*EVM User's Guide: TMUXHS4612-EVM*

# *TMUXHS4612 6-Channel 20Gbps Differential 2:1 Mux / 1:2 Demux Evaluation Module*

## Description

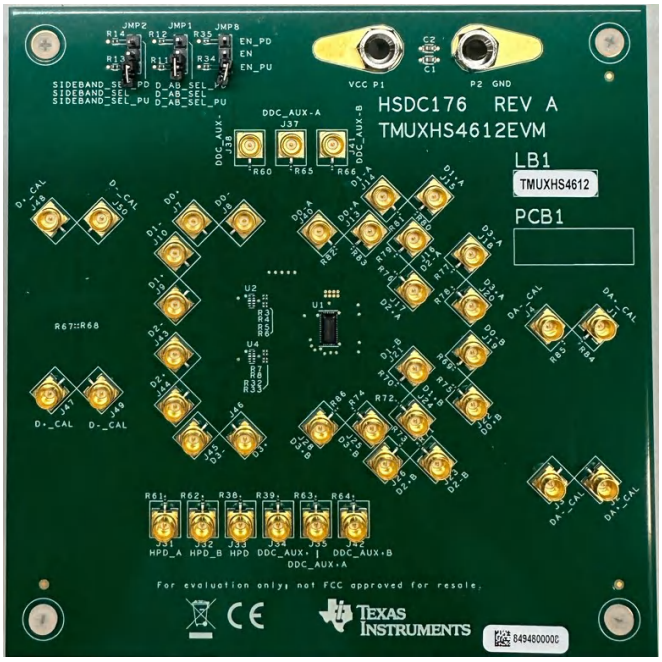
The TMUXHS4612 EVM features the HDMI™ 2.1 and DP 2.1 capable TMUXHS4612. This high speed video mux is capable of 20Gbps per lane and supports a common mode range from GND to VCC. This EVM implements this high speed MUX with SMP connectors for excellent signal integrity and calibration traces for de-embedding applications in compliance testing.

## Features

- TMUXHS4612: High-speed path supports wide common mode voltage range (0V to VCC)
- Supports HDMI 1.4b/2.0/2.1 up to 12Gbps, DisplayPort™ 1.4/2.1 up to UHBR20
- Low RON of 6Ω typical for high-speed data pins
- –3dB differential BW of 14GHz for high-speed data pins
- Excellent dynamic characteristics at 10GHz (20Gbps) – Insertion loss: -2.3 dB – Return loss: –15 dB – Cross talk: -35dB
- TMUXHS4612: All sideband signals can pass-thru up to 5V levels and are 5.5V tolerant
- TMUXHS4612: Support 1.8V or 3.3V control logic
- TMUXHS4612: Single supply voltage of 3.3V
- Low active (350µA) and standby power (0.1µA)
- IOFF protection that prevents current leakage when supply rail collapsed (VCC = 0V)
- -40℃ to 105℃ temperature range
- 40-pin, 3 x 6mm, 0.4mm pitch WQFN package

## Applications

- PC and notebooks
- Gaming, home theater and entertainment, and TV
- Data center and enterprise computing
- Medical and healthcare
- Test and measurement
- Factory automation and control
- Aerospace and defense
- Electronic point of sale (EPOS)
- Wireless infrastructure



# 1 Evaluation Module Overview

## 1.1 Introduction

This user's guide describes the characteristics, operation, performance, and use of the Texas Instruments' TMUXHS4612 evaluation module (EVM). The TMUXHS4612-EVM is designed to help users easily set up and configure the EVM to test the functionality and signal integrity of the TMUXHS4612 device. This user's guide includes setup instructions for the hardware, design schematics, printed-circuit board layouts, and the bill of materials.

## 1.2 Kit Contents

- TMUXHS4612 device
- SMP connectors for channel A, channel B, and common channel main links and sidebands
- Headers for configuring TMUXHS4612
- Banana receptacles for 3.3V and GND

## 1.3 Specification

The TMUXHS4612 is a 4 channel 1:2 or 2:1 bidirectional multiplexer/demultiplexer. The TMUXHS4612 operates from a 3.0V to 3.6V supply, The device provides switching on differential channels between Port A or Port B to common port. See Figure 1-1.

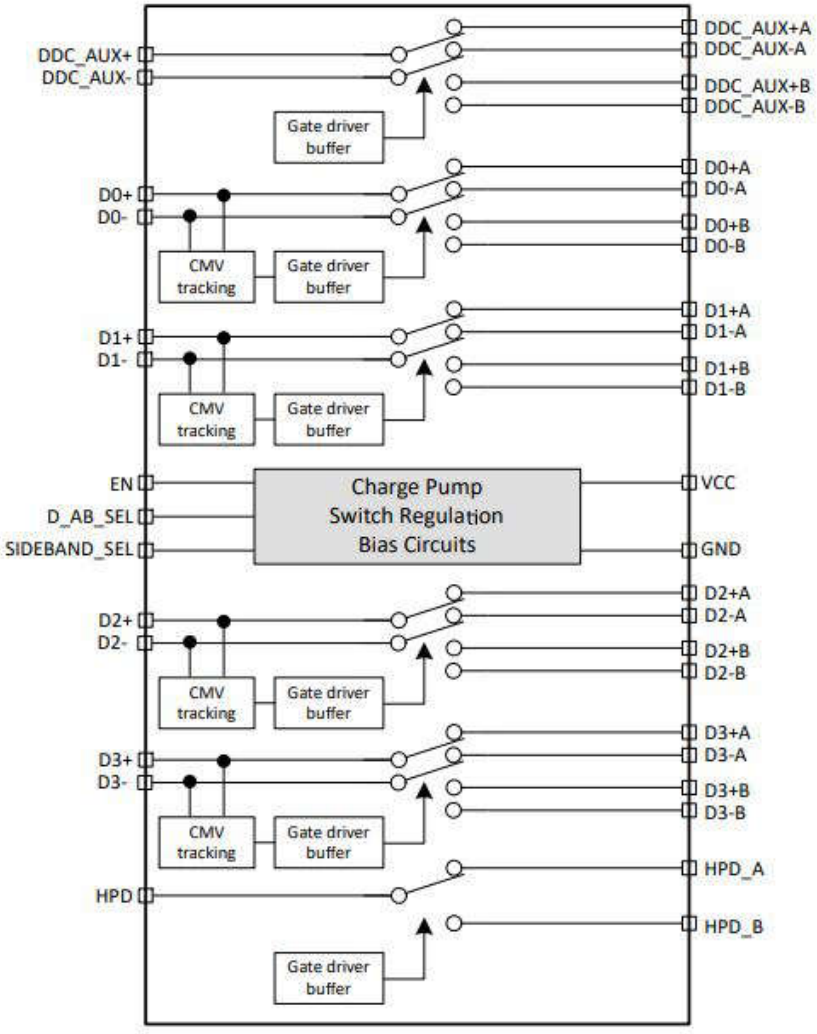



**Figure 1-1. TMUXHS4612 Functional Block Diagram**

## 1.4 Device Information

The TMUXHS4612 is a high-speed bidirectional passive switch in mux or demux configurations. The device is an excellent choice for many applications including HDMI 1.4 / 2.0 / 2.1 and DisplayPort 1.4 / 2.1. The TMUXHS4612 is a generic analog differential passive mux or demux that works for many high-speed differential interfaces with data rates up to 20Gbps. The TMUXHS4612 supports both differential signaling in the Dxx data paths and 5V tolerant single ended signals for sideband datapaths. The dynamic characteristics of the TMUXHS4612 allows high-speed switching with minimal attenuation to the signal eye diagram, and with very little added jitter. The silicon design of the device is optimized for excellent frequency response at higher frequency spectrum of the signals. The device supports differential signaling with common mode voltage range (CMV) of 0 to 3.6V in the Dxx data paths. The TMUXHS4612 consumes very low active power of 350µA. The device also offers a power-down mode, in which all channels become Hi-Z and the device operates with minimal power of just 0.1µA.

# 2 Hardware

## 2.1 Setup and Configuration

### 2.1.1 Power

The TMUXHS4612-EVM is designed to operate from an external 3.3V power supply using standard banana jack plug cables. Terminal P1 must be connected to the supply positive output and P2 to ground. A power supply current limit of 100mA is more than adequate to power the EVM.

### 2.1.2 Jumper Configuration

The TMUXHS4612-EVM is controlled by an active-high enable signal and port select signals. (EN) is used to enable or disable the switch. Jumper (D_AB_SEL) and (SIDEBAND_SEL) control the port selection: Port D to Port DB, or Port D to Port DA. Both jumpers and the operational positions are labeled with silkscreens on the EVM for ease of use.

| EN | SEL1 | SEL2 | FUNCTION |
|---|---|---|---|
| L | X | X | Switch disabled. All channel are Hi-Z. |
| H | L | L | All A channels are enabled. All B channels are Hi-Z. |
| H | L | H | All A data high-speed channels are enabled and B sideband channels are enabled. All other channels are Hi-Z. |
| H | H | L | All B data high-speed channels are enabled and A sideband channels are enabled. All other channels are Hi-Z. |
| H | H | H | All B channels are enabled. All A channels are Hi-Z. |

### 2.1.3 Signal Connection

The EVM provides SMP receptacles for the high-speed signal connections. Each SMP receptacle is labeled with the signal's port (D, DA, or DB), channel (A or B), and polarity (P or N). SMA to SMP cables can be required to connect to test equipment or fixtures. The signal traces are all equal length and have 50Ω single-ended impedance.

### 2.1.4 Optional Termination Resistors

Most interfaces require AC coupling between the transmitter and receiver. For example, the DisplayPort specification requires AC coupling capacitors in the range of 75 – 200nF on the TX. By default, the TMUXHS4612-EVM is populated with 0Ω resistors on the input and output which can be replaced with capacitors if needed.

### 2.1.5 Calibration Trace

The TMUXHS4612-EVM provides a pair of calibration traces to allow the EVM trace to be de-embedded from the TMUXHS4612 during measurement. The calibration traces are length matched to the combined length of the input and output traces to the TMUXHS4612-EVM. The traces are also populated with the same resistors.

## 2.2 Get Started

1. Place a jumper across pins 2 and 3 on JMP8 to enable the device.
2. Enable the channel the is being used.
   a. Place a jumper across pins 1 and 2 on JMP1 and JMP2 to enable channel A.
   b. Place a jumper across pins 2 and 3 on JMP1 and JMP2 to enable channel B.
3. Power the board using the 3.3V and GND reference banana plugs.
4. See signal pass through the mux.

# 3 Hardware Design Files

## 3.1 Schematic

Figure 3-1 shows the TMUXHS4612-EVM schematic

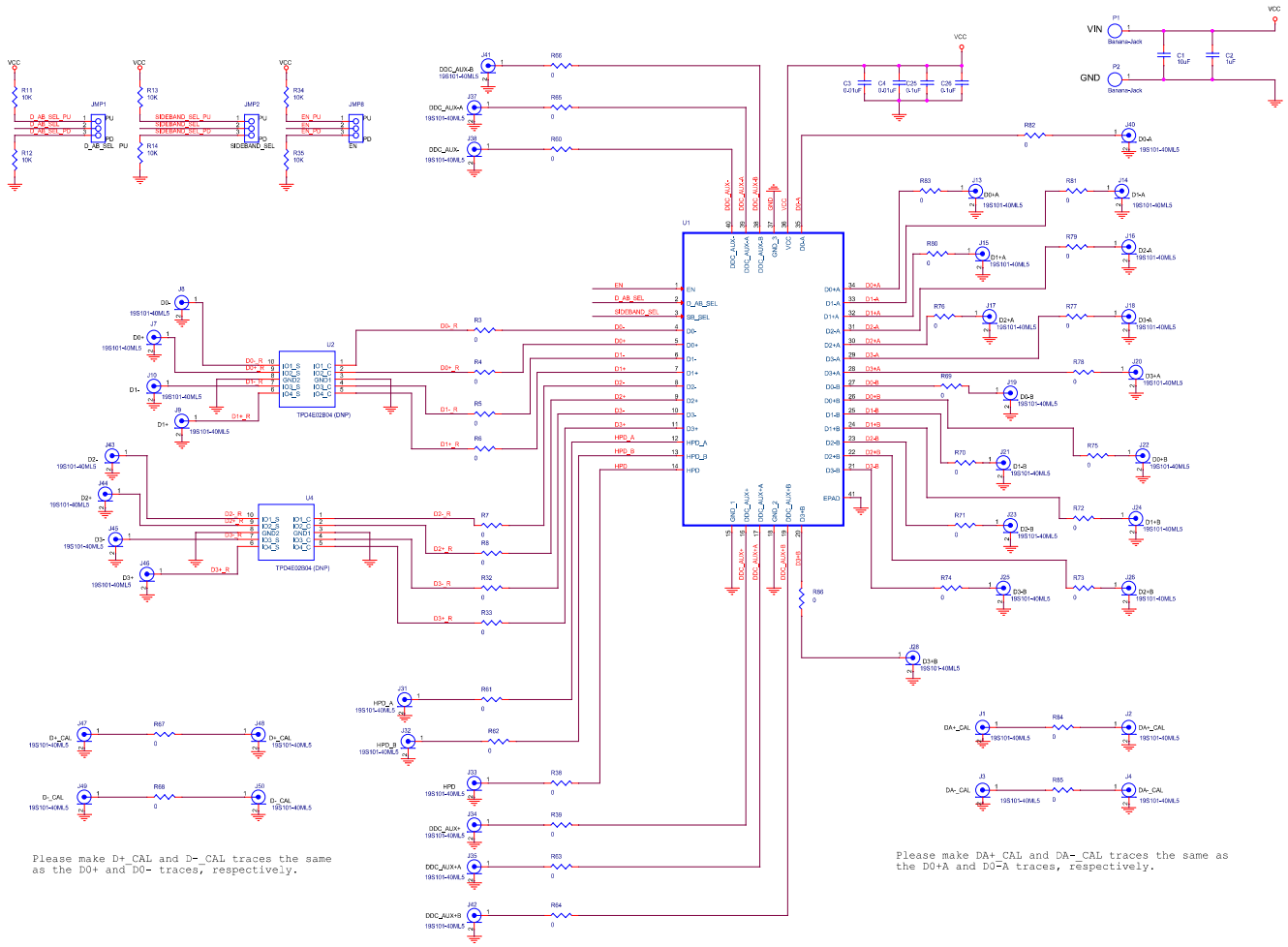



**Figure 3-1. TMUXHS4612-EVM Schematic**

## 3.2 PCB Layouts

Figure 3-2 through Figure 3-5 shows the TMUXHS4612-EVM layout.

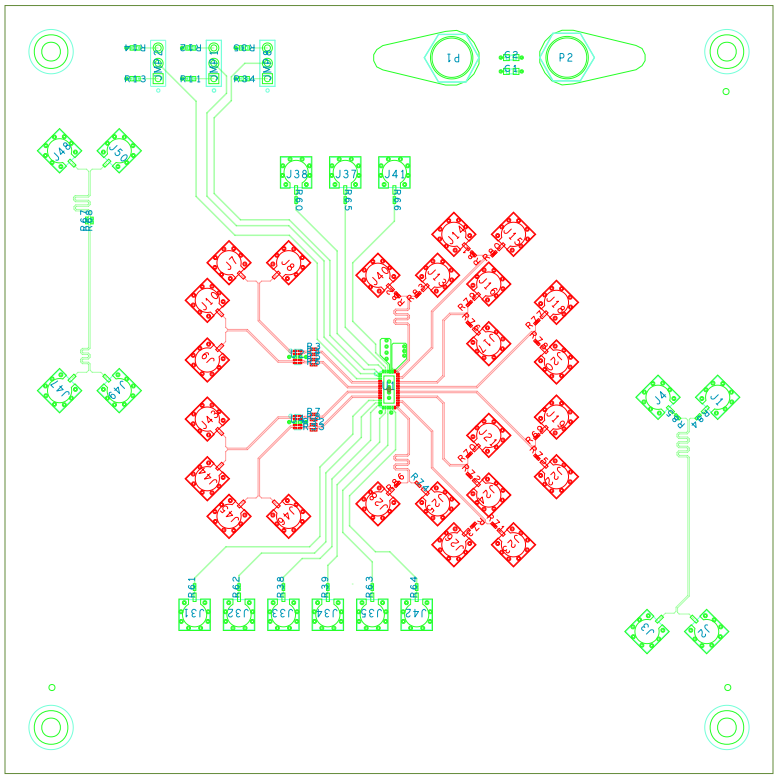


**Figure 3-2. TMUXHS4612-EVM Top Layer**

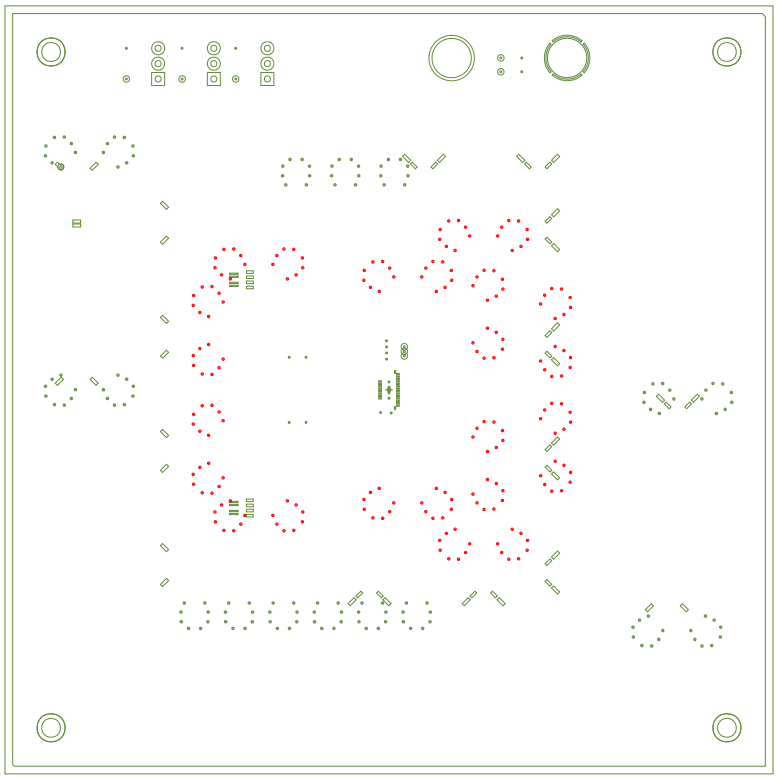


**Figure 3-3. TMUXHS4612-EVM Layer 2 [GND]**

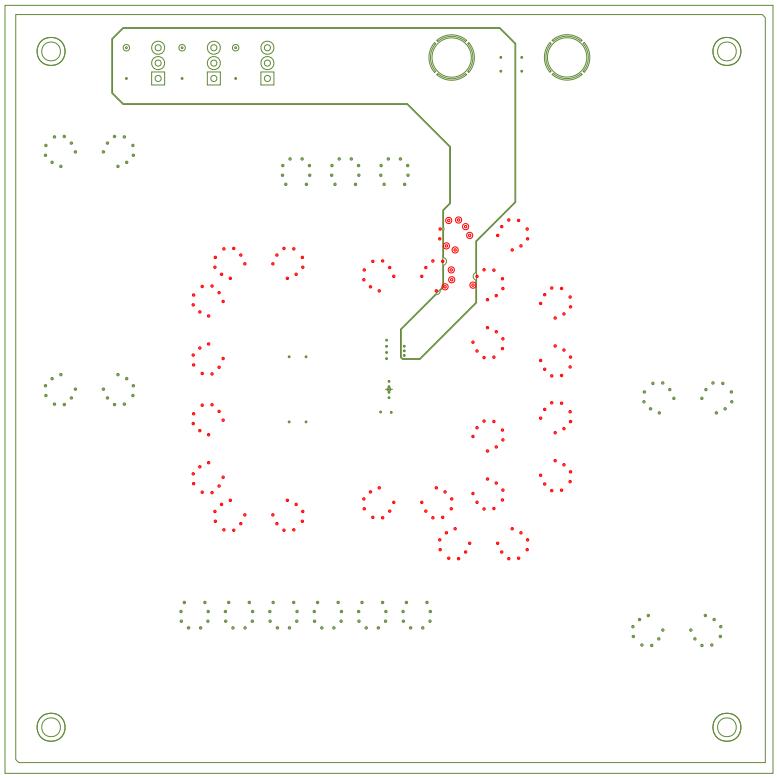


**Figure 3-4. TMUXHS4612-EVM Layer 3 [Power]**

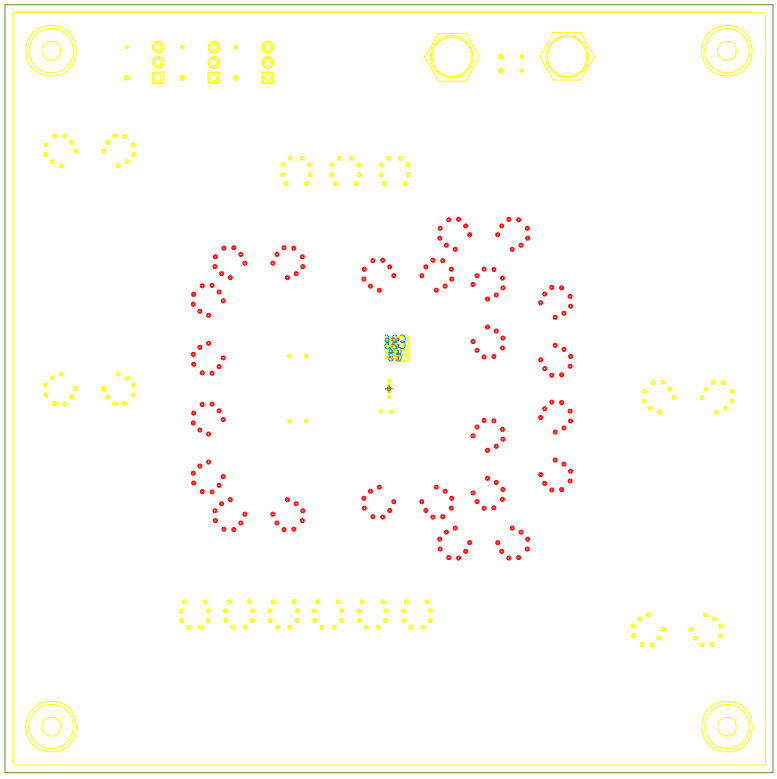


**Figure 3-5. TMUXHS4612-EVM Bottom Layer**

## 3.3 Bill of Materials

Table 3-1 shows the TMUXHS4612-EVM Bill of Materials

**Table 3-1. Bill of Materials**

| Item | Quantity | Designator | Description | Value | Manufacturer | Part Number |
|---|---|---|---|---|---|---|
| 1 | 1 | C1 | Capacitor | 10uF | Murata | GRM188R61A106KE69D |
| 2 | 1 | C2 | Capacitor | 1uF | Taiyo Yuden | LMK107B7105KA-T |
| 3 | 2 | C3, C4 | Capacitor | .01uF | KEMET | C0402C103K8RACTU |
| 4 | 2 | C25, C26 | Capacitor | .1uF | KEMET | C0402C104M8RACTU |
| 5 | 3 | JMP1, JMP2, JMP8 | Config. Jumpers | HDR3X1 M .1 | Samtec | TSW-103-07-G-S |
| 6 | 41 | J1, J2, J3, J4, J7, J8, J9, J10, J13, J14, J15, J16, J17, J18, J19, J20, J21, J22, J23, J24, J25, J26, J28, J31, J32, J33, J34, J35, J37, J38, J40, J41, J42, J43, J44, J45, J46, J47, J48, J49, J50 | Config. Jumpers | 19S101-40ML5 | ROSENBERGER | 19S101-40ML5 |
| 7 | 1 | LB1 | Label | PCB Label 0.650"H x 0.200"W | Brady | THT-14-423-10 |
| 8 | 1 | PCB1 | PCB | HSDC091 | Any | HSDC042 |
| 9 | 2 | P1,P2 | Power Interface | Banana-Jack | Pomona | 3267 |
| 10 | 37 | R3, R4, R5, R6, R7, R8, R32, R33, R38, R39, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R72, R73, R74, R75, R76, R77, R78, R79, R80, R81, R82, R83, R84, R85, R86 | Resistor | O ohm | Vishay Dale | CRCW02010000Z0EDRC0402JR-072KL |
| 11 | 6 | R11, R12, R13, R14, R34, R35 | Resistor | 10k ohms | Yageo | RC0402JR-072KL |
| 12 | 4 | SCRW1, SCRW2, SCRW3, SCRW4 | Mech. Part | NY PMS 440 005 PH | B&F Fastener | NY PMS 440 005 PH |
| 13 | 3 | SHNT1, SHNT2, SHNT3 | Mech. Part | QPC02SXGN-RC | Sullins | QPC02SXGN-RC |
| 14 | 4 | STDOFF1, STDOFF2, STDOFF3, STDOFF4 | Mech. Part | 1902E | Keystone | 1902E |
| 15 | 1 | U1 | Mux | TMUXHS4612 | Texas Instruments | TMUXHS4612 |
| 16 | 2 | U2, U3 | ESD Diode | TPD4E02B04 (DNP) | Texas Instruments | TPD4E02B04 |

# 4 Additional Information

## 4.1 Trademarks

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DisplayPort™ is a trademark of Video Electronics Standards Association.
All trademarks are the property of their respective owners.

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   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 DEGREDATION 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/lsds/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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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:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs 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 assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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