EVM User's Guide: TRF1213EVM

TRF1213 Evaluation Module

Description

The TRF1213 evaluation module (EVM) is used to evaluate the TRF1213 device, which is a single-ended input to differential output RF amplifier available in a 2mm × 2mm, 12-pin WQFN package.

Get Started

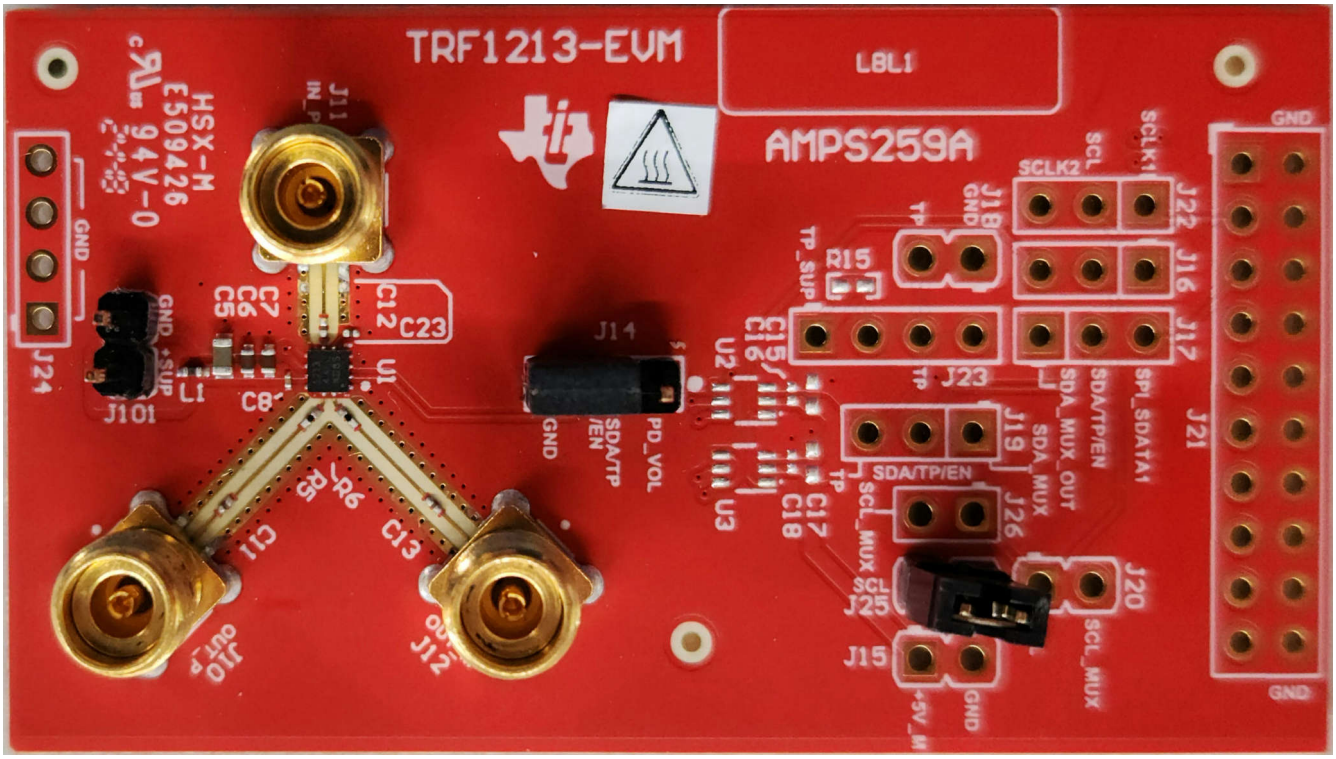
1. Order the EVM.
2. Download the comprehensive reference design files from the TRF1213EVM tool folder.

Features

- Operates on a single 5V supply
- Designed for single-ended, 50Ω input matching
- Simple interface to the input and outputs through onboard SMA connectors
- Power-down option available onboard using a jumper

Applications

- RF sampling or GSPS ADC driver
- Aerospace and defense
- Radar seeker front end
- Phased array radar
- Military radios
- Test and measurement
- High-speed digitizers
- Vector signal transceiver (VST)
- 4G/5G wireless BTS 3



TRF1213EVM

1 Evaluation Module Overview

1.1 Introduction

This document includes the basic steps and functions that are required to provide the proper operation and quick setup of the TRF1213EVM. This document also includes a schematic diagram, a bill of materials (BOM), printed-circuit board (PCB) layouts, and test block diagrams. Throughout this document, the abbreviations *EVM, TRF1213 EVM* and the term *evaluation module* are synonymous with the TRF1213EVM, unless otherwise noted.

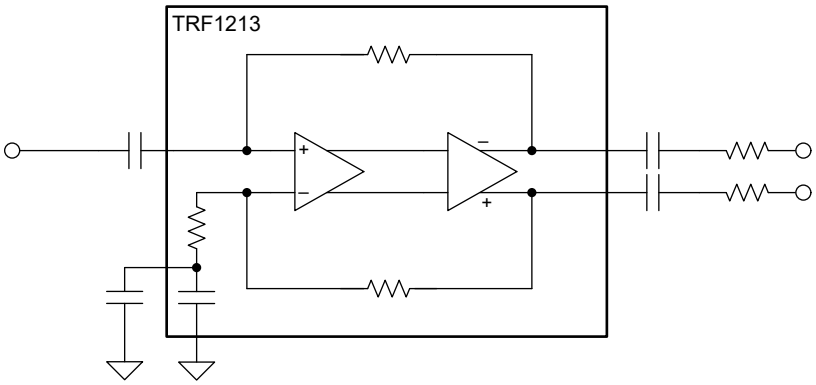


Figure 1-1. TRF1213 Functional Block Diagram

CAUTION

Hot surface. Contact can cause burns. Do not touch.

1.2 Kit Contents

- TRF1213EVM

1.3 Device Information

The TRF1213 is a very high performance, radio-frequency (RF) amplifier optimized for RF applications. This device is excellent for ac-coupled applications that require a single-ended to differential conversion when driving an RF sampling analog-to-digital converter (ADC), such as the high-performance AFE7950 or ADC12DJ5200RF. The device combines the functionality of a wide-band gain block and a wide-band passive balun. The on-chip matching components simplify printed circuit board (PCB) implementation and provide the highest performance over the usable bandwidth. The device is fabricated in Texas Instruments' advanced complementary BiCMOS process and is available in a space-saving, WQFN-FCRLF package.

The TRF1213 operates on a single-rail supply and consumes 170mA to 180mA of active current. A power-down feature is also available for power savings.

2 Hardware

2.1 Setup

2.1.1 General Use

This section provides general use information for the TRF1213EVM. See Section 2.1.2.1 for a general, single-tone setup diagram as a reference point for the following instructions (some components, such as supply bypass capacitors, are omitted for clarity):

1. Recommended power-up sequence:
   a. Before connecting the power-supply cables to the EVM, set the dc output power supply to 5V.
   b. Set the current limit of the dc output power supply at 250mA.
   c. Ensure that the supply is turned off, and then connect the power supply cables to the J101 connector of the EVM.
   d. Turn on the dc power supply of V_{CC} = 5V. The quiescent current (I_Q) drawn from the power supply is 170mA to 180mA.
   e. If the supply current is low, then verify that the device is not disabled by the PD pin, labeled as SDA/TP/EN on J14.
2. Power-down option:
   a. To power down the device, connect 1.8V to the SDA/TP/EN, or connect a jumper between the PD_VOL and SDA/TP/EN pins on J14 to power down the chip. To enable the device, connect the jumper between the GND and SDA/TP/EN pins on J14.
3. Single-tone measurement setup recommendation:
   a. Connect an RF signal generator to input SMA connector, J11.
   b. The RF signal generator used must support up to 14GHz signal frequency for testing out the TRF1213EVM.
   c. The TRF1213EVM device input is 50Ω in the pass band. To minimize signal reflections due to impedance mismatch, use an attenuator pad of approximately 3dB to 6dB between the source and J11 SMA input.
   d. The EVM outputs are fully differential (or 180° out of phase) at J10 and J12 SMA connectors. The TRF1213EVM device has low output impedance at dc and low frequencies.
   e. When connecting to a spectrum analyzer, the differential signal out of the EVM must be converted to a single-ended signal using an external passive balun as shown in Section 2.1.2.1. To minimize reflections, use an attenuator pad approximately 3dB to 6dB at the three terminals of the passive balun.
   f. Lastly, properly characterize and account for the insertion loss of RF coaxial (coax) cables, attenuator pads, and passive baluns to measure accurate gain and power levels for the device.
4. Matching considerations:
   a. The TRF1213 is a wideband amplifier and expects 50Ω input matching over the operating bandwidth up to approximately 14GHz. For more information, see the *TRF1213 Near-DC to > 14GHz, 3dB-Bandwidth, Single-Ended-to-Differential RF Amplifier* data sheet.

2.1.2 Test Setup Diagrams

This section includes general recommendations for gain, OP1dB, S-parameter, noise figure, and two-tone OIP3 setup while measuring the TRF1213 device.

2.1.2.1 Gain and OP1dB Test Setup

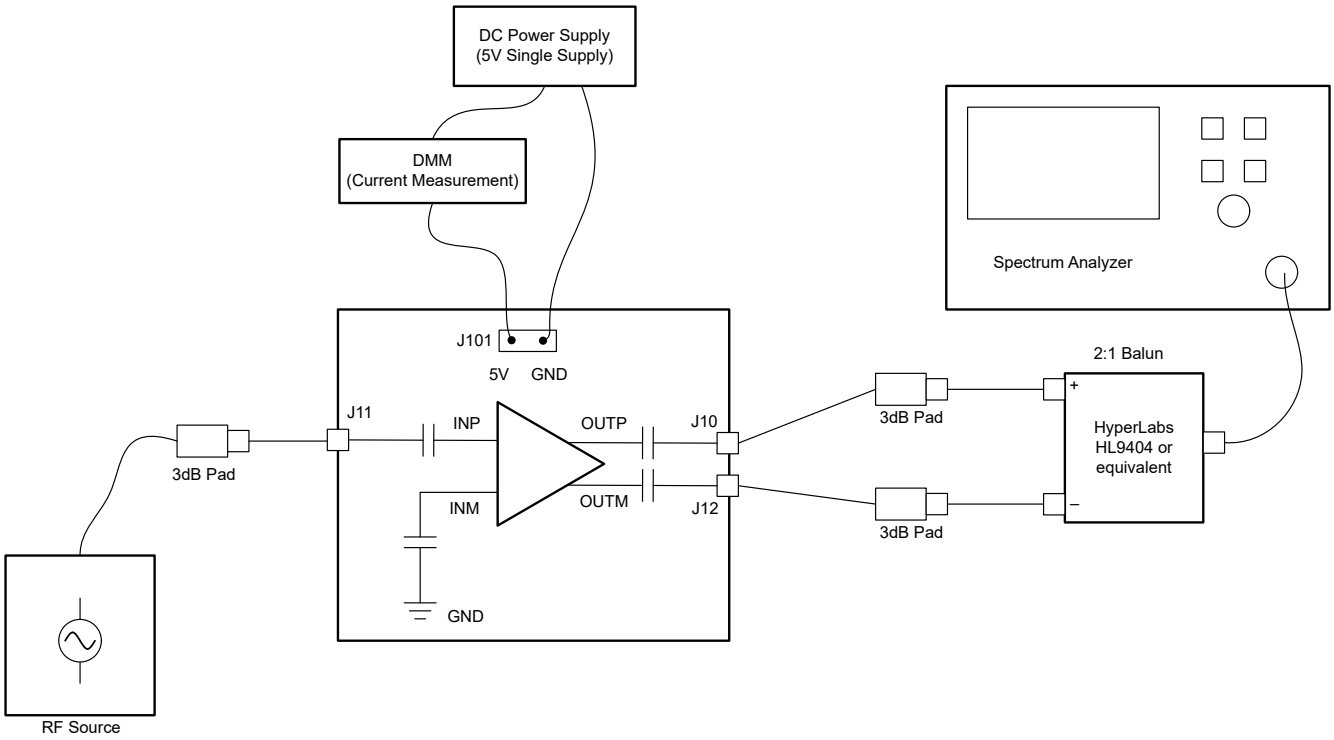


Figure 2-1. Gain and OP1dB Test Setup

2.1.2.2 S-Parameter Test Setup

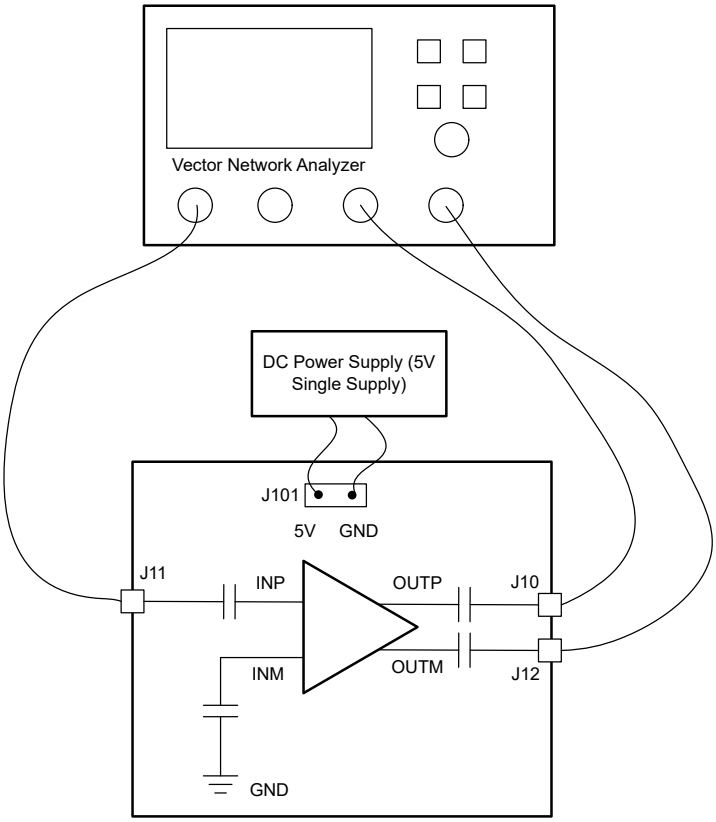


Figure 2-2. S-Parameter Test Setup

Use the following guidelines for S-parameter measurement:

1. Figure 2-2 shows the S-parameter measurement, typically done using a vector network analyzer (VNA). For measuring the TRF1213EVM, use a 3-port VNA that can generate single-ended signals and receive differential signals at the input and output ports of EVM, respectively.
2. Before connecting the RF coax cables to the EVM, calibrate the VNA along with the cables using a calibration kit.
3. Ensure that the frequency sweep and output power level from the VNA is set within the linear operating range of the TRF1213 device. The resolution bandwidth (RBW) and dynamic range of the VNA can be adjusted to give optimum sweep time for the measurement.
4. Account for board trace losses at the input and output side of the device during gain measurements. Figure 2-3 gives typical input and output trace losses measured on the EVM.

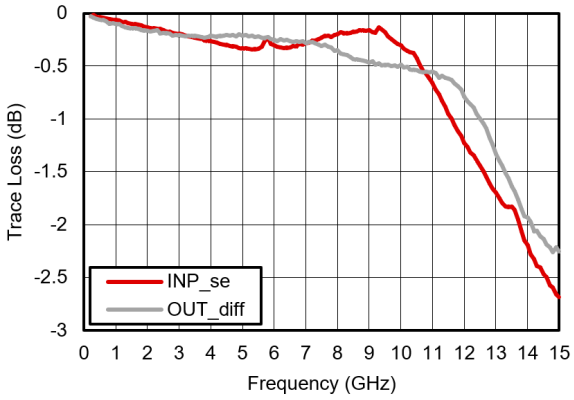


Figure 2-3. PCB Trace Loss vs Frequency

2.1.2.3 Noise Figure Test Setup

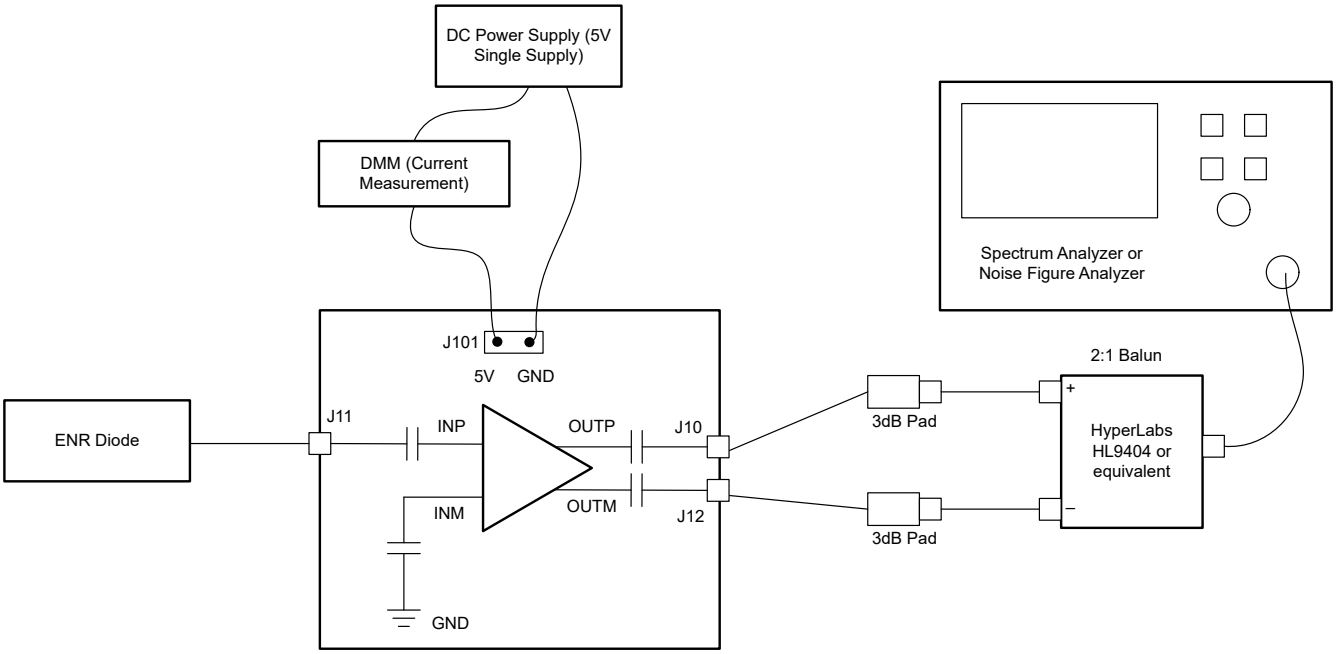


Figure 2-4. Noise Figure Test Setup

Use the following guidelines for noise figure (NF) measurement:

1. Figure 2-4 shows the traditional Y-factor method for NF measurement, using a noise diode and a spectrum analyzer (or a noise figure analyzer).
2. While measuring, take into account any RF cable losses to the EVM. Any external input attenuator added for matching results in proportional NF degradation and must be calibrated out in the measurement.
3. Onboard losses of the input traces at the device input pin must be factored into the NF measurement.
4. If the loss after the device output is significant, factoring the output loss into the NF measurement is important. Equation 1 shows the *Friis* equation for a cascaded noise factor used to calculate the NF of the device from the total measured NF. The noise factor of the device, F_1 , can then be extracted and converted into a logarithmic scale to give the TRF1213 NF. The loss of the EVM traces themselves is shown in Figure 2-3.

$$F_{total} = F_1 + \frac{F_2 - 1}{G_1} \quad (1)$$

where

- F_{total} = the total measured noise factor
- F_1 = the noise factor of the device
- G_1 = the gain of the device
- F_2 = the noise factor of the loss on the output

2.1.2.4 Two-Tone OIP3 Test Setup

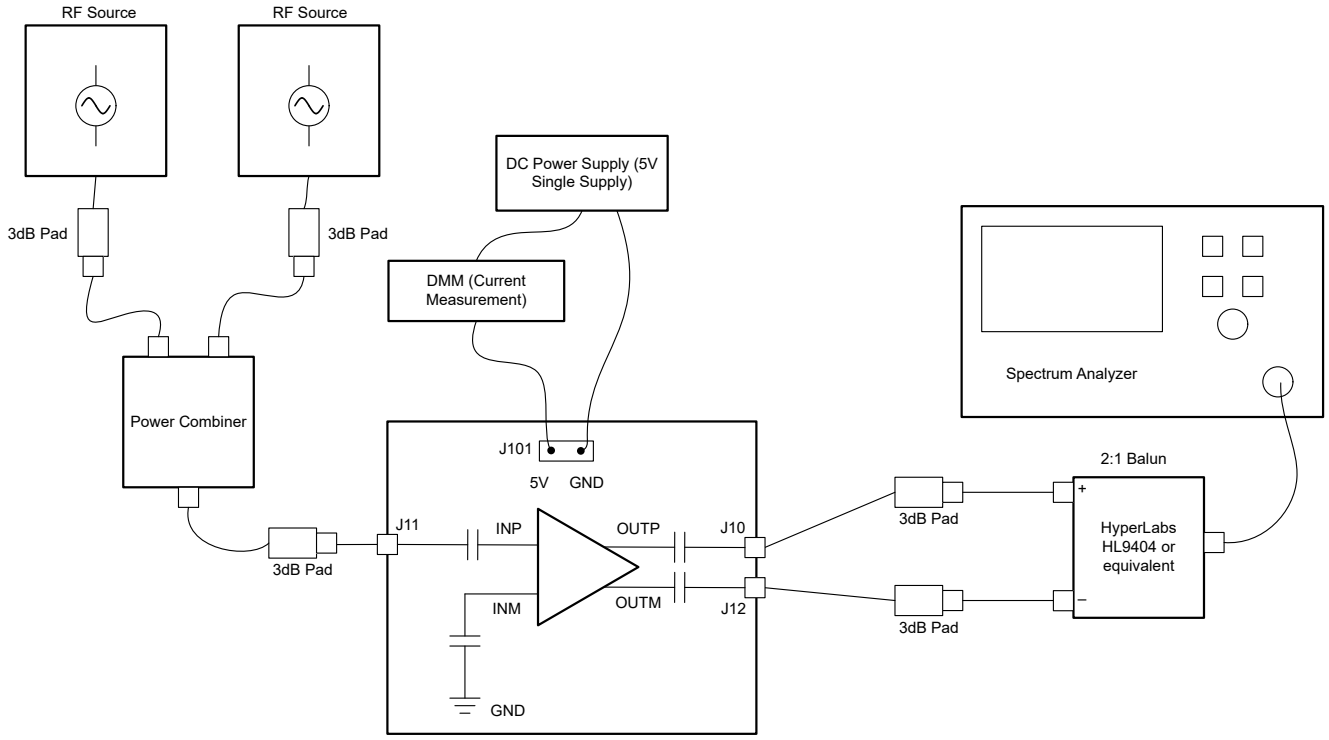


Figure 2-5. OIP3 Test Setup

Use the following guidelines for two-tone OIP3 measurement:

1. Figure 2-5 shows the combination of two signal generator outputs using an in-phase power splitter and combiner. Use a 3dB to 6dB attenuator at the signal-generator outputs to prevent the generators from communicating, resulting in signal-generator IMD3 spurs.
2. Set both the signal generator outputs to a power level and frequency spacing so that the signal generator yields the desired output power, P_{OUT} , at the device.
3. Keep the output power level within the TRF1213 linear operating range. For example, if the total desired output power at the device is 8dBm, set the signal generators so that each of the fundamental output powers results in 2dBm per tone. As a general rule, keep the total output power level approximately 6dB to 8dB less than the 1dB compression point. See the device data sheet for the supported output power levels.
4. For the OIP3 test, the two tones can be spaced by the specified frequency.
5. Set the spectrum analyzer attenuation setting appropriately so that the spectrum analyzer nonlinearity does not affect the measurements.
6. Keep spectrum analyzer RBW and VBW settings identical for main tone and IM3 products.

For output IP3 calculation, take into account the combined losses at the desired frequency band between the TRF1213EVM output to the spectrum analyzer input. The combined power loss is due to the PCB output trace, RF coax cable, 180° passive balun, and any attenuator pad used for external matching. Equation 2 gives the calculated OIP3. The loss at the output of the device, P_{LOSS} , is found using the combination of the Figure 2-3 and any attenuation added after the EVM.

$$\text{Output IP3} = \left(P_{IN\_SA} - IMD3\right)/2 + P_{IN\_SA} + P_{LOSS} \quad (2)$$

where

- P_{IN_SA} = Input power per tone into the spectrum analyzer
- P_{LOSS} = Power loss from the device output to the spectrum analyzer input
- $IMD3$ = Higher power of the two intermodulation distortion products recorded at either 2f1 – f2 or 2f2 – f1
- $P_{IN\_SA} + P_{LOSS} = P_{OUT}$ is the amplifier output power per tone

3 Hardware Design Files

3.1 Schematic

Figure 3-1 shows the TRF1213EVM schematic.

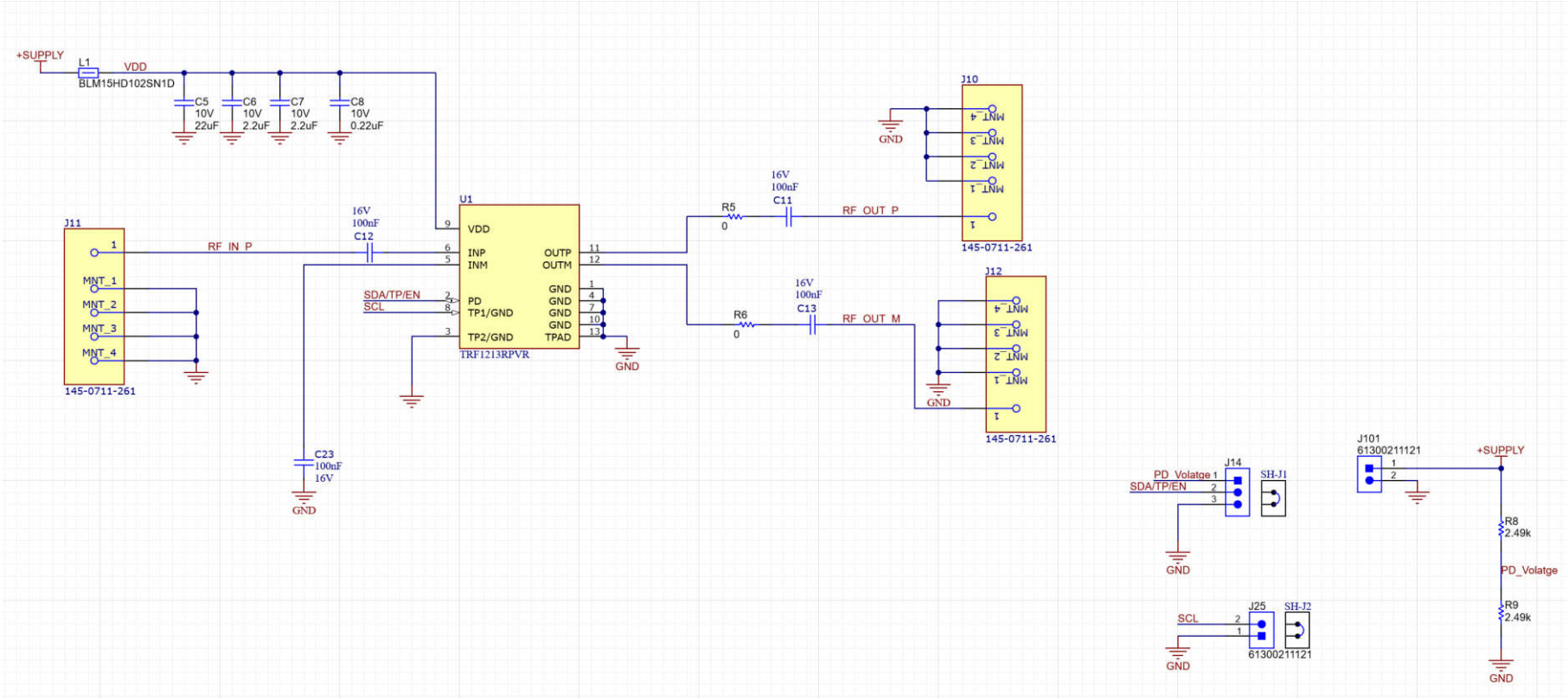


Figure 3-1. TRF1213EVM Schematic

3.2 PCB Layout

Figure 3-2 through Figure 3-5 illustrate the PCB layers for this EVM.

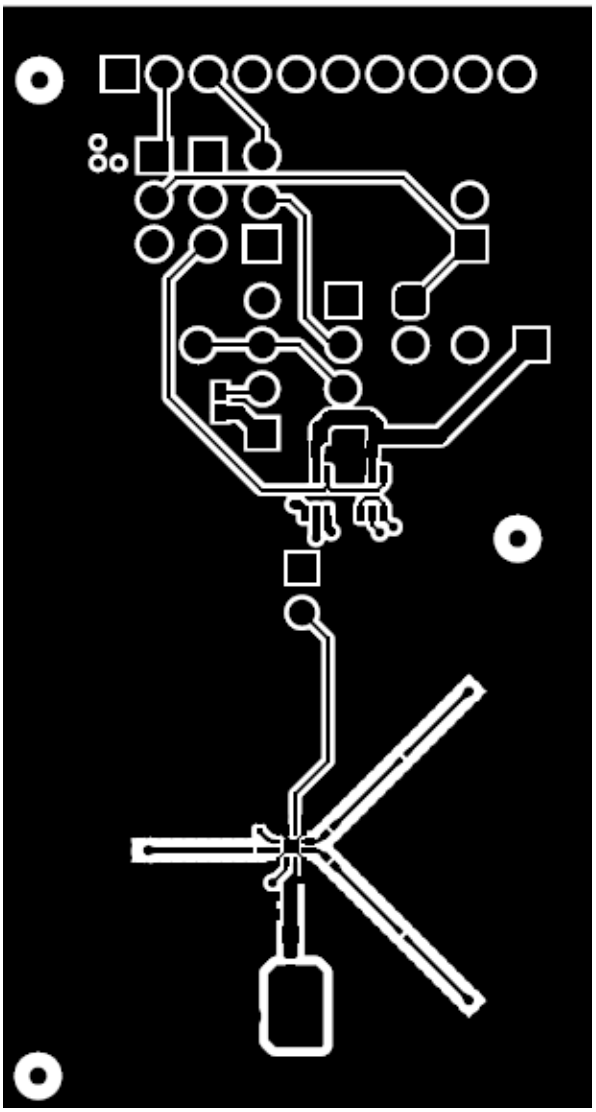


Figure 3-2. Top Layer

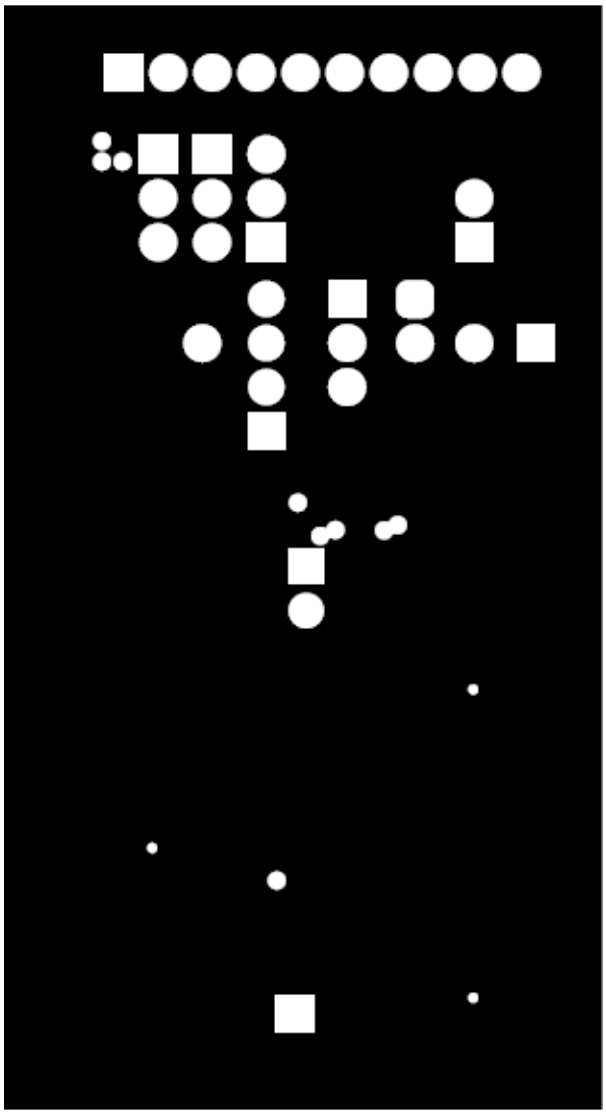


Figure 3-3. Layer 2

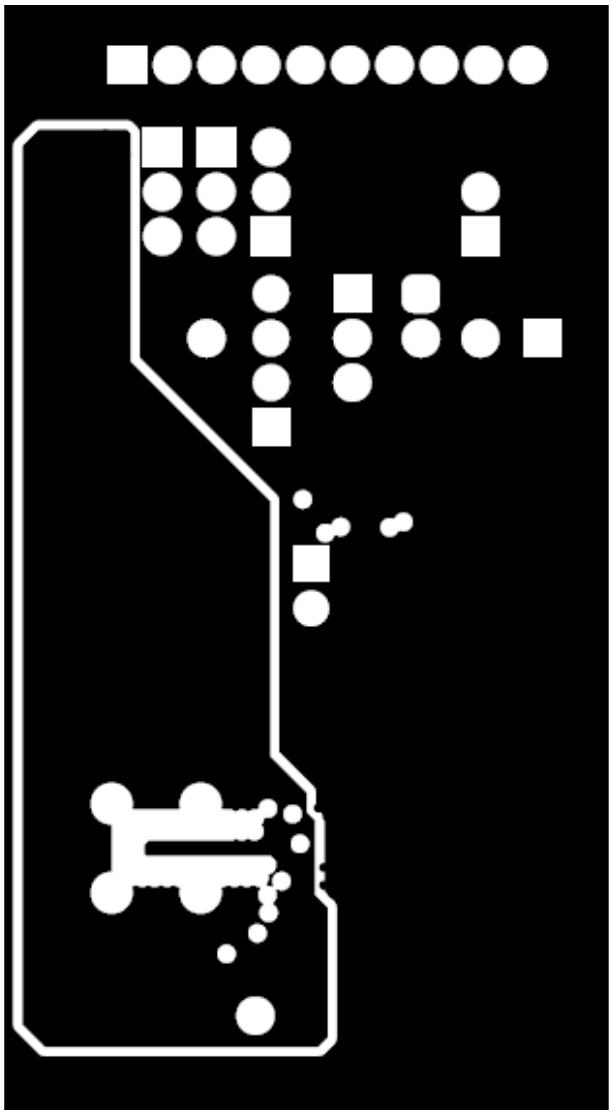


Figure 3-4. Layer 3

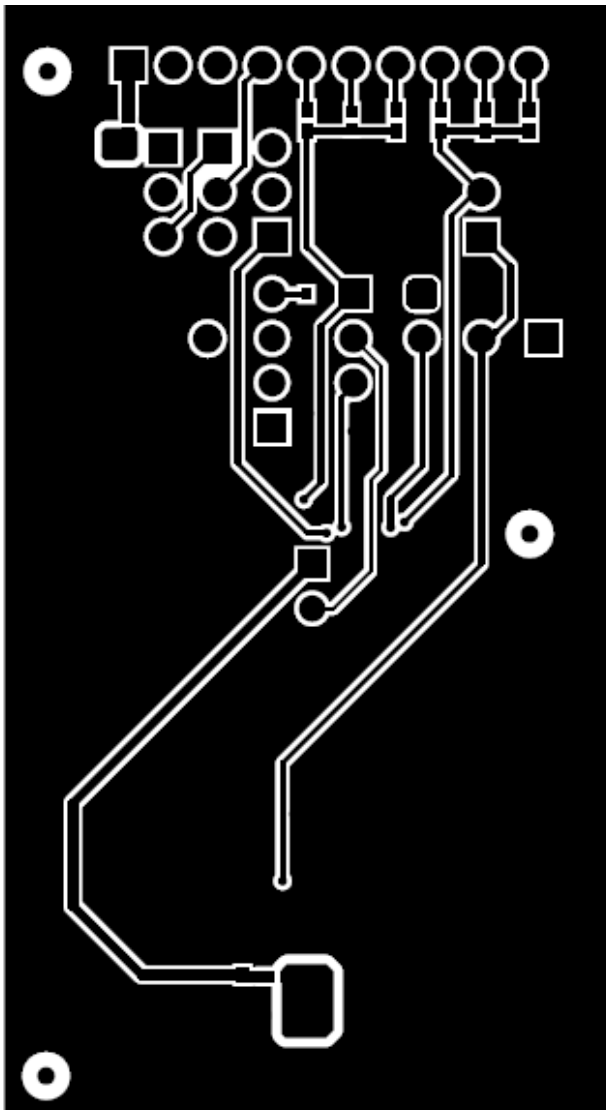


Figure 3-5. Bottom Layer

3.2.1 Stack-Up and Material

The TRF1213EVM is a four-layer board whose material type is Rogers® 4350B. The top layer routes the power, ground, and signals between SMA connectors and the device. Second layer is the reference RF ground layer. The signal trace impedance is targeted at 50Ω. The bottom three layers are ground layers. Table 3-1 lists the EVM stack-up.

Table 3-1. TRF1213EVM Stack-Up

Layer	Name	Material	Thickness (mils)	Dielectric Constant
	Top Overlay			
	Top Solder	Solder Resist	1.00	3.5
1	Top Layer	Copper	1.40	
	Dielectric 1	Rogers 4350B	5.00	3.48
2	GND	Copper	1.40	
	Dielectric 2	FR4	44.80	4.2
3	PWR	Copper	1.40	
	Dielectric 3	FR4	5.00	4.2
4	Bottom Layer	Copper	1.40	
	Bottom Solder	Solder Resist	1.00	3.5
	Bottom Overlay			

3.3 Bill of Materials (BOM)

Table 3-2 lists the BOM.

Table 3-2. Bill of Materials (BOM)

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
!PCB	1		Printed Circuit Board		AMPS259	Any
C5	1	22uF	CAP, CERM, 22 uF, 10 V, +/- 20%, X5R, 0603	0603	CL10A226MP8NUNE	Samsung Electro-Mechanics
C6, C7	2	2.2uF	CAP, CERM, 2.2 uF, 10 V, +/- 10%, X7S, 0402	0402	C1005X7S1A225K050BC	TDK
C8	1	0.22uF	CAP, CERM, 0.22 uF, 10 V, +/- 20%, X5R, 0201	0201	LMK063BJ224MP-F	Taiyo Yuden
C11, C12, C13, C23	4	100nF	0.1 µF ±20% 16V Ceramic Capacitor 0201 (0603 Metric)	0201	560Z104MTT	KYOCERA AVX
J10, J11, J12	3		2.92mm Connector Jack, Female Socket 50 Ohms Through Hole Solder	RF_JACK	145-0711-261	Cinch Connectivity Solutions
J14	1		Header, 100mil, 3x1, Tin, TH	Header, 3 PIN, 100mil, Tin	PEC03SAAN	Sullins Connector Solutions
J25, J101	2		Header, 2.54 mm, 2x1, Gold, TH	Header, 2.54mm, 2x1, TH	61300211121	Wurth Elektronik
L1	1	1000 ohm	Ferrite Bead, 1000 ohm @ 100 MHz, 0.25 A, 0402	0402	BLM15HD102SN1D	MuRata
R5, R6	2	0	RES, 0, 5%, .05 W, AEC-Q200 Grade 0, 0201	0201	ERJ-1GN0R00C	Panasonic
R8, R9	2	2.49k	RES, 2.49 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04022K49FKED	Vishay-Dale
SH-J1, SH-J2	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	SNT-100-BK-G	Samtec
U1	1		TRF1213RPVR	WQFN-FCRLF12	TRF1213RPVR	Texas Instruments

4 Additional Information

Trademarks

Rogers® is a registered trademark of Isola USA Corporation.
All trademarks are the property of their respective owners.

5 Related Documentation

For related documentation, see the following:

- Texas Instruments, *TRF1213 Near-DC to > 14GHz, 3dB-Bandwidth, Single-Ended-to-Differential RF Amplifier* 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.

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   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 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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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。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/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:*

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.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

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