LMX248x Evaluation Board

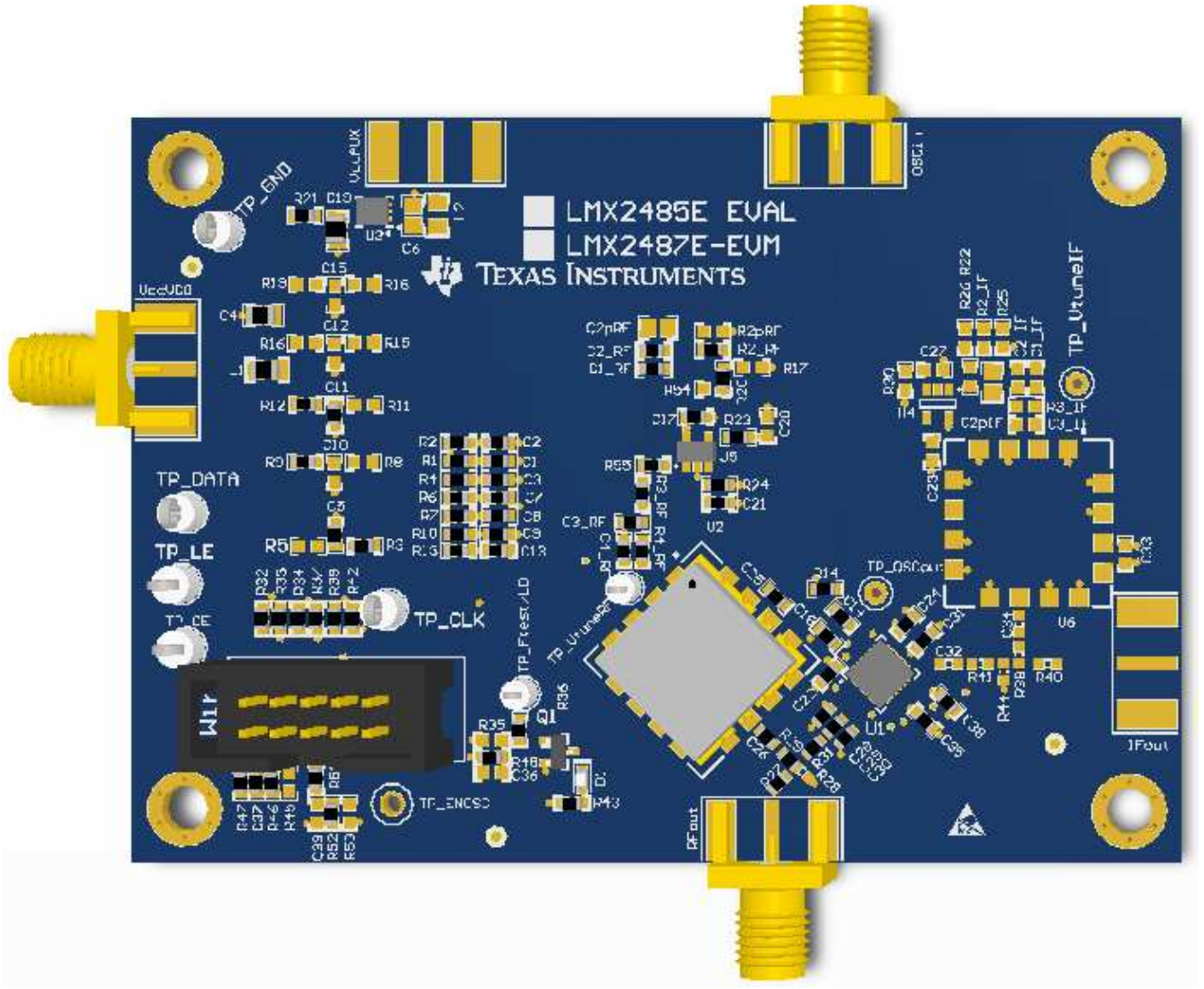
User's Guide

Literature Number: SNAU137B
March 2014–Revised July 2018

Contents

LMX248x Evaluation Board

The Texas Instruments LMX2485E-EVM/LMX2487E-EVM helps designers evaluate the operation and performance of any device in the LMX248x family. Although only two options are offered, the other members in the family are all pinout-compatible and program-compatible to one of these existing board option. They would be expected to have similar performance, just different in the maximum frequency of operation.



1 Trademarks

All trademarks are the property of their respective owners.

2 Introduction

The EVM contains one Frequency Synthesizer (see Table 1).

Table 1. Evaluation Device and Package Configurations

DEVICE	RF PLL FREQUENCY RANGE	EVALUATION VEHICLE
LMX2485E	50 to 3000 MHz	LMX2485E EVAL
LMX2485	500 to 3000 MHz	
LMX2486	1000 to 4500 MHz	LMX2487E EVAL
LMX2487	1000 to 6000 MHz	
LMX2487E	3000 to 7500 MHz	

Table 2. Evaluation Device and Package Configurations

BOARD VERSION	DESIGNATOR	IC	PACKAGE	VCO MODEL	VCO FREQUENCY RANGE
LMX2485E-EVM	U1	LMX2485E	QFN24	Crystek CVCO55CL	60-80 MHz
LMX2487E-EVM	U1	LMX2487E	QFN24	Crystek CVCO44BH	4100-4300 MHz

Although the devices are very broadband, the VCO is ultimately what limits the frequency range of the evaluation board. These VCOs were chosen primarily for their availability, standard footprint, and for their lower risk of becoming obsolete.

3 Setup

3.1 Input/Output Connector Description

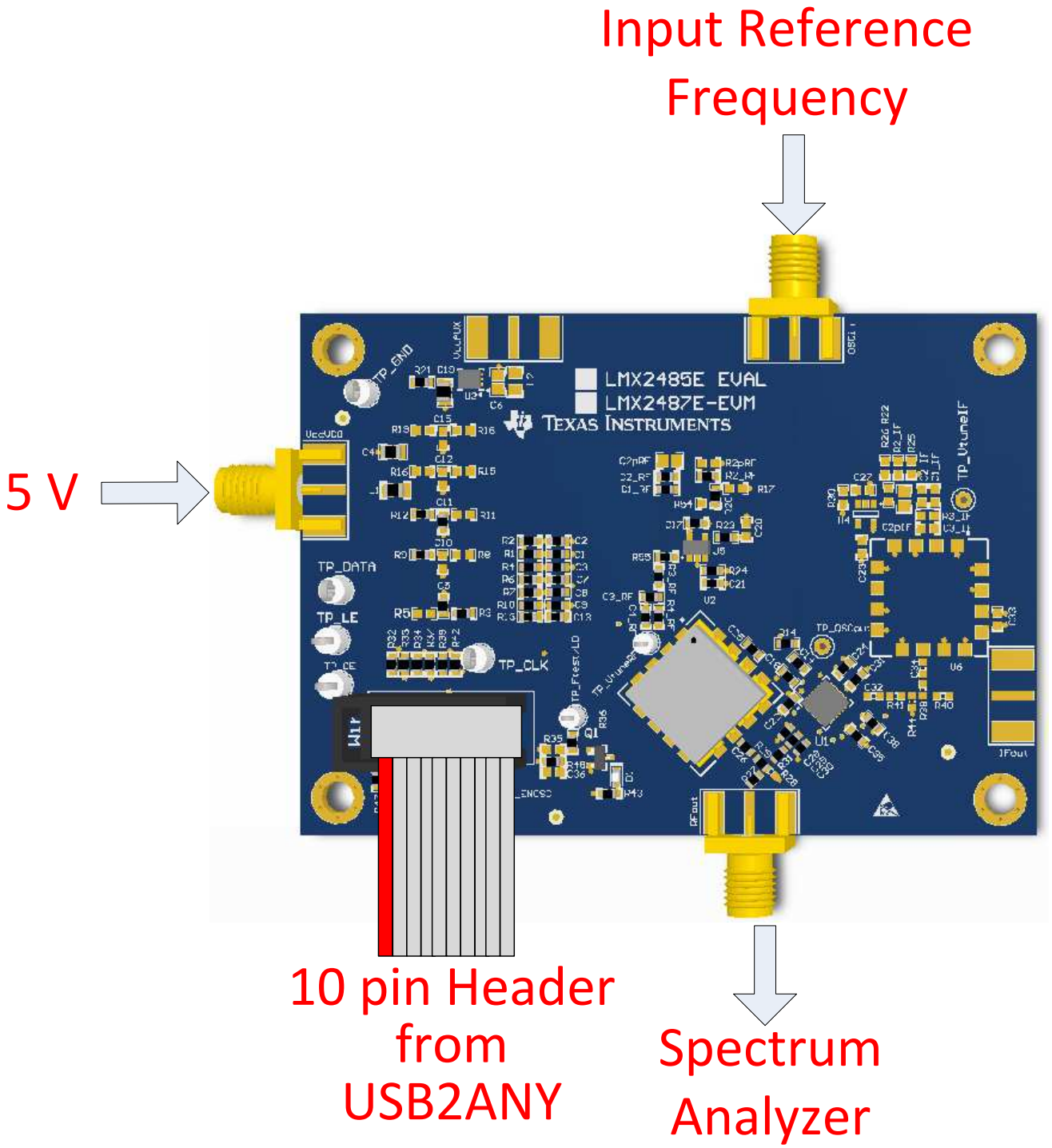


Figure 1. Evaluation Board Setup

VccVCO

Connect this to a 5-V Power supply.

OSCin

Connect this to a signal generator at +4 dBm. Default frequency is 50 MHz for the LMX2485E-EVM and 100 MHz for the LMX2487E-EVM.

RFout

Connect this to a spectrum analyzer. The board has DC-blocking capacitors, so the signal is AC coupled.

uWire

Hook this to the programming interface.

3.2 Loop Filter Values

TI's Clock Design Tool can be used to optimize the PLL phase noise/jitter for given specifications. See: http://www.ti.com/tool/pllatinumsim-sw.

3.3 RF PLL Loop Filter

Table 3. RF PLL Loop Filter Parameters

Parameter	LMX2485E	LMX2487E
VCO Used	Crystek CVCO55CL	Crystek CVCO55BH
VCO Gain (K_{VCO})	8 MHz/V	100 MHz/V
VCO Input Capacitance	330 pF	10 pF
Nominal Output Frequency	60 to 80 MHz	4100 to 4300 MHz
Phase Margin	44	50
Loop Bandwidth	8.7	15
Reference Clock Frequency	50 MHz	100 MHz
K_{PD}(Charge Pump)	16X (1520 µA)	8X (760 µA)
Phase Detector Freq	2000 kHz	20000 kHz
PLL Supply	3.3 V from LDO	3.3 V from LDO
VCO Supply	5 V	5 V
C1	10 nF	5.6 nF
C2	680 nF	120 nF
C3	15 nF	220 pF
C4	1 nF	1 nF
R2	180 Ω	270 Ω
R3	220 Ω	1.2 kΩ
R4	3.3 k Ω	1.2 k Ω

NOTE: PLL Loop Bandwidth is a function of K_{PD}, K_{VCO}, N, and the loop components. Changing K_{PD} and N will thereforechange the loop bandwidth.

3.4 Installing the EVM Software

1. Go to http://www.ti.com/tool/ticspro-sw
2. Click on the download button to download the software.
3. Run the executable file.

3.5 Using the EVM Software

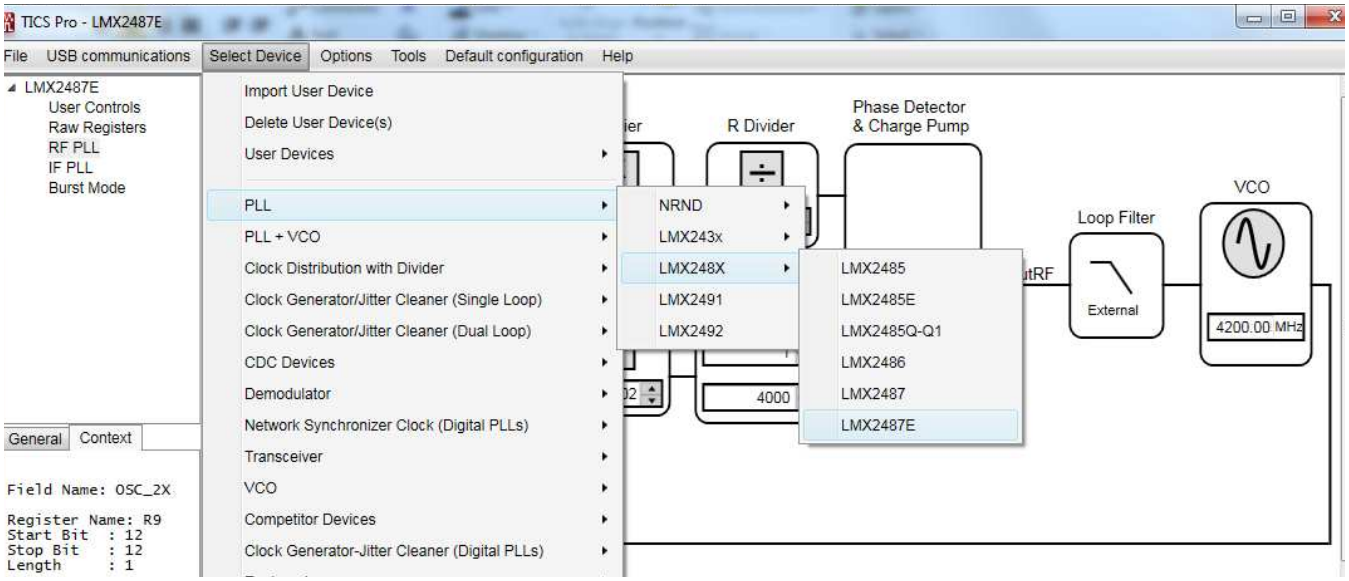


Figure 2. Choosing the LMX2487E Device in TICS Pro

NOTE: Don't forget to press <Cntrl>+L or do Keyboard Controls → Load Device, to load the settings

4 Schematic

View Section 5 for actual component values.

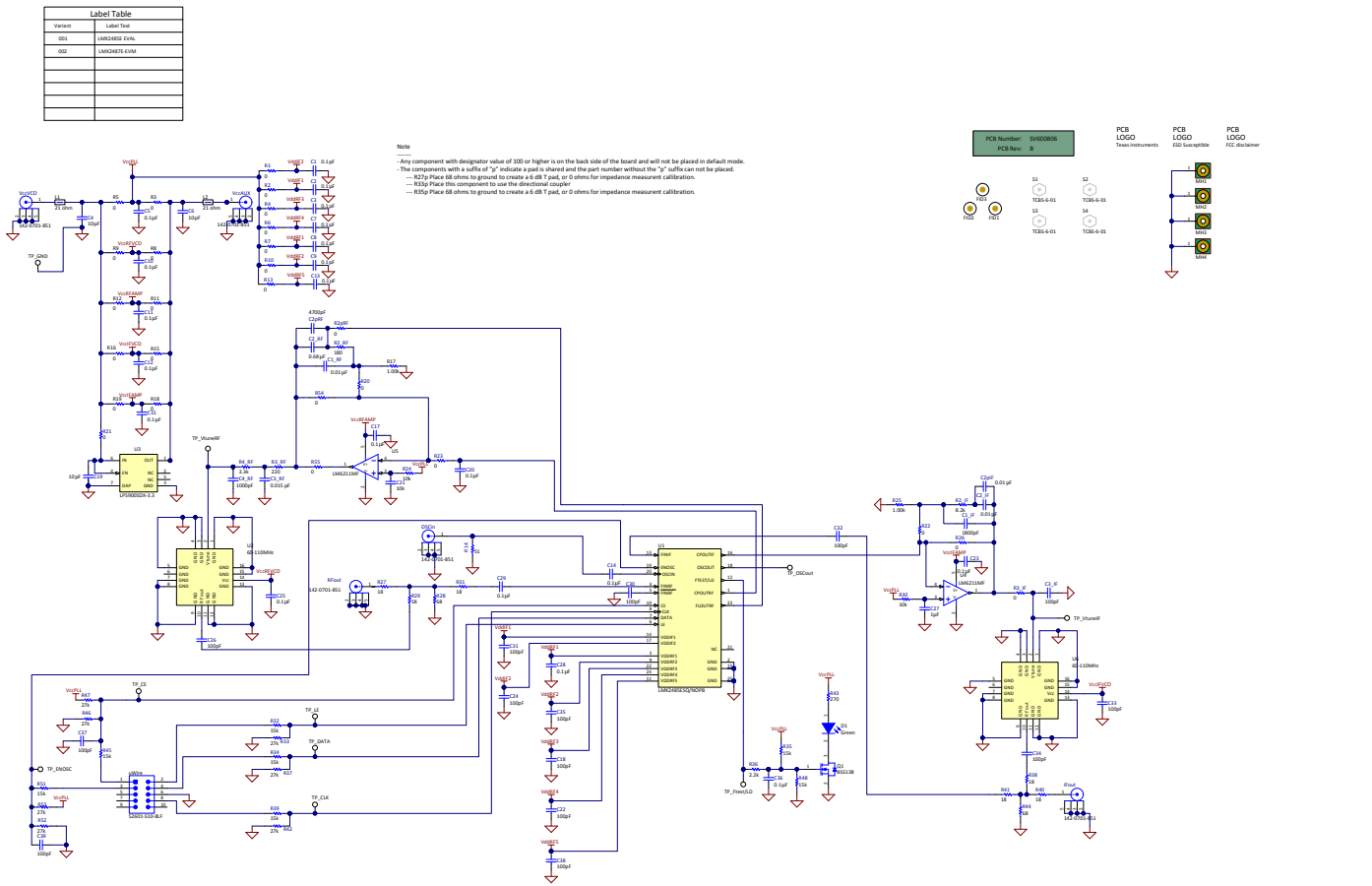


Figure 3. LMX2485E/87E EVM Schematic

5 Bill of Materials

Table 4. Bill of Materials

ITEM	DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QUANTITY
1	AA1	Printed Circuit Board	TBD by TI	551600806-001 REV A	1
2	C18, C22, C24, C26, C30, C31, C35, C41	CAP, CERM, 100pF, 25V, +/-10%, X7R, 0603	AVX	06033C101KAT2A	8
3	C5, C10, C11, C14, C16, C17, C25, C28, C29, C36	CAP, CERM, 0.1uF, 16V, +/-10%, X7R, 0603	Kemet	C0603C104K4RACTU	10
4	C1, C2, C3, C7, C8, C9, C37, C40	CAP, CERM, 1uF, 16V, +/-10%, X5R, 0603	Kemet	C0603C105K4PACTU	8
5	C4, C19	CAP, CERM, 10uF, 10V, +/-10%, X5R, 0805	Kemet	C0805C106K8PACTU	2
6	D1		Lumex	1594540000	1
7	L1	FB, 120 ohm, 500mA, 0603	Murata	BLM18AG121SN1D	1
8	OSCin, RFout, VccVCO	Connector, SMT, End launch SMA 50 ohm	Emerson Network Power	142-0701-851	3
9	R3, R20, R21, R23, R55	RES, 0 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06030000Z0EA	5
10	R1, R2, R4, R6, R7, R9, R10, R12, R56	RES, 10.0 ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW060310R0FKEA	9
11	R27, R29, R31	RES, 18 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060318R0JNEA	3
12	R14	RES, 51 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060351R0JNEA	1
13	R43	RES, 270 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603270RJNEA	1
14	R24, C21	RES, 1k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060310K0JNEA	1
15	R32, R34, R35, R36, R39	RES, 15k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060315K0JNEA	5
16	R33, R37, R42, R47	RES, 27k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060327K0JNEA	4
17	S1,S2, S3, S4	0.375" Standoff	Voltrex	SPCS-6	4
18	U3	Ultra Low Noise, 150mA Linear Regulator for RF/Analog Circuits Requires No Bypass Capacitor, 6-pin LLP	Texas Instruments	LP5900SDX-3.3	1
19	U5	Low Noise, RRO Op Amp with CMOS Input	Texas Instruments	LM6211MF	1
20	U7		Fairchild	BSS138	1
21	uWire		FCI	52601-G10-8LF	1
22	S1, TP_Ftest/LD, TP_OSCout, TP_TRIGGER, TP_VtuneIF, TP_VtuneRF	Open	Open	None	6
23	FID1, FID2, FID3	Fiducial mark. There is nothing to buy or mount.	N/A	N/A	3

Table 5. Additional LMX2485E-EVM Specific Components

ITEM	DESIGNATOR	DESCRIPTION	MANUFACTURER	PART NUMBER	QUANTITY
24	U1	LMX2485E	Texas Instruments		1
25	U2	VCO	Crystek	CVCO55CL-0060-0110	1
26	C1_RF	CAP, CERM, 0.01uF, 100V, +/-5%, X7R, 0603	Kemet	C0603C103J1RACTU	1
27	C2_RF	CAP, CERM, 0.68uF, 10V, +/-10%, X5R, 0603	Kemet	C0603C684K8PAC	1
28	C3_RF	CAP, CERM, 0.015uF, 100V, +/-10%, X7R, 0603	Kemet	C0603C153K1RACTU	1
29	C4_RF	CAP, CERM, 1000pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C102J5GAC	1
30	R2_RF	RES, 180 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603180RJNEA	1
31	R3_RF	RES, 220 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603220RJNEA	1
32	R4_RF	RES, 3.3k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06033K30JNEA	1

Table 6. Additional LMX2487E-EVM Specific Components

ITEM	DESIGNATOR	DESCRIPTION	MANUFACTURER	PARTNUMBER	QUANTITY
24	U1	LMX2487E	Texas Instruments		1
25	U2		Crystek	CVCO55BH-4100-4300	1
26	C1_RF	CAP, CERM, 5600pF, 100V, +/-5%, X7R, 0603	AVX	06031C562JAT2A	1
27	C2_RF	CAP, CERM, 0.12uF, 10V, +/-10%, X5R, 0603	MuRata	GRM188R61A124KA01D	1
28	C3_RF	CAP, CERM, 220pF, 100V, +/-10%, X7R, 0603	AVX	06031C221KAT2A	1
29	C4_RF	CAP, CERM, 1000pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C102J5GAC	1
30	R2_RF	RES, 270 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603270RJNEA	1
31	R3_RF	RES, 1.2k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031K20JNEA	1
32	R4_RF	RES, 1.2k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031K20JNEA	1

6 Layers Stackup

4-layer PCB Stackup includes:

- Top Layer for high-priority high-frequency signals (1 oz.)
- Rogers 4003 Dielectric, 16 mils
- RF Ground plane (1 oz.)
- FR4
- Power (PWR) Layer
- FR4, 23 mils
- Bottom Layer copper clad for thermal relief (1 oz.)
- Total board thickness is 62 mils

7 PCB Layouts

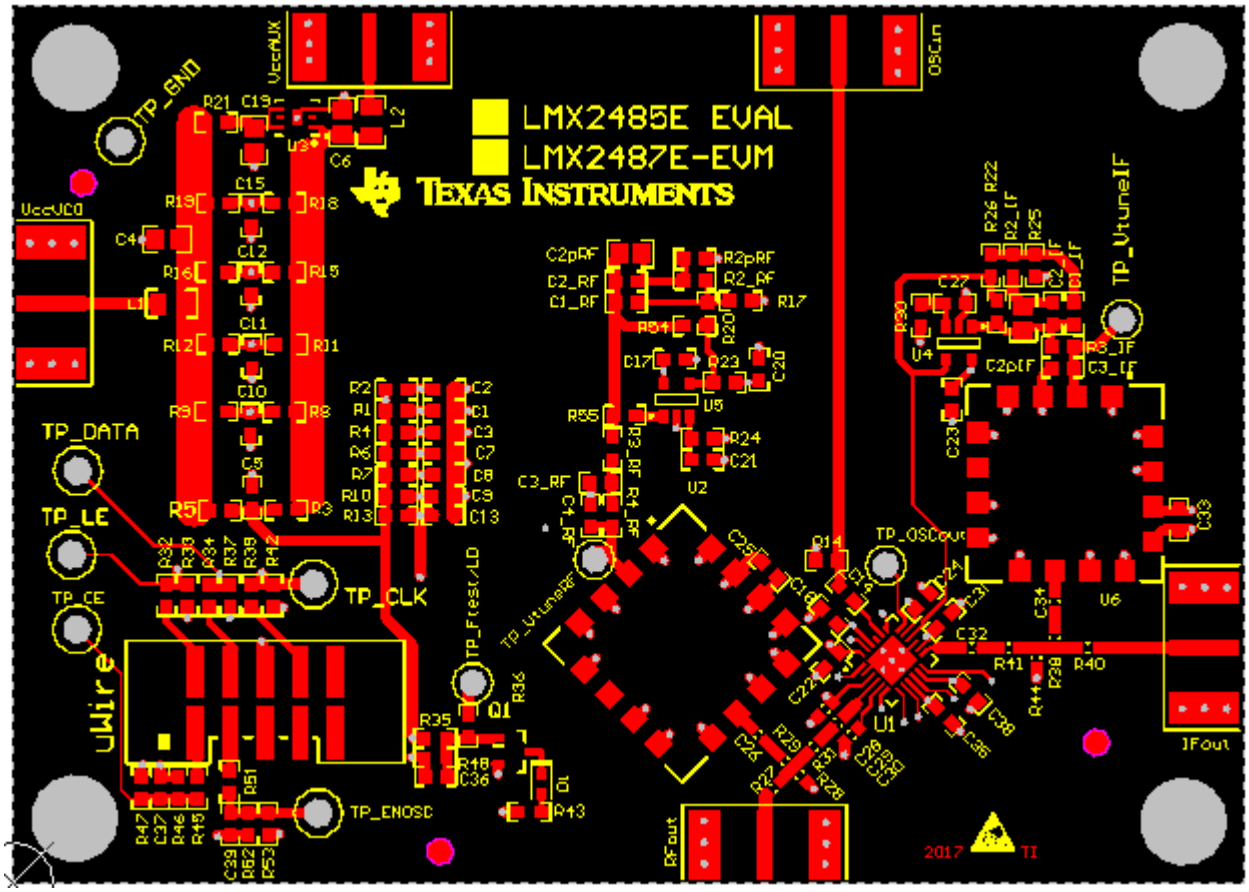


Figure 4. Layer #1 – Top

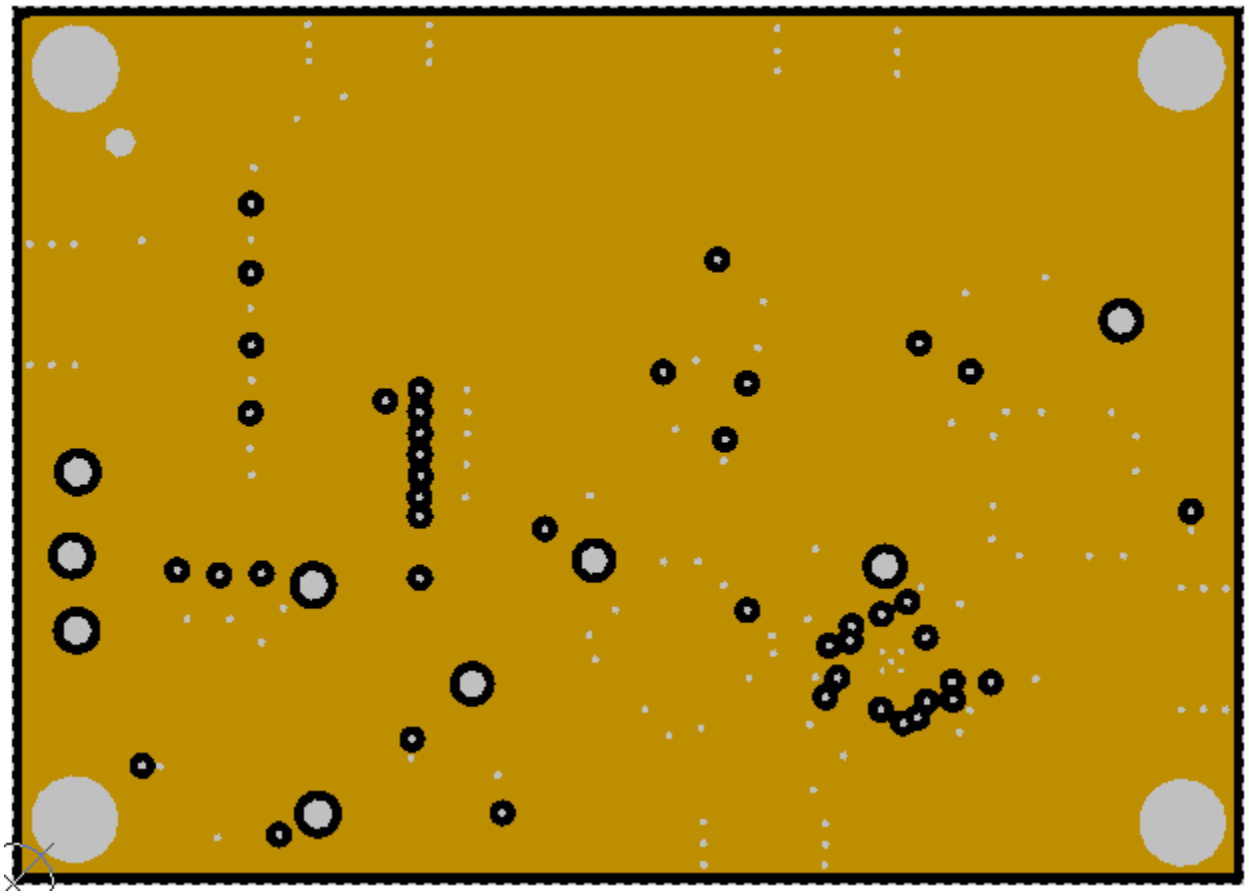


Figure 5. Layer #2 – RF Ground Plane

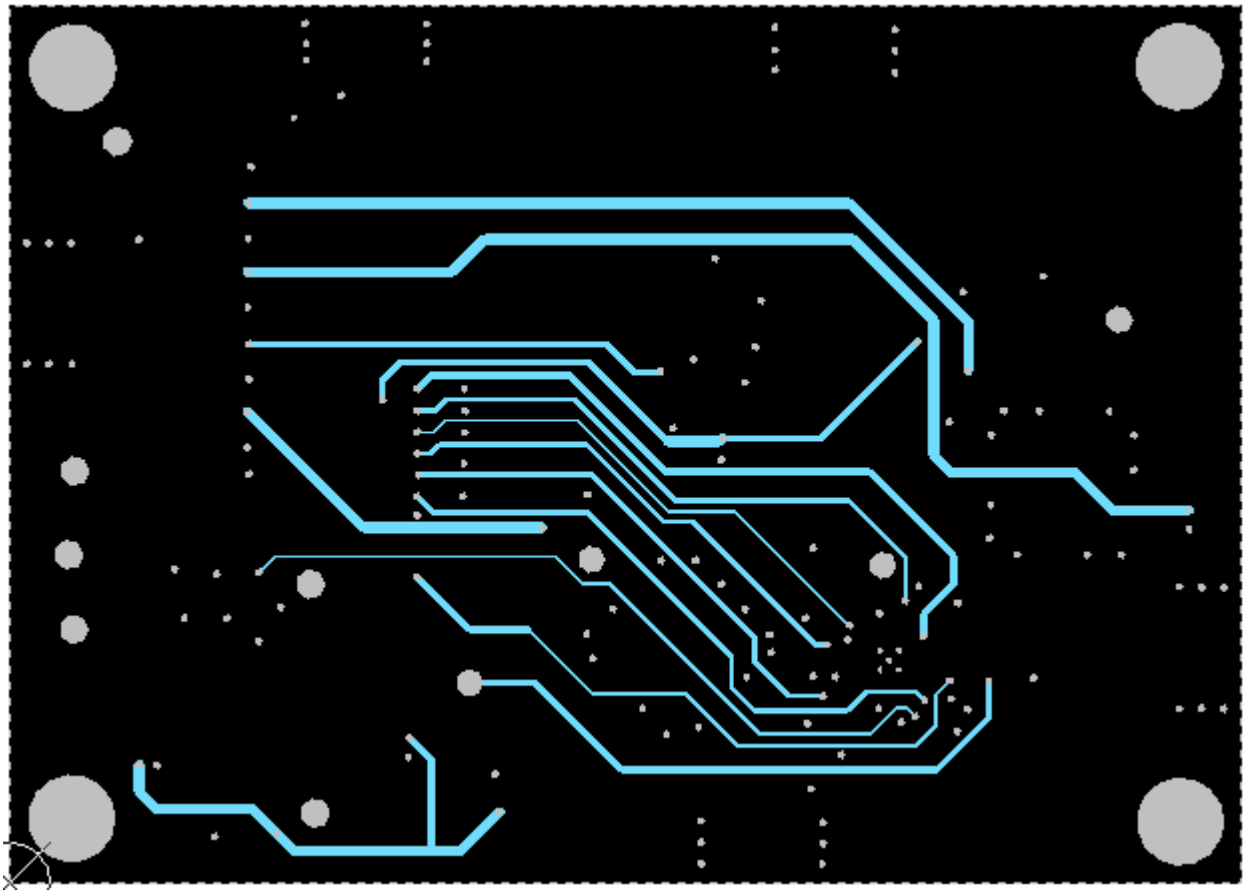


Figure 6. Layer #3 – Power

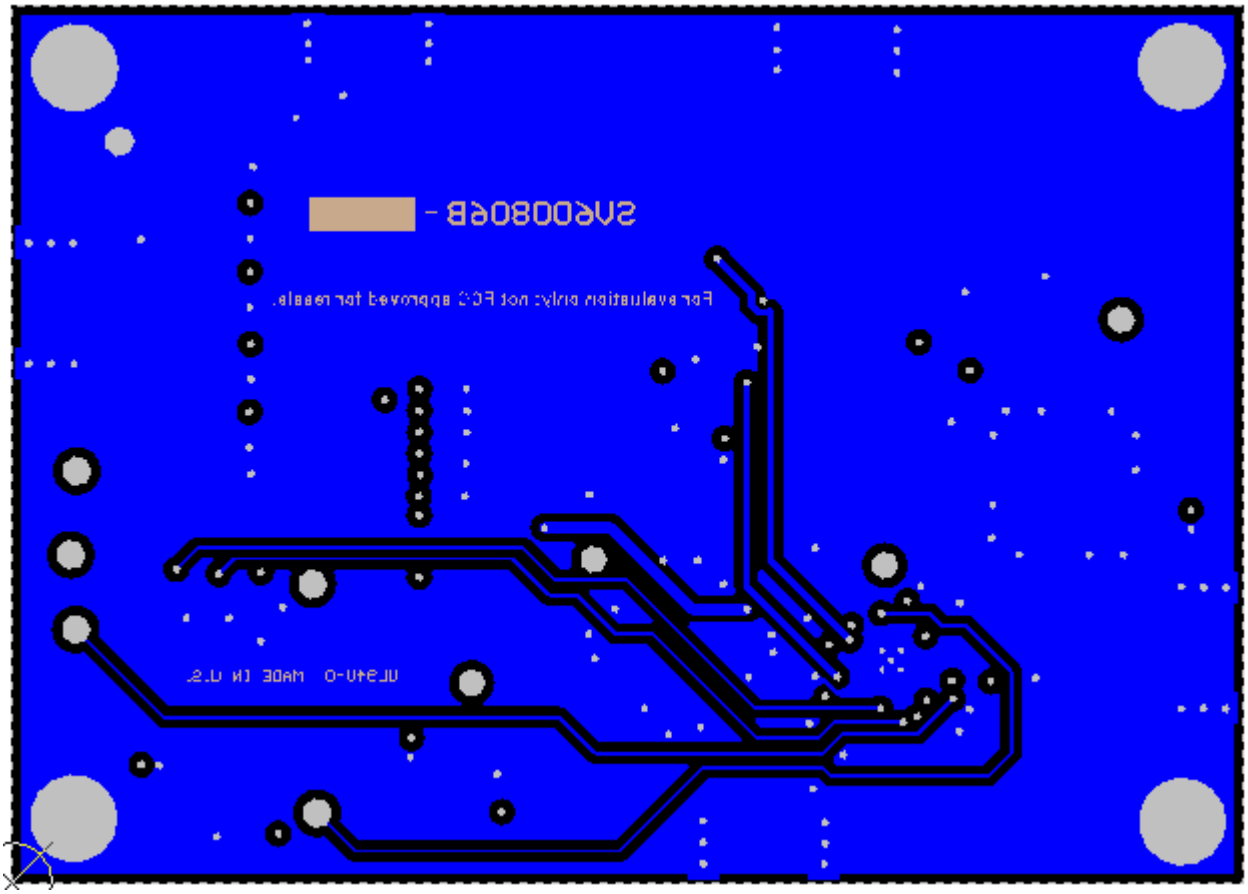


Figure 7. Layer #3 – Bottom Layer

8 Typical Phase Noise Performance Plots

8.1 LMX2485E Phase Noise Plots

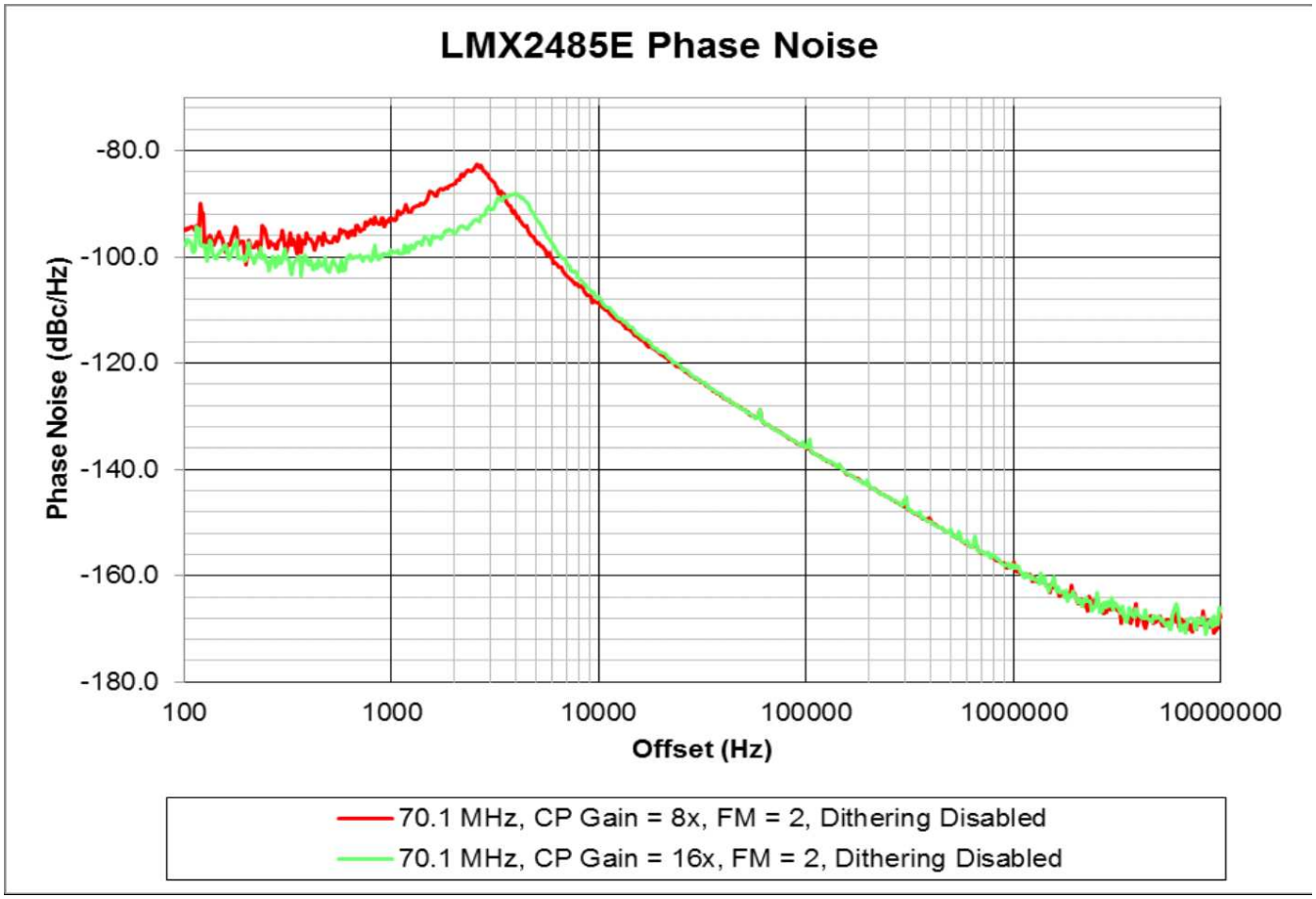


Figure 8. Impact of CPG on Phase Noise

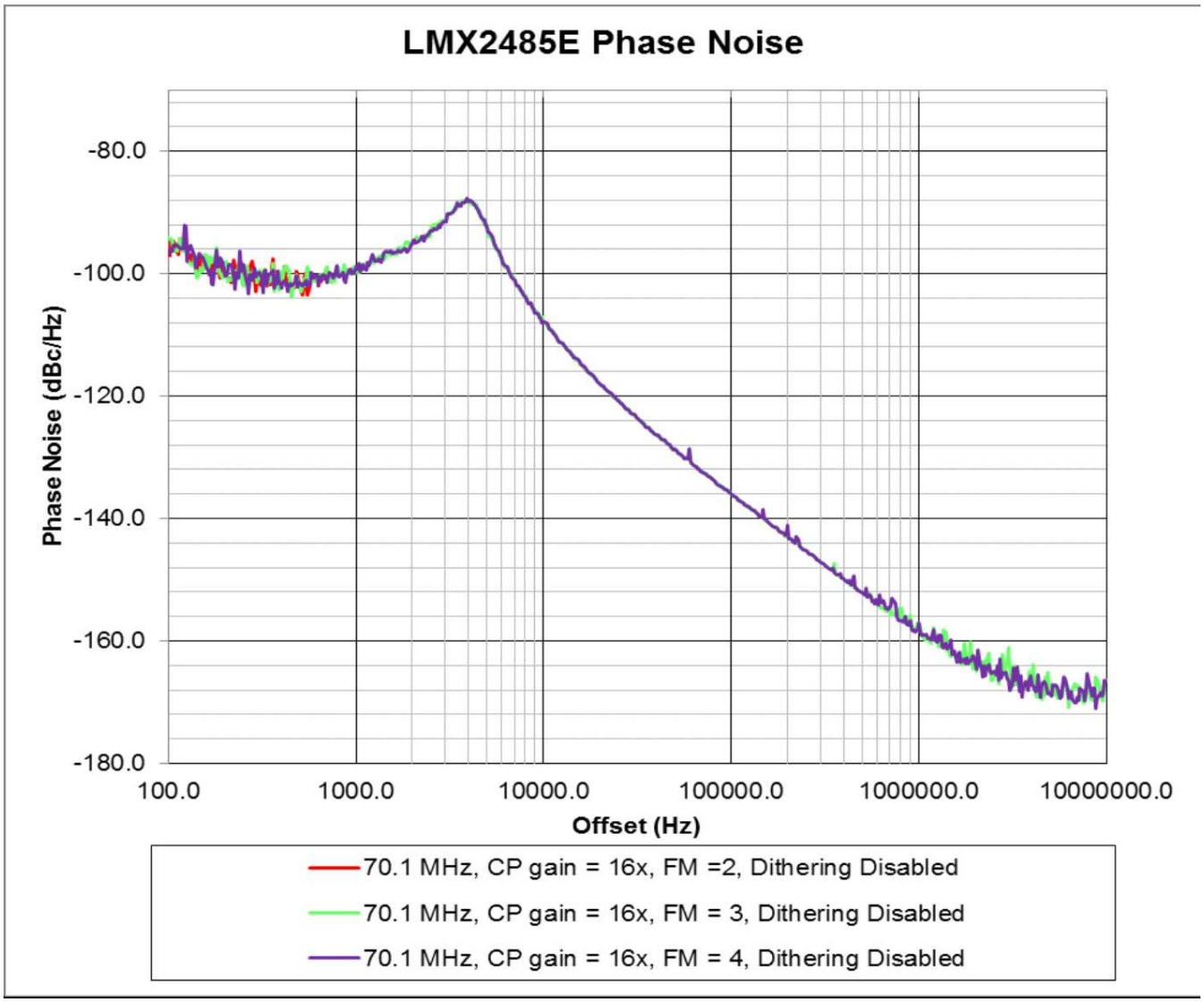


Figure 9. LMX2485E Impact of Fractional Modulator Order

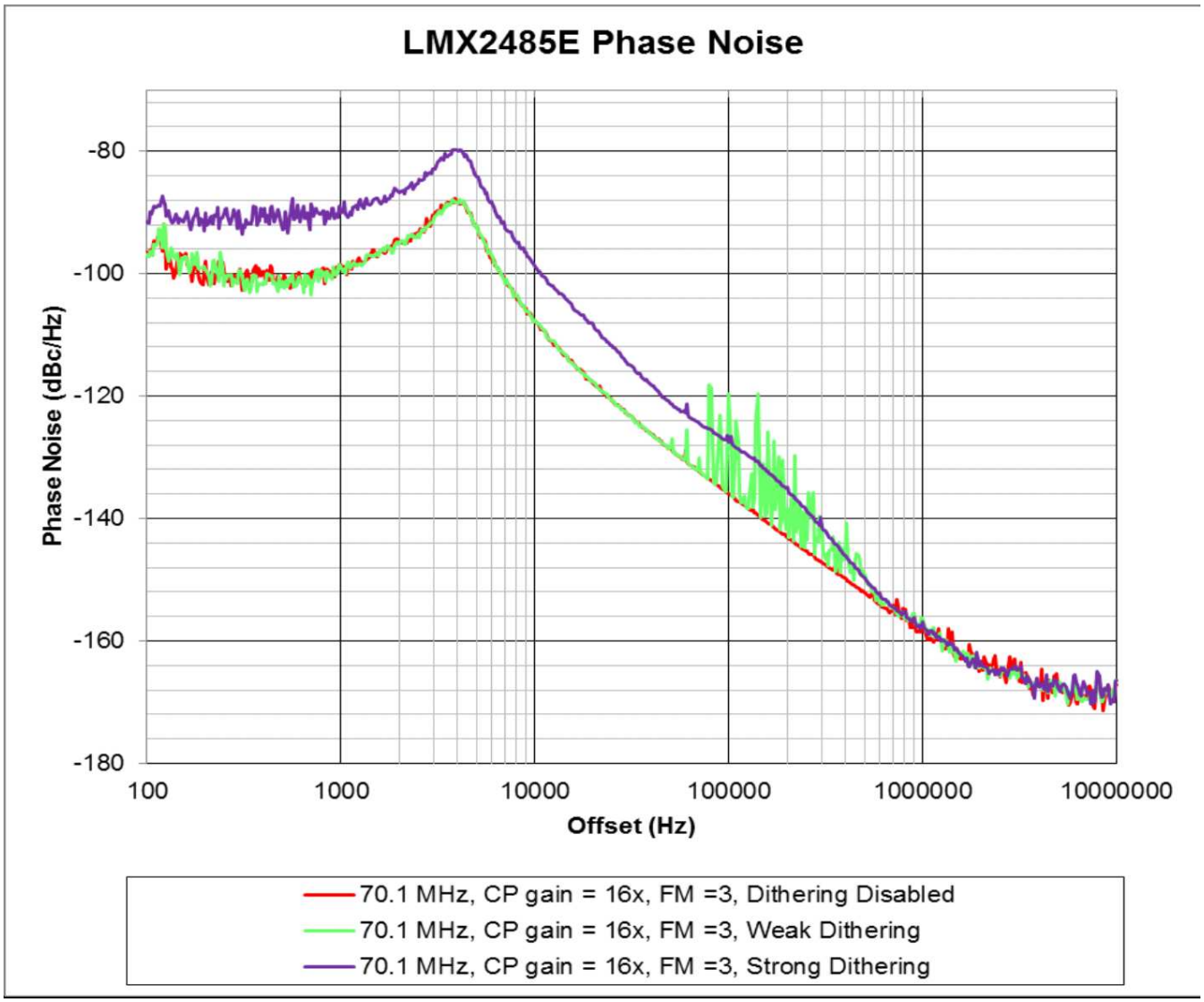


Figure 10. LMK2485E Impact of Dithering

8.2 LMX2487E Phase Noise Plots

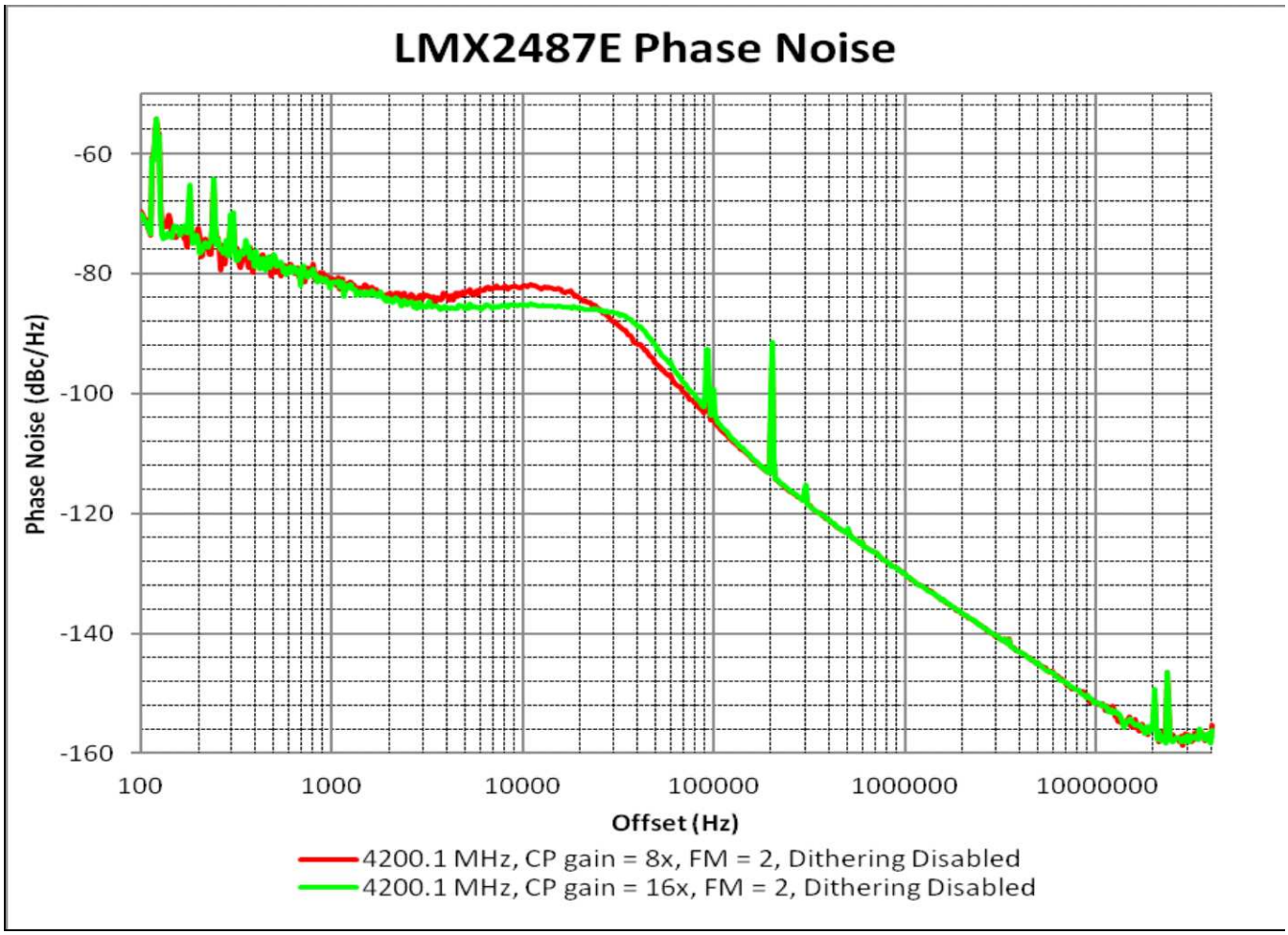


Figure 11. LMX2487E Impact of CPG on Phase Noise

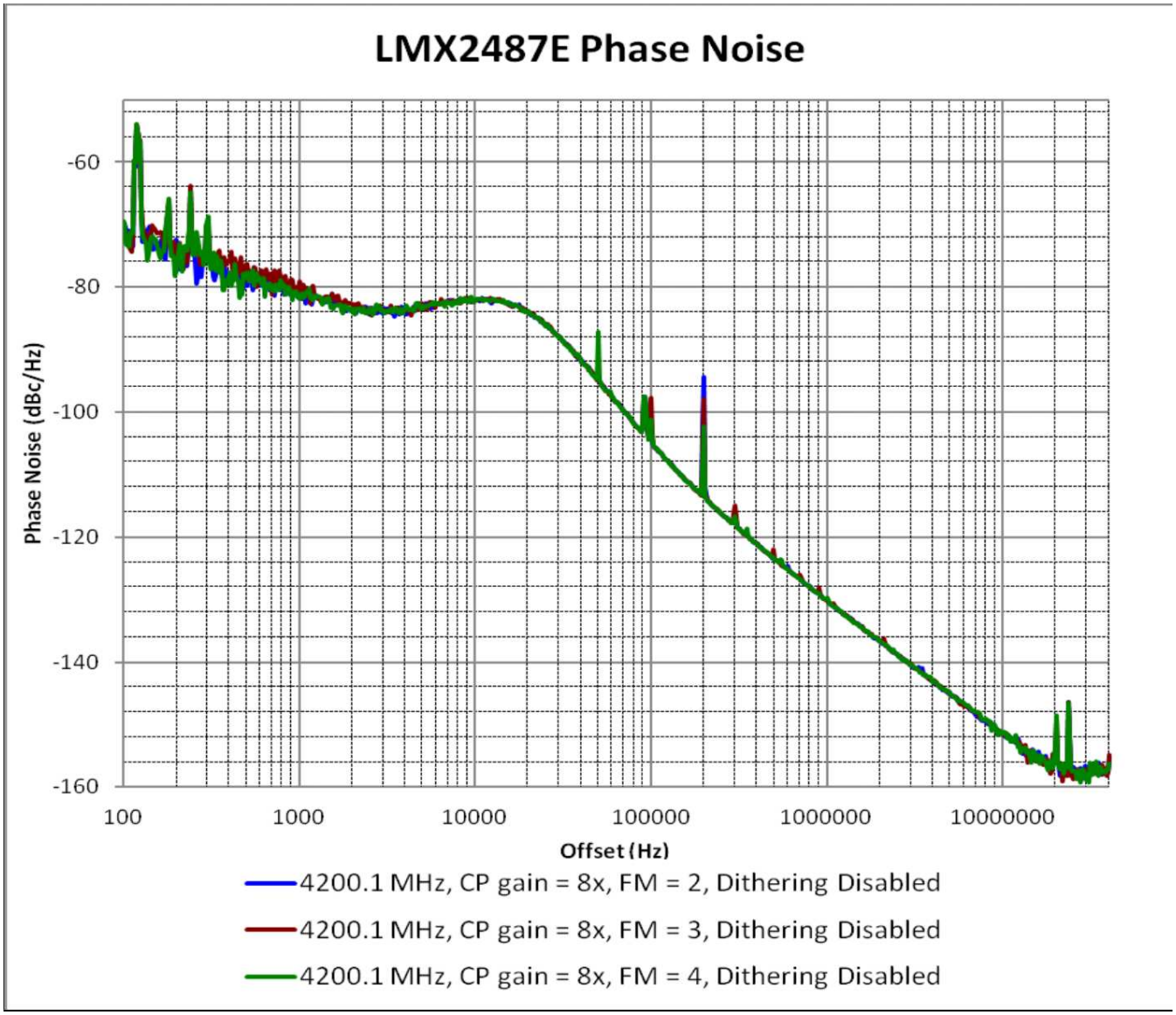


Figure 12. LMX2487E Impact on Fractional Modulator

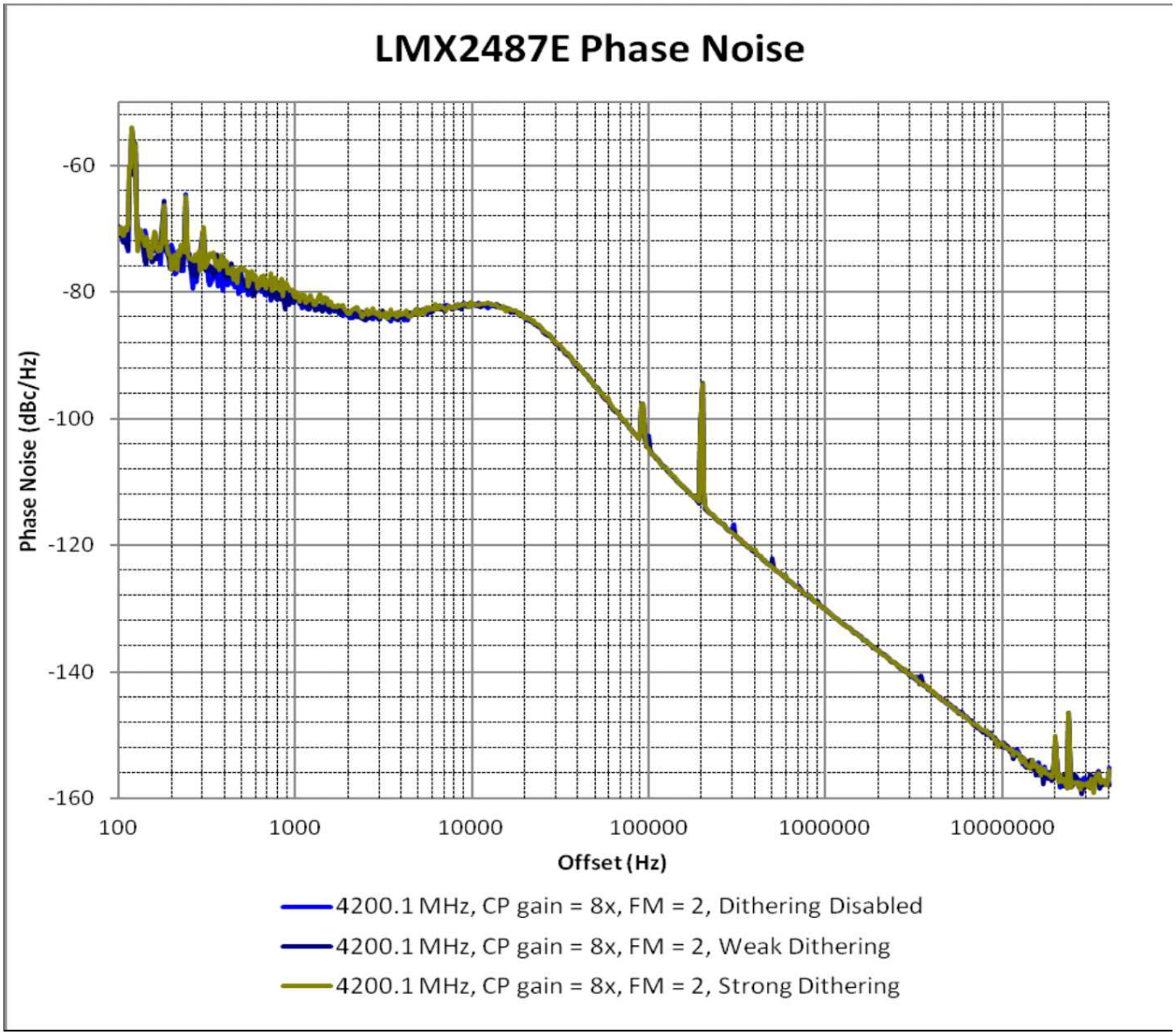


Figure 13. LMX2487E Impact of Dithering

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (March 2014) to B Revision **Page**

- Changed the EVM guide images and layout to the latest SDS standards 3
- Replaced the LMX2485, LMX2486, and LMX2487 board information sections with more generic EVM set-up sections .. 3
- Deleted *Quick Start for EVM Communications* section 3
- Changed Clock Design Tool to PLLatinum Sim 6
- Changed CodeLoader software to TICSPro 6

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.

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。
http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page

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。

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西新宿三井ビル

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。http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

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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