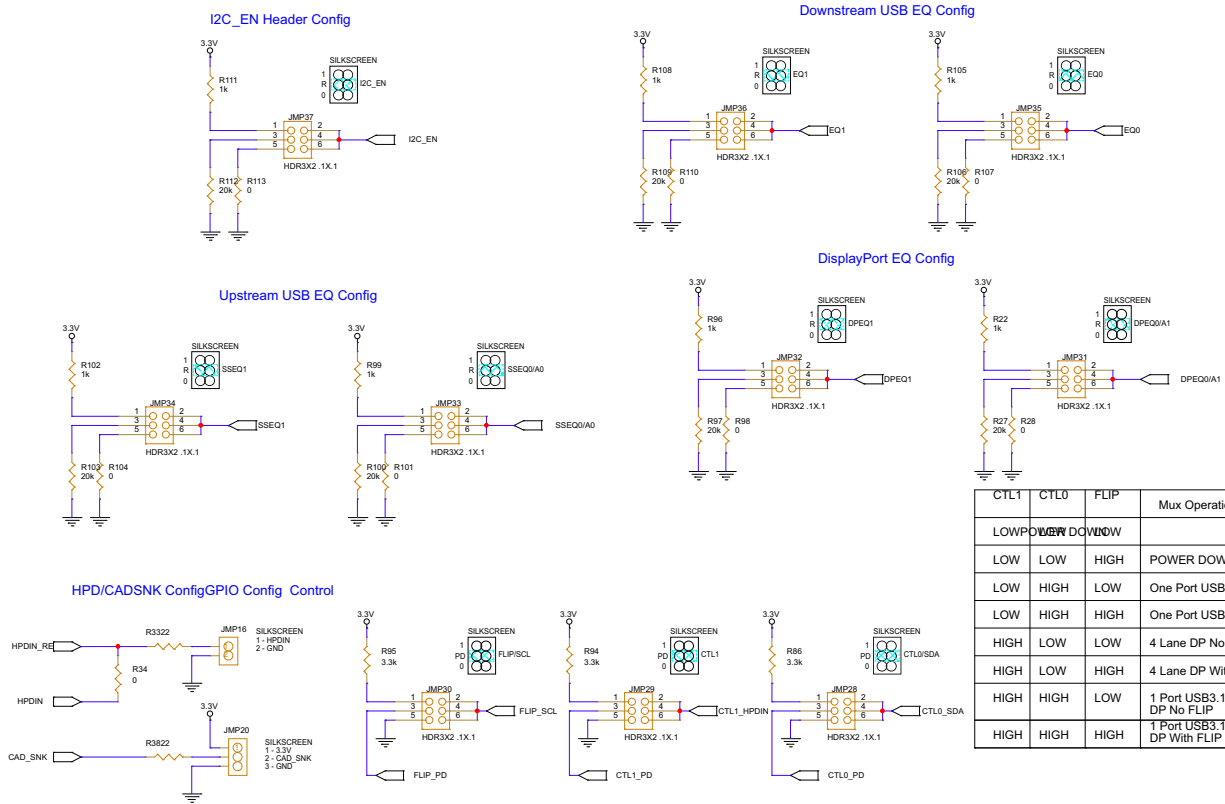


Figure 4-2. TUSB1146-Q1 EVM Schematic (Page 2)

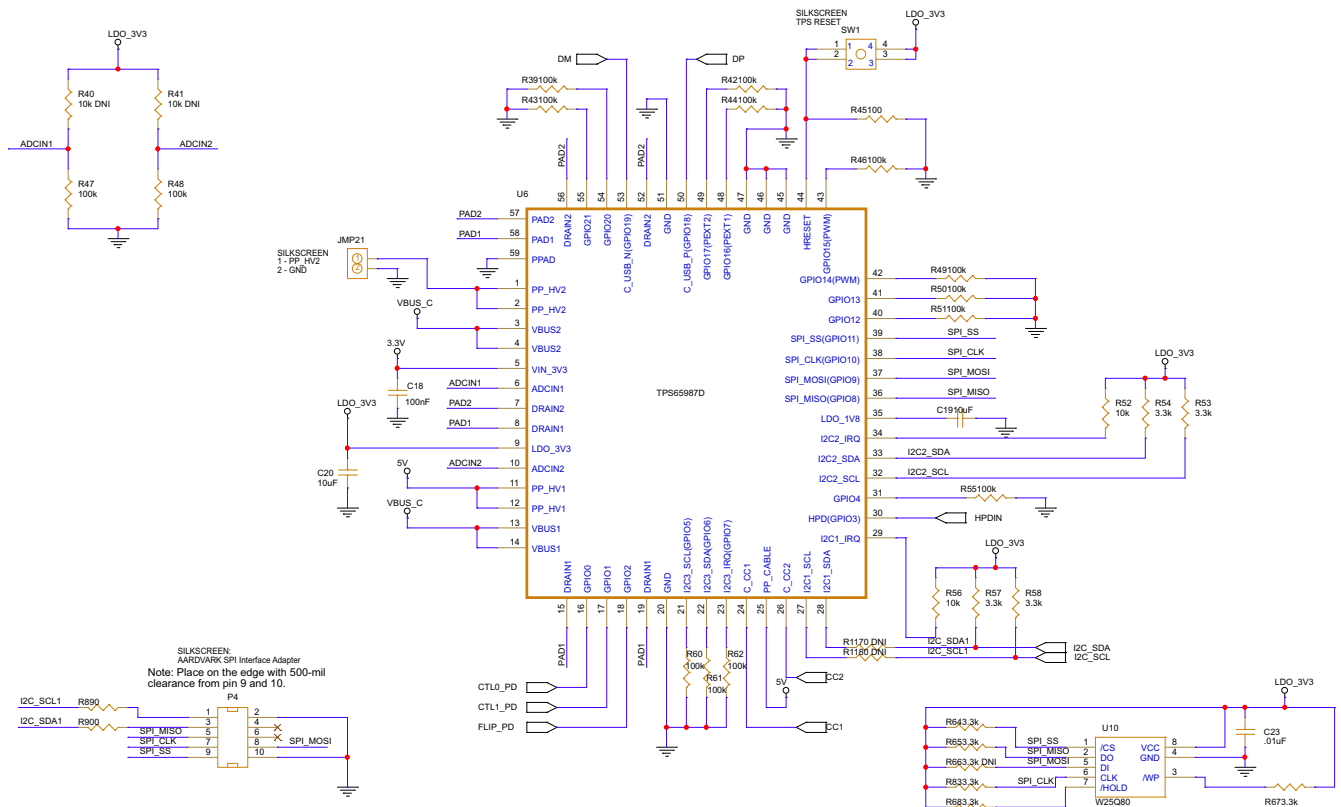
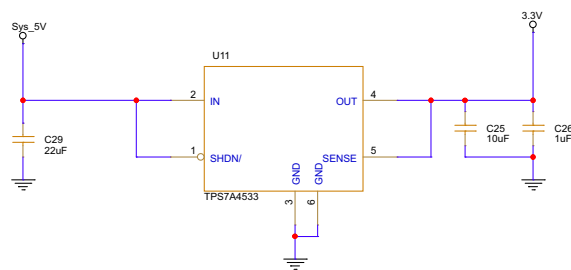
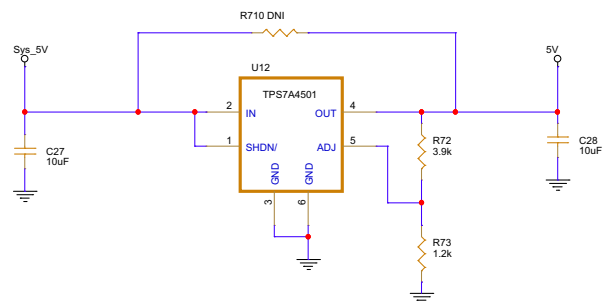


Figure 4-3. TUSB1146-Q1 EVM Schematic (Page 3)

### 3.3V REGULATOR



### 5V REGULATOR



### External 5V IN

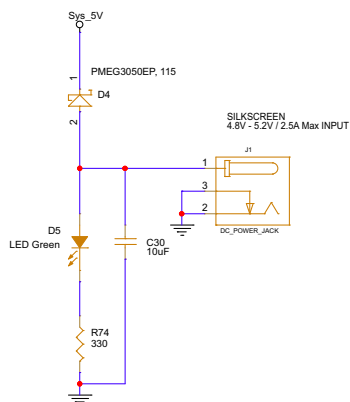
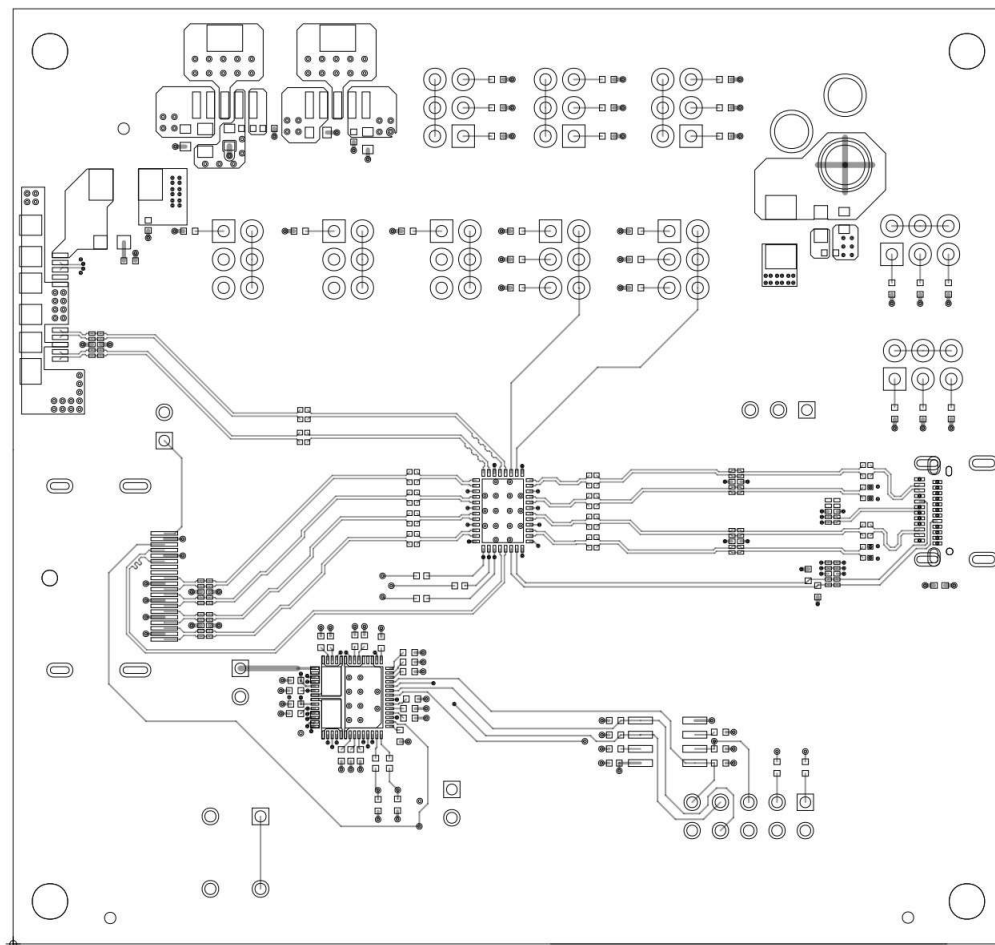


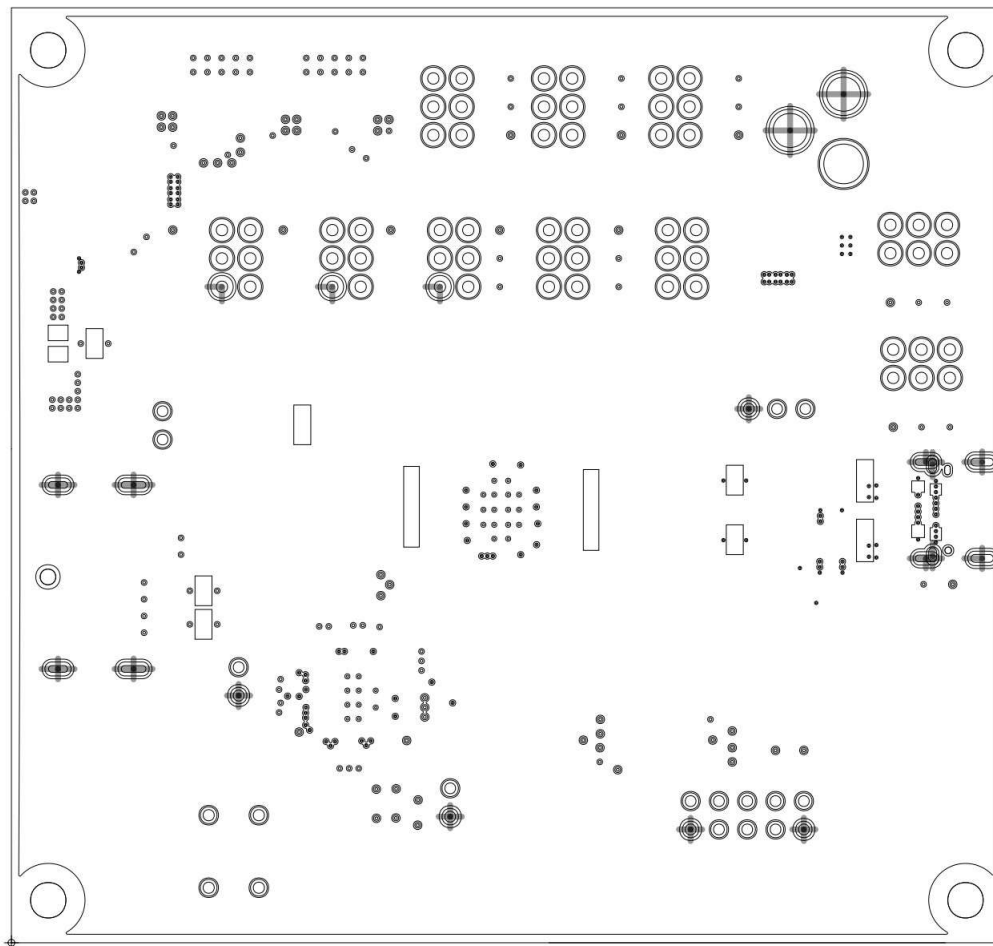
Figure 4-4. TUSB1146-Q1 EVM Schematic (Page 4)

## 4.2 PCB Layouts

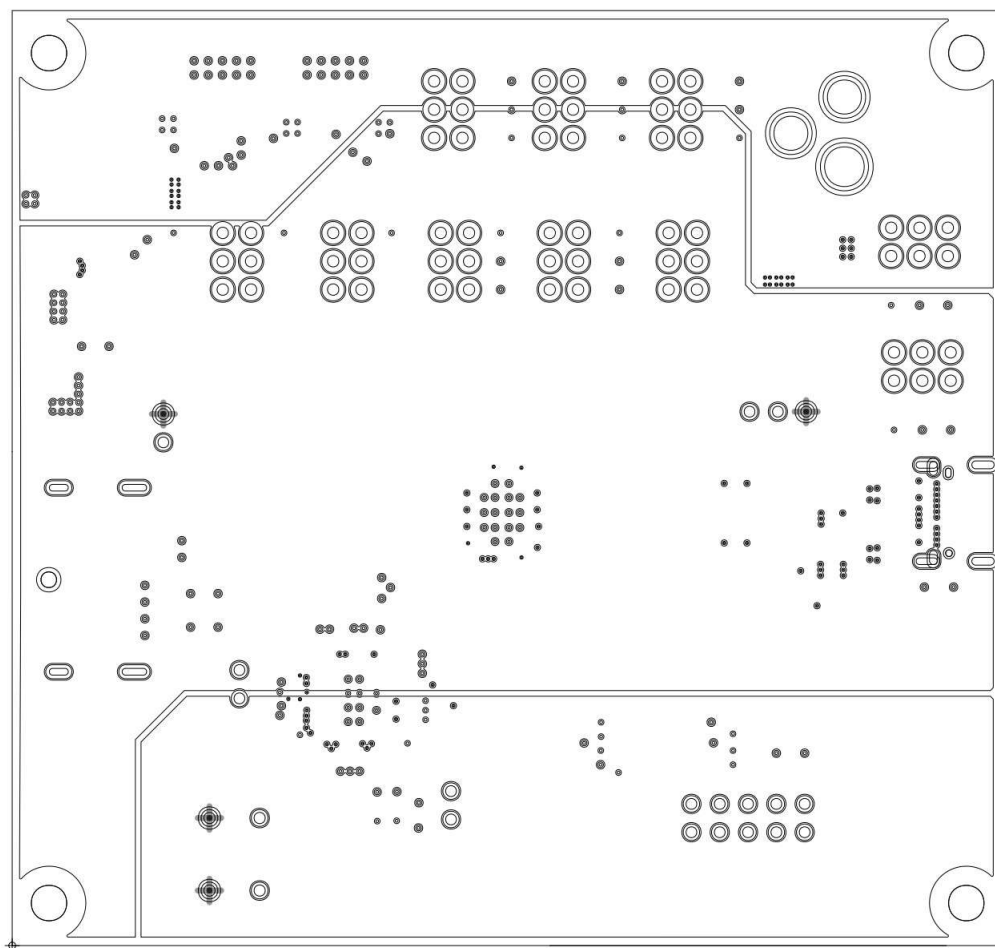


**Figure 4-5. TUSB1146-Q1 EVM PCB Layer 1 (Top)**

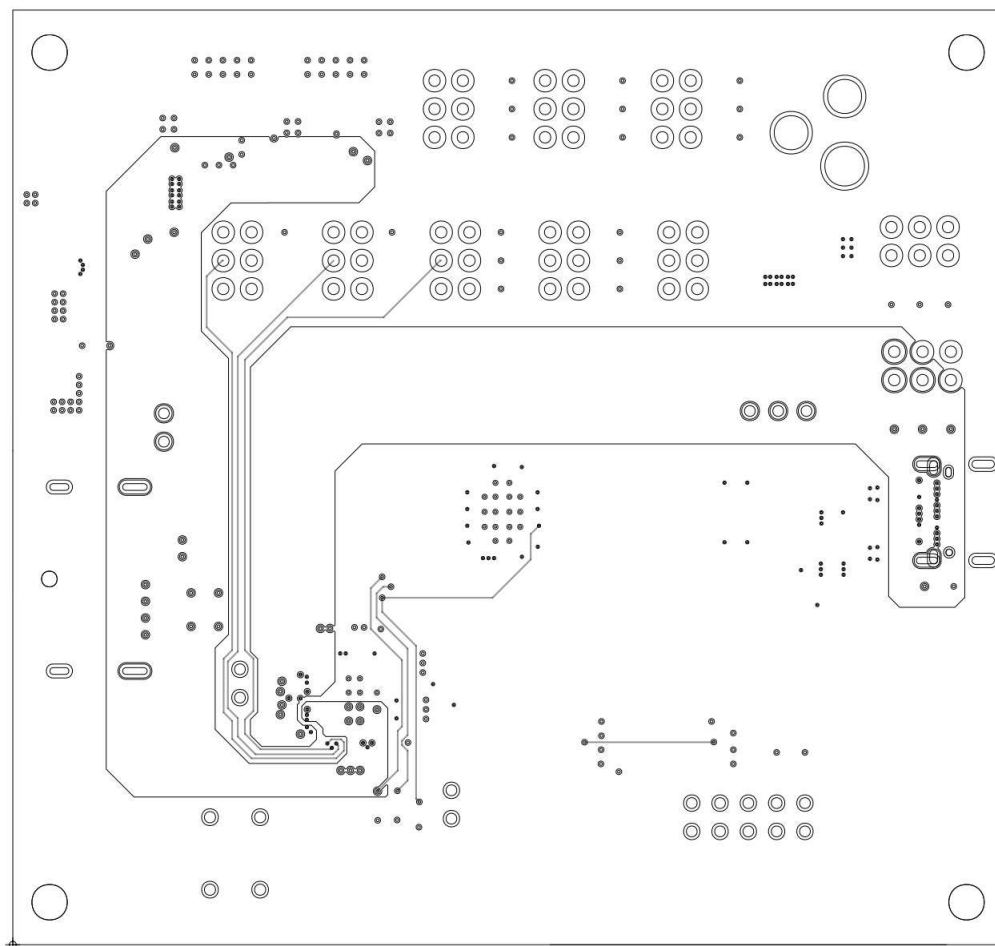




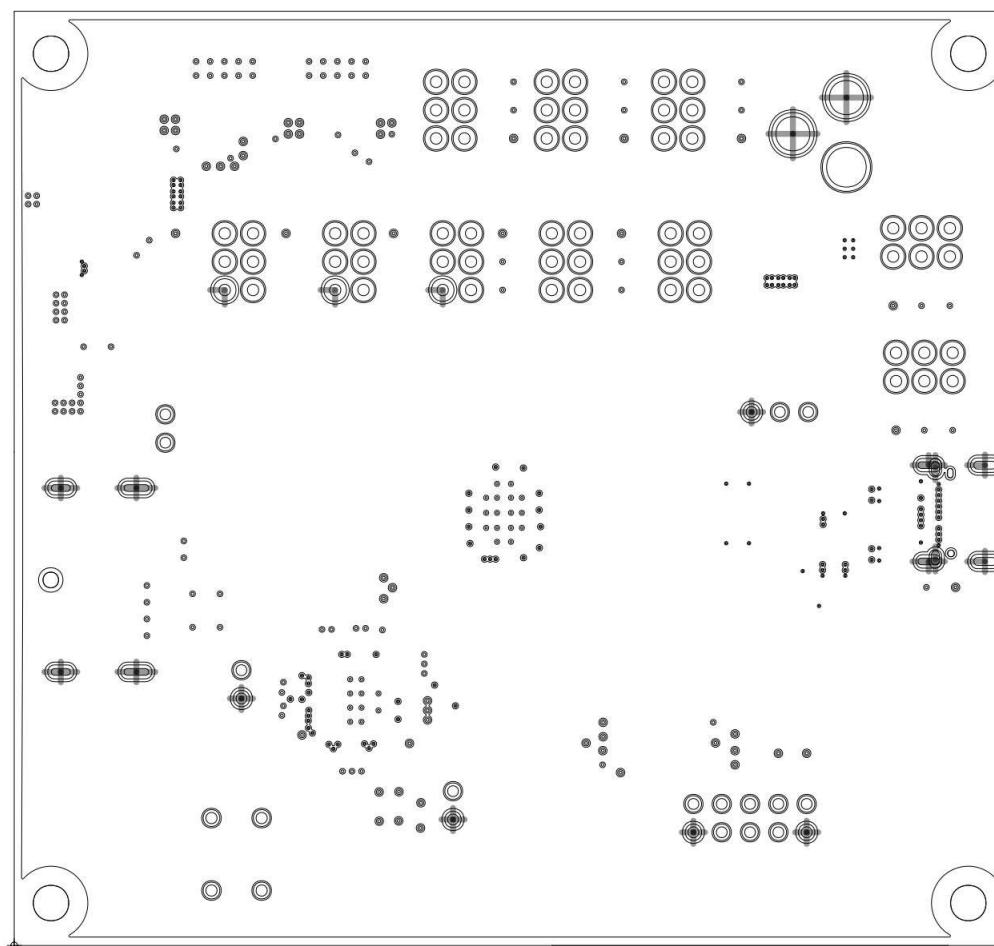
**Figure 4-6. TUSB1146-Q1 EVM PCB Layer 2 (GND)**



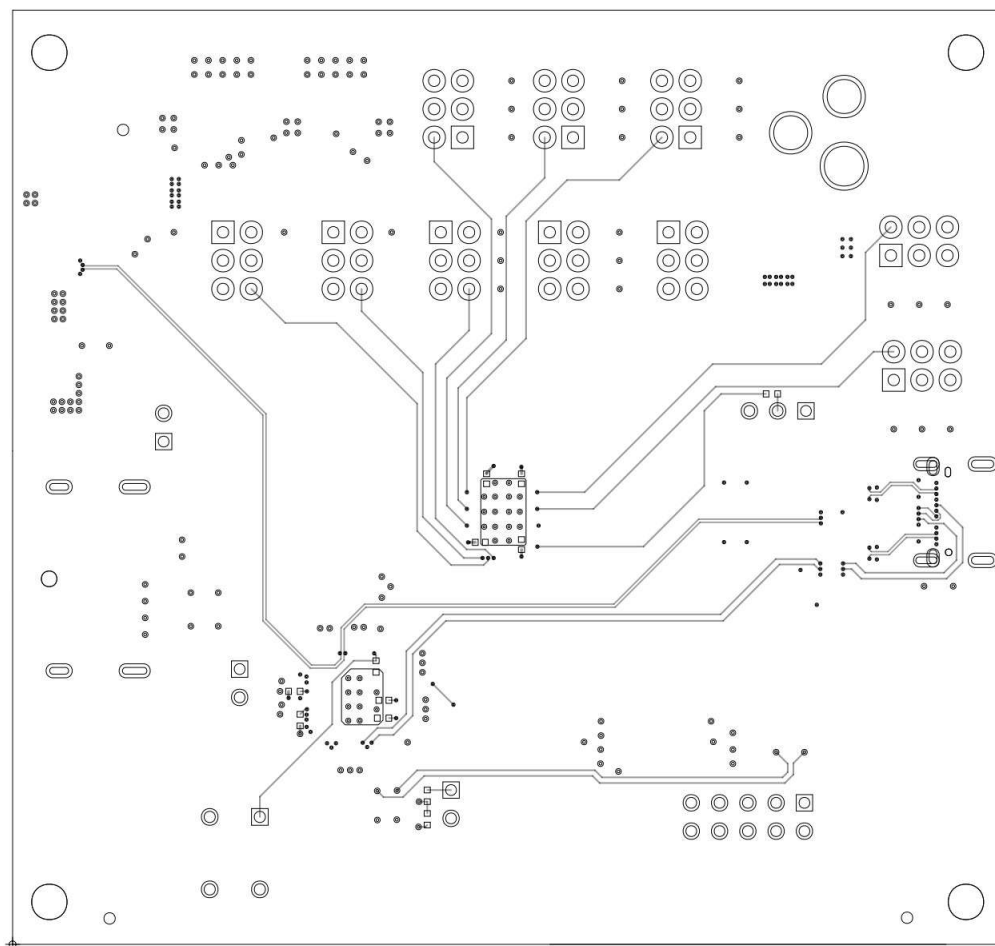
**Figure 4-7. TUSB1146-Q1 EVM PCB Layer 3 (Power)**



**Figure 4-8. TUSB1146-Q1 EVM PCB Layer 4 (Signal)**



**Figure 4-9. TUSB1146-Q1 EVM PCB Layer 5 (GND)**



**Figure 4-10. TUSB1146-Q1 EVM PCB Layer 6 (Bottom)**

## 4.3 Bill of Materials (BOM)

**Table 4-1. Bill of Materials**

Quantity	Designator	Part	Manufacturer	Part Number
6	C1,C2,C10,C11,C12,C13	220nF	Murata	GRM033R60J224ME15D
6	C3,C6,C14,C15,C16,C17	330nF	Murata	GRM033R60J334ME90D
5	C4,C7,C8,C9,C18	100nF	Murata	GRM155R71E104KE14D
3	C5,C19,C20	10uF	Murata	GRM155R60G106ME44D
1	C23	.01uF	Murata	GRM155R71H103KA88D
4	C25,C27,C28,C30	10uF	Murata	GRM188R61C106MA73D
1	C26	1uF	Murata	GRM155C81A105KA12D
1	C29	22uF	Murata	GRM188R61A226ME15D
2	D1,D4	SCHOTTKY	NXP	PMEG3050EP,115
2	D2,D5	LED Green	LITE-ON TECHNOLOGY CORPORATION	LTST-C170KGKT
1	D3	TPD1E10B06	Texas Instruments	TPD1E10B06DPYR
3	JMP1,JMP16,JMP21	Header 2x1	FCI	68001-402HLF
1	JMP20	Header 3x1	3M	961103-6404-AR
10	JMP28,JMP29,JMP30,JMP31,JMP32,JMP33,JMP34,JMP35,JMP36,JMP37	HDR3X2 .1X.1	Harwin	M20-9980345
1	J1	DC_PWR_JACK	CUI Inc.	PJ-202AH
1	LB1	THD-47-478-10	Brady	THT-14-423-10
1	PCB1	HSDC069	Any	HSDC069
1	P1	JAE DX07S024JJ2	Jae	DX07S024JJ2R1300
1	P2	USB3_Micro_B	Amphenol	GSB343133HR
1	P3	DP SINK-SIDE CONNECTOR	Molex Inc	0472720001
1	P4	Header 5x2 0.1" Shroud RA thru-hole	3M	D2510-5002-AR
2	R1,R74	330	Panasonic Electronic Components	ERJ-2GEJ331X
16	R2,R3,R4,R5,R6,R7,R8,R9,R75,R76,R77,R78,R79,R80,R81,R82	1	Panasonic Electronic Components	ERJ-1GNJ1R0C
2	R10,R11	2M	Panasonic Electronic Components	ERJ-2GEJ205X

**Table 4-1. Bill of Materials (continued)**

Quantity	Designator	Part	Manufacturer	Part Number
7	R22,R96,R99,R102,R105,R108,R111	1k	Panasonic Electronic Components	ERJ-2GEJ102X
7	R27,R97,R100,R103,R106,R109,R112	20k	Panasonic Electronic Components	ERJ-2GEJ203X
10	R28,R34,R89,R90,R98,R101,R104,R107,R110,R113	0	Panasonic Electronic Components	ERJ-2GE0R00X
2	R33,R38	22	Panasonic Electronic Components	ERA-2AKD220X
14	R39,R42,R43,R44,R46,R47,R48,R49,R50,R51,R55,R60,R61,R62	100k	Panasonic Electronic Components	ERJ-2GEJ104X
2	R40,R41	10k DNI	Panasonic Electronic Components	ERJ-2GEJ103X
1	R45	100	Panasonic Electronic Components	ERA-2AED101X
2	R52,R56	10k	Panasonic Electronic Components	ERJ-2GEJ103X
12	R53,R54,R57,R58,R64,R65,R67,R68,R83,R86,R94,R95	3.3k	Panasonic Electronic Components	ERJ-2GEJ332X
1	R66	3.3k DNI	Panasonic Electronic Components	ERJ-2GEJ332X
6	R71,R87,R88,R91,R92,R93	0 DNI	Panasonic Electronic Components	ERJ-6GEY0R00V
1	R72	3.9k	Panasonic Electronic Components	ERJ-2GEJ392X
1	R73	1.2k	Panasonic Electronic Components	ERJ-2GEJ122X
4	SCRW1,SCRW2,SCRW3,SCRW4	NY PMS 440 005 PH	B & F Fastener	NY PMS 440 0050 PH
9	SHNT1,SHNT2,SHNT3,SHNT4,SHNT5,SHNT6,SHNT7,SHNT8,SHNT9	QPC02SXGN-RC	Sullins Connector Solutions	QPC02SXGN-RC
4	STDOFF1,STDOFF2,STDOFF3,STDOFF4	1902E	Keystone	1902E
1	SW1	B3F-1020	Omron Electronics	B3F-1020
1	U1	TUSB1146-Q1	Texas Instruments	TUSB1146-Q1
7	U2,U3,U4,U5,U13,U14,U15	PUSB3FR4	Nexperia	PUSB3FR4Z
1	U6	TPS65987D	Texas Instruments	TPS65987DDHRSHR
1	U10	W25Q80	WINBOND	W25Q80DVSNIQ
1	U11	TPS7A4533	Texas Instruments	TPS7A4533DCQR
1	U12	TPS7A4501	Texas Instruments	TPS7A4501DCQR

## 5 Additional Information

### 5.1 Trademarks

DisplayPort™ is a trademark of VESA.

USB Type-C® is a registered trademark of USB Implementers Forum.

VESA® is a registered trademark of Video Electronics Standards Association.

All trademarks are the property of their respective owners.

## 6 Related Documentation

For related documentation, see the following:

- Texas Instruments, [TUSB1146-Q1 USB Type-C® DisplayPort™ Alt Mode Source 8.1Gbps Linear Redriver Crosspoint Switch data sheet](#)



## STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
  - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
  - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
  - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
  - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
  - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

### **WARNING**

**Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.**

**User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.**

**NOTE:**

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

### 3 Regulatory Notices:

#### 3.1 United States

##### 3.1.1 Notice applicable to EVMs not FCC-Approved:

**FCC NOTICE:** This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

##### 3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

#### **CAUTION**

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

#### **FCC Interference Statement for Class A EVM devices**

*NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

#### **FCC Interference Statement for Class B EVM devices**

*NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

#### 3.2 Canada

##### 3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

#### **Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

#### **Concernant les EVMs avec appareils radio:**

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

#### **Concerning EVMs Including Detachable Antennas:**

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

### Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

#### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/sds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号  
西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see [http://www.tij.co.jp/sds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_02.page)

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

#### 3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

#### 4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

##### 4.3 *Safety-Related Warnings and Restrictions:*

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