User's Guide
SNAU114C–March 2006–Revised May 2015

Using the LMX2485E & LMX2478E Evaluation Board

The Texas Instruments LMX2485E-EVM/LMX2487E-EVM helps designers evaluate the operation and performance of any of the devices 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.

Topic **Page**

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	

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

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
				Crystem CVCO55BE-1800-2200	1800-2200 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 availability, standard footprint, and for lower risk of being obsoleted.
WARNING! Due to availability issues, the LMX2485E-EVM has two different suppliers for VCO. Be sure to check the VCO model number to know what VCO model you have!

1 Setup

Input/Output Connector Description

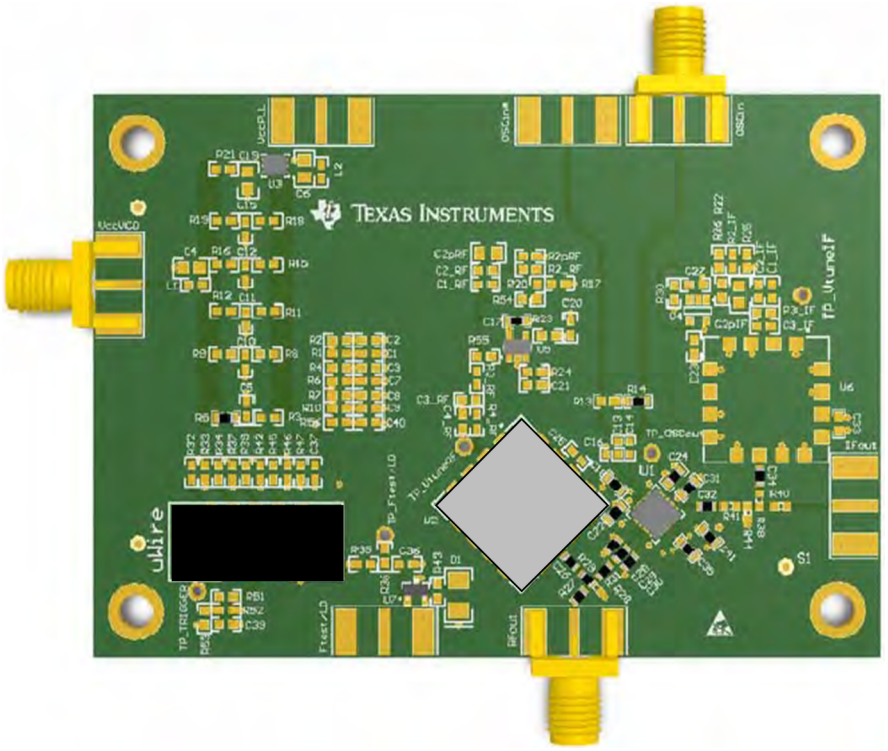

Figure 1. Evaluation Board Setup

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.

1.1 Loop Filter Values

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

1.2 RF PLL Loop Filter

Table 3. RF PLL Loop Filter Parameters

	LMX2485E	LMX2487E
VCO Used	Crystek CVCO55CL	Crystek CVCO55BH
VCO Gain	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
Kφ (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 kΩ

1.3 Installing the EVM Software

Go to http://www.ti.com/tool/codeloader
Click on the download button to download the software.
Run the executable file.

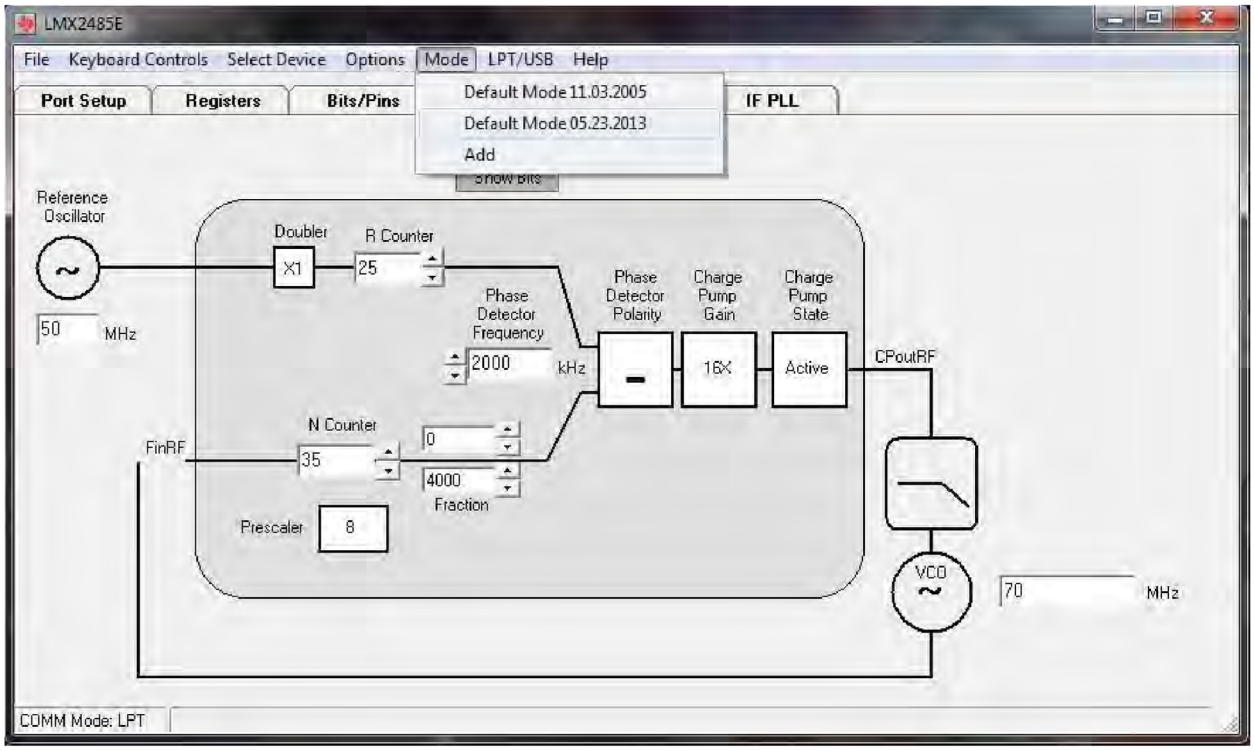

Figure 2. Using the EVM Software

On the Port Setup tab, the user may select the type of communication port (USB or Parallel) that will be used to program the device on the evaluation board. If parallel port is selected, the user should ensure that the correct port address is entered.
Don't forget to press <Ctrl>+L or do Keyboard Controls -> Load Device, to load the settings

2 Schematic

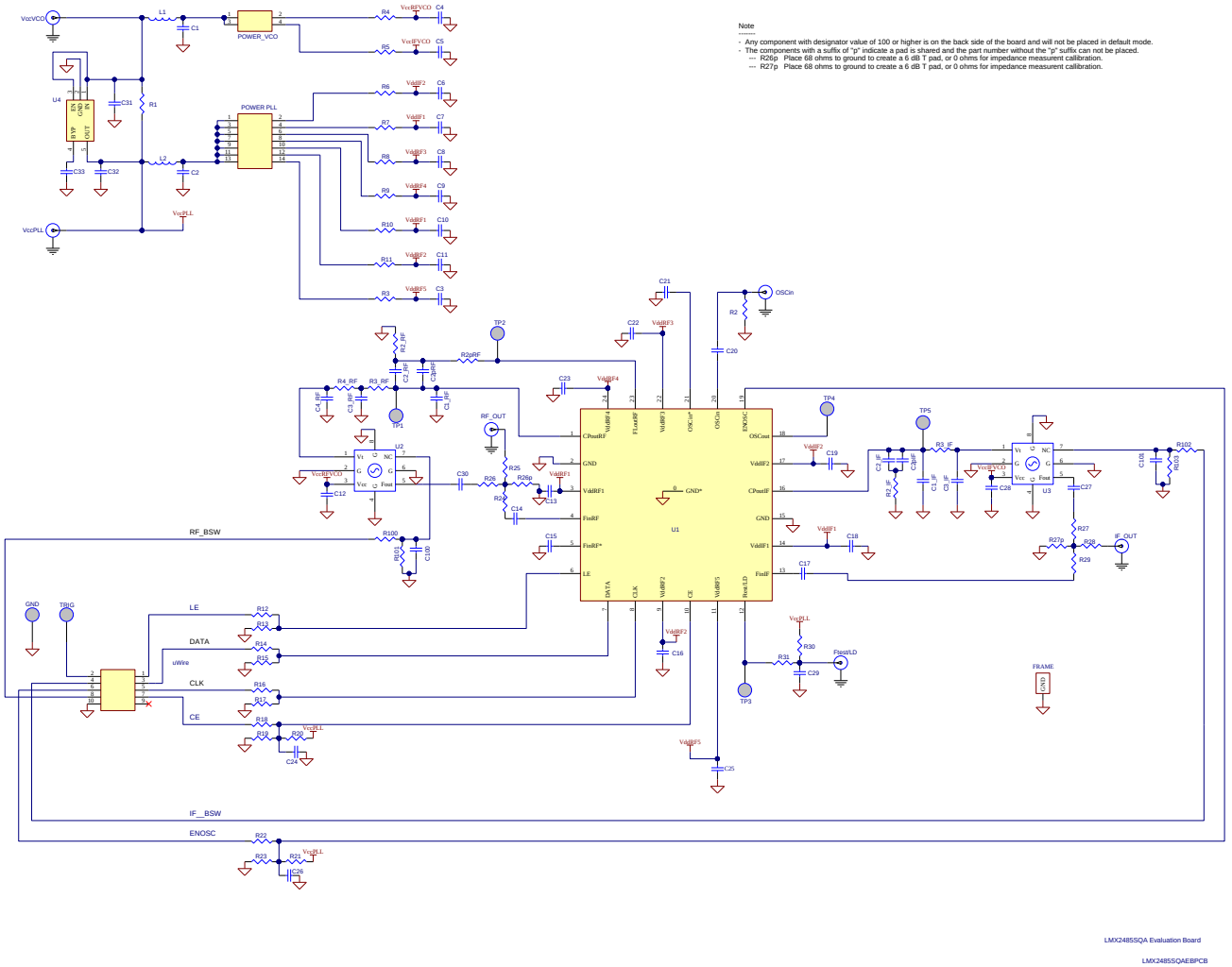

Figure 3. LMX2485E/87E-EVM Schematic

View Section 3 Bill of Materials for actual component values.

3 Bill of Materials

Table 4. Bill of Materials

Item	Designator	Description	Manufacturer	Part Number	Qty
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
24					
25					
26					
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

Table 4. Bill of Materials (continued)

Item	Designator	Description	Manufacturer	Part Number	Qty
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 5. Additional LMX2485E-EVM Specific Components

Item	Designator	Description	Manufacturer	Part Number	Qty
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 Componenents

Item	Designator	Description	Manufacturer	Part Number	Qy
33	U1	LMX2487E	Texas Instruments		1
34	U2		Crystek	CVCO55BH-4100-4300	1
35	C1_RF	CAP, CERM, 5600pF, 100V, +/-5%, X7R, 0603	AVX	06031C562JAT2A	1
36	C2_RF	CAP, CERM, 0.12uF, 10V, +/-10%, X5R, 0603	MuRata	GRM188R61A124KA01D	1
37	C3_RF	CAP, CERM, 220pF, 100V, +/-10%, X7R, 0603	AVX	06031C221KAT2A	1
38	C4_RF	CAP, CERM, 1000pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C102J5GAC	1
39	R2_RF	RES, 270 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603270RJNEA	1
40	R3_RF	RES, 1.2k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031K20JNEA	1
41	R4_RF	RES, 1.2k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06031K20JNEA	1

4 PCB Layers Stackup

6-layer PCB Stackup includes:

- Top Layer for high-priority high-frequency signals (2 oz.)
- FR4 Dielectric, 10 mils
- RF Ground plane (1 oz.)
- FR4, 23 mils
- Power plane #1 (1 oz.)
- FR4, 23 mils
- Bottom Layer copper clad for thermal relief (2 oz.)

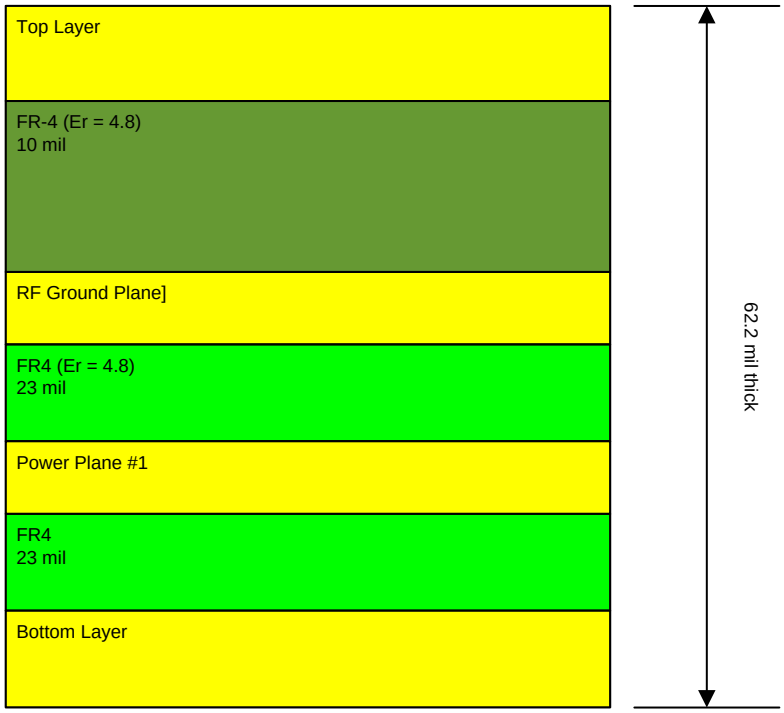

Figure 4. PCB Layers

5 PCB Layout

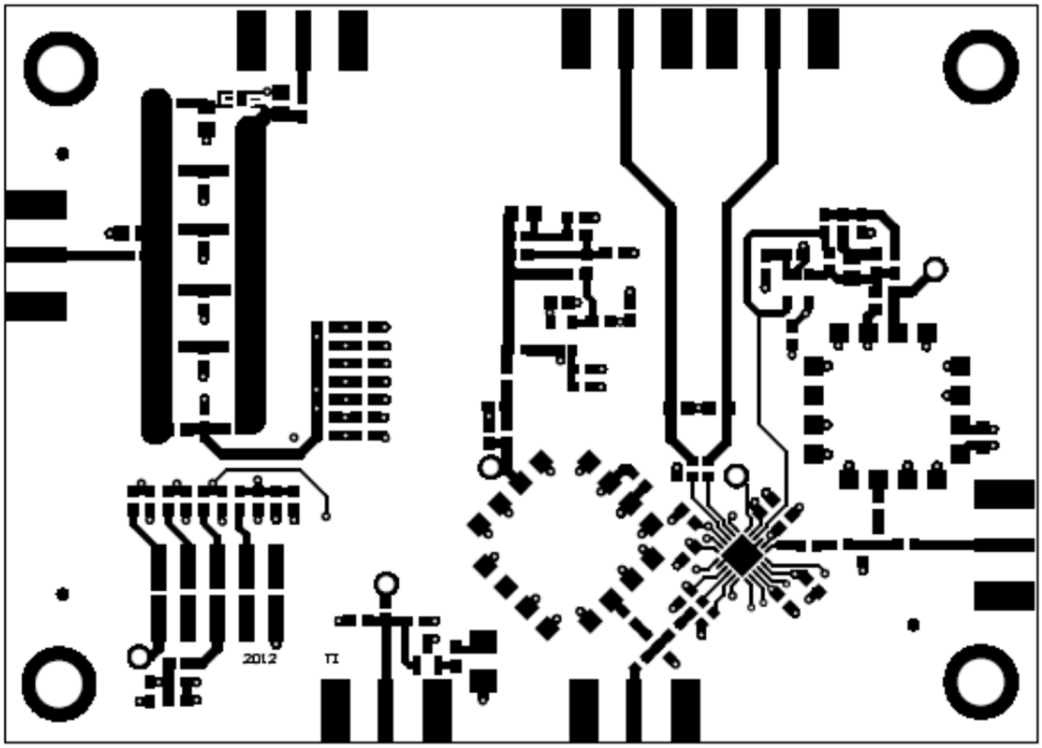

Figure 5. Layer #1 – Top

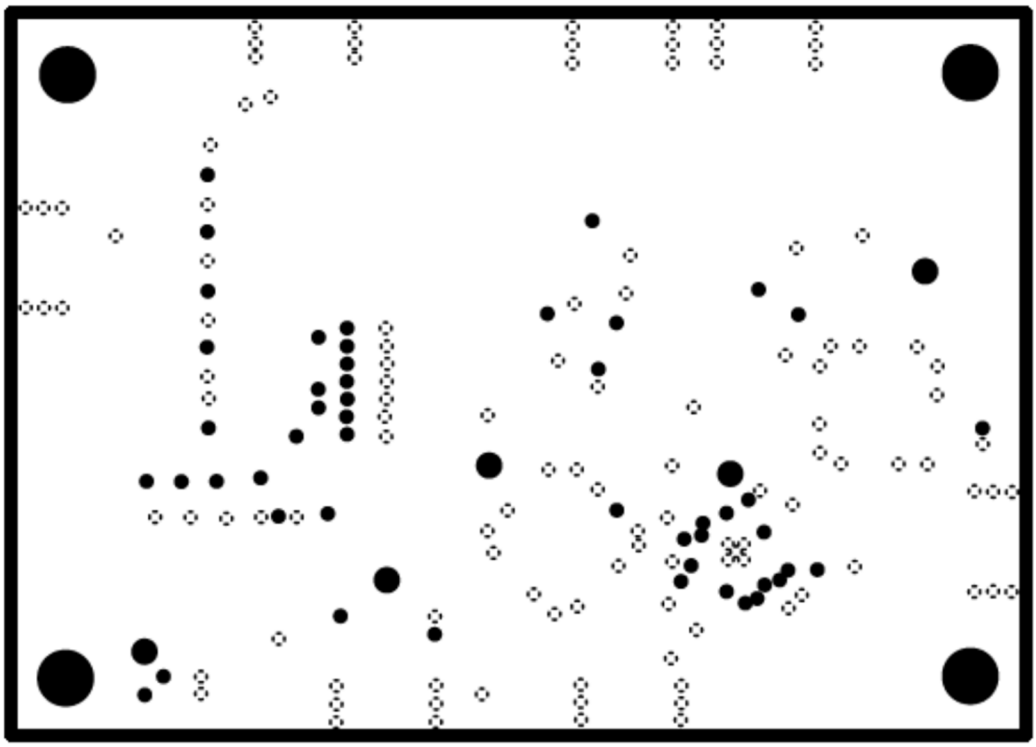

Figure 6. Layer #2 – RF Ground Plane

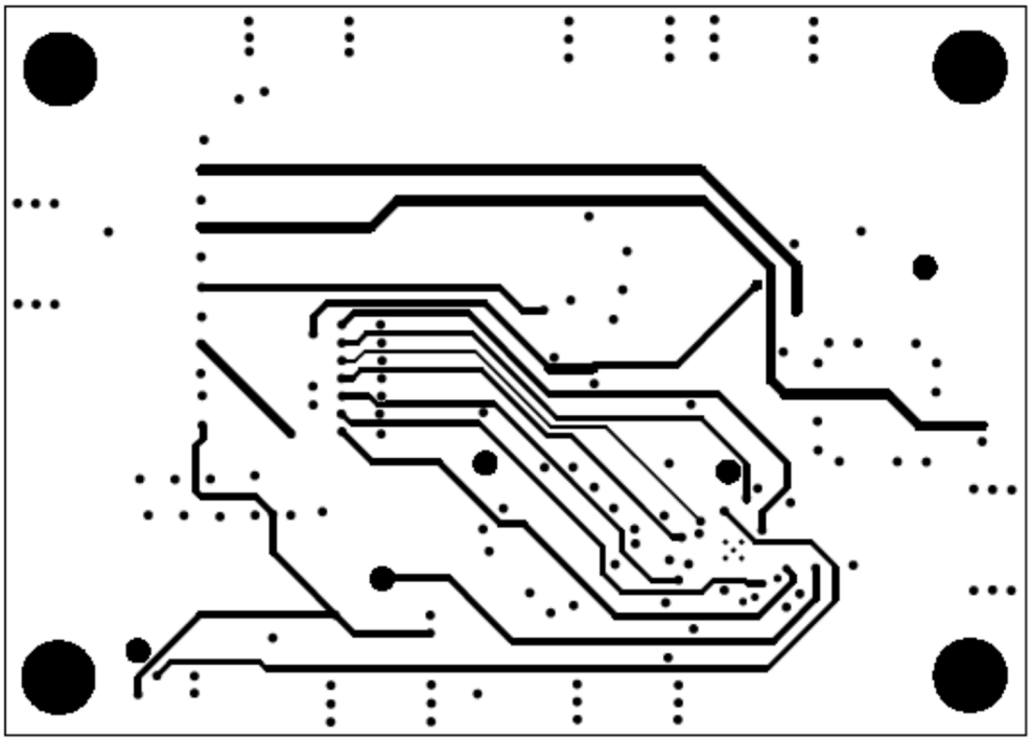

Figure 7. Layer #3 – Power

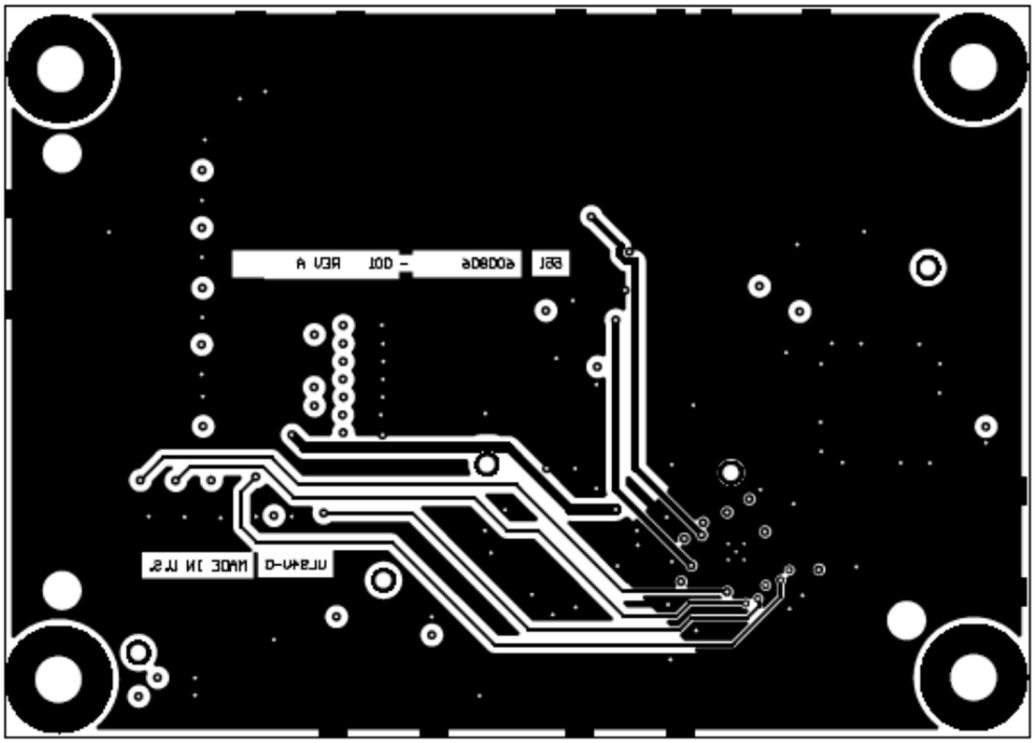

Figure 8. Layer #3 – Bottom Layer

6 Typical Phase Noise Performance Plots

LMX2485E Phase Noise Plots

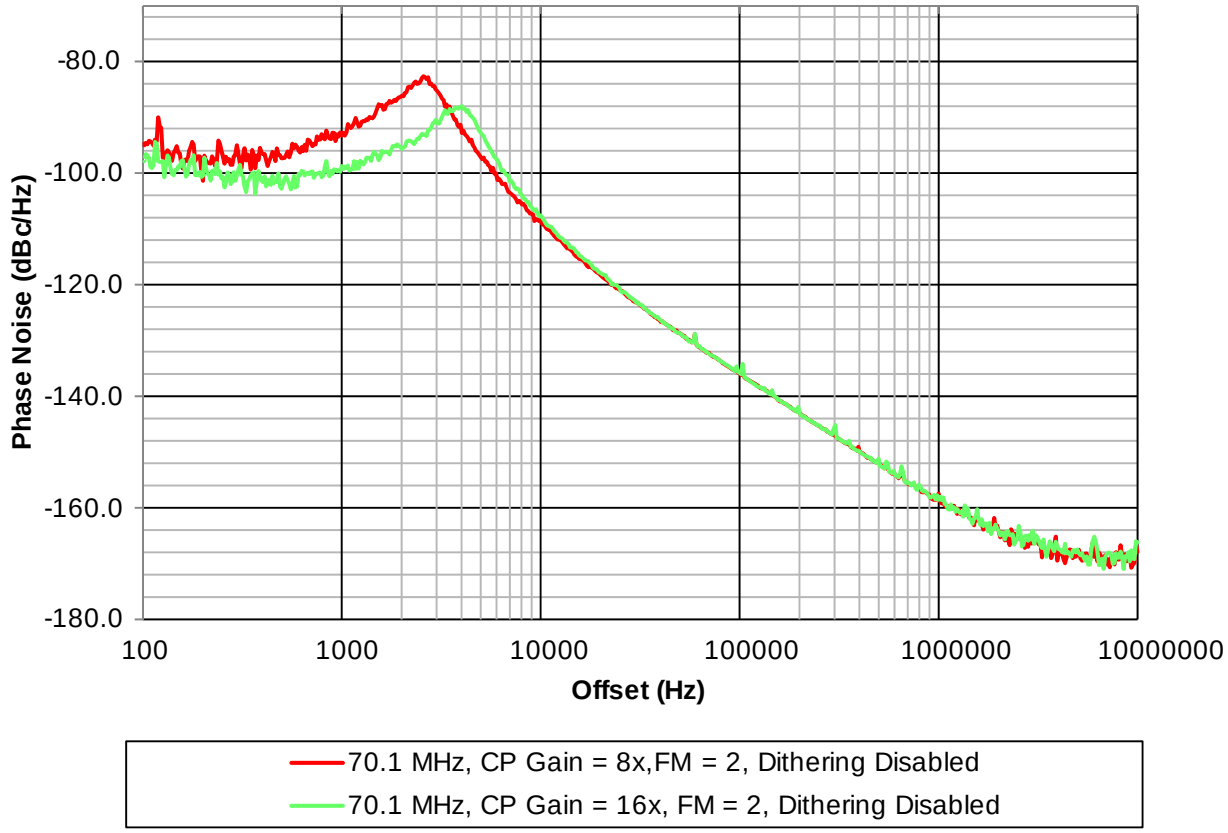

Figure 9. Impact of CPG on Phase Noise

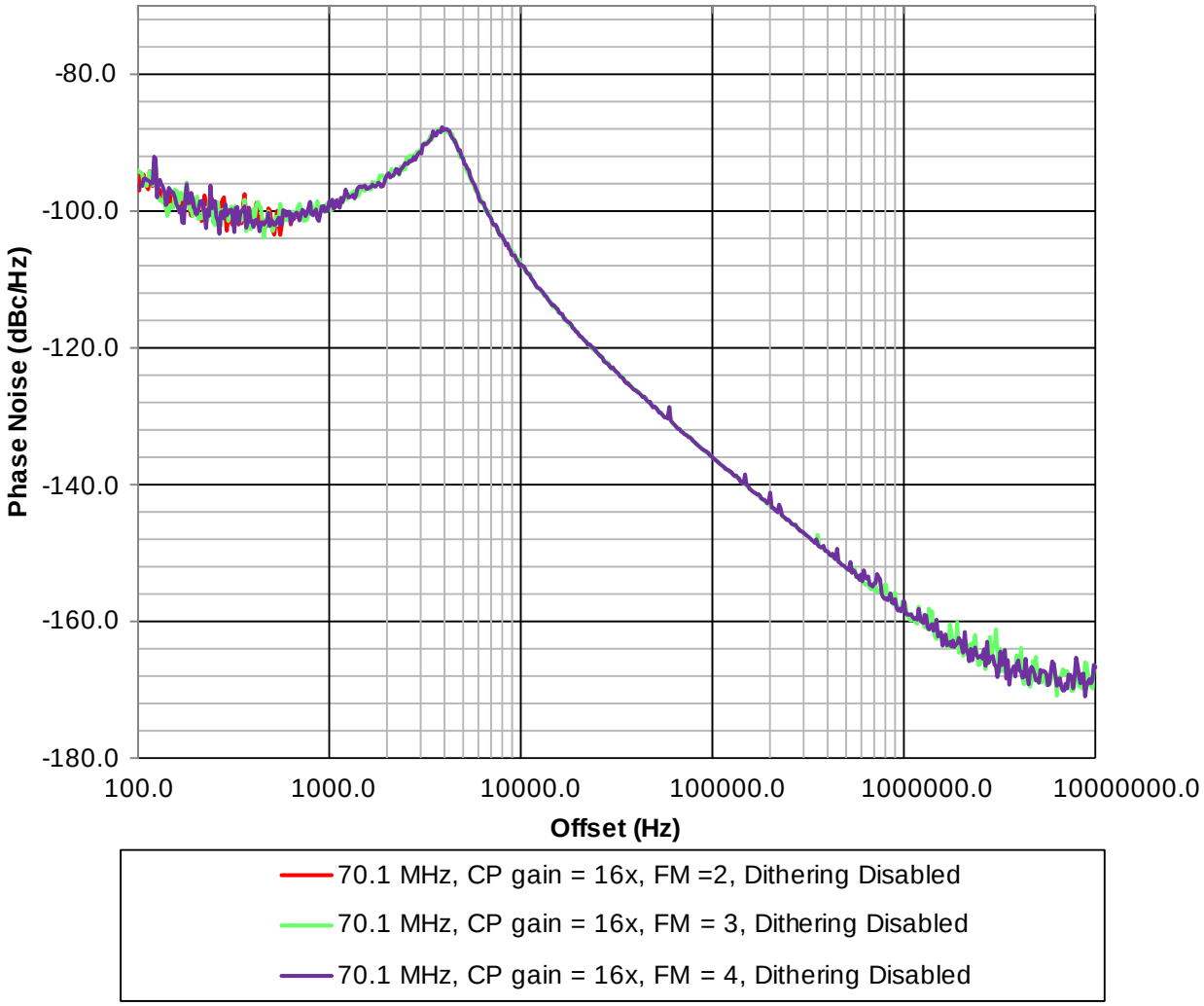

Figure 10. LMX2485E Impact of Fractional Modulator Order

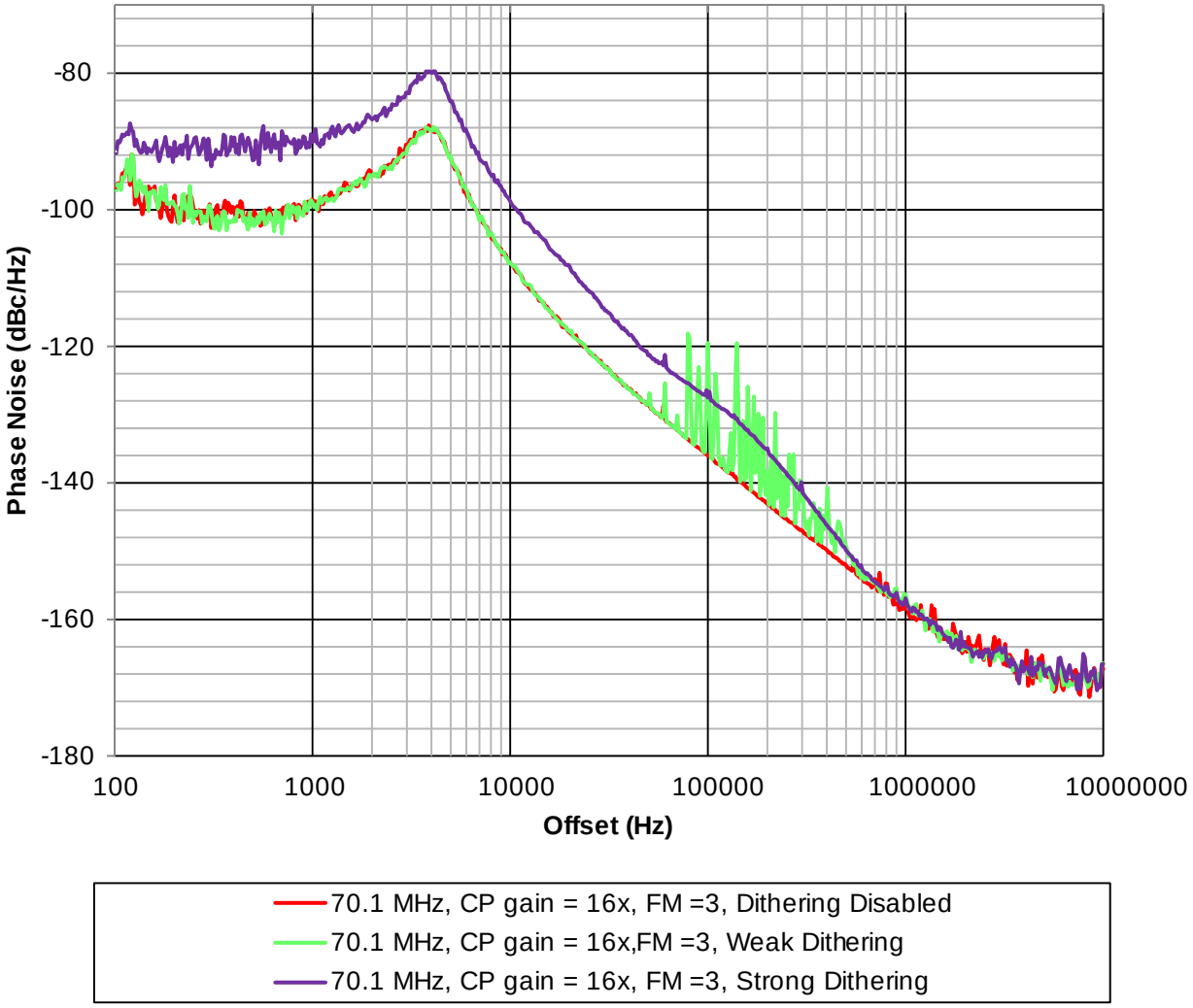

Figure 11. LMK2485E Impact of Dithering

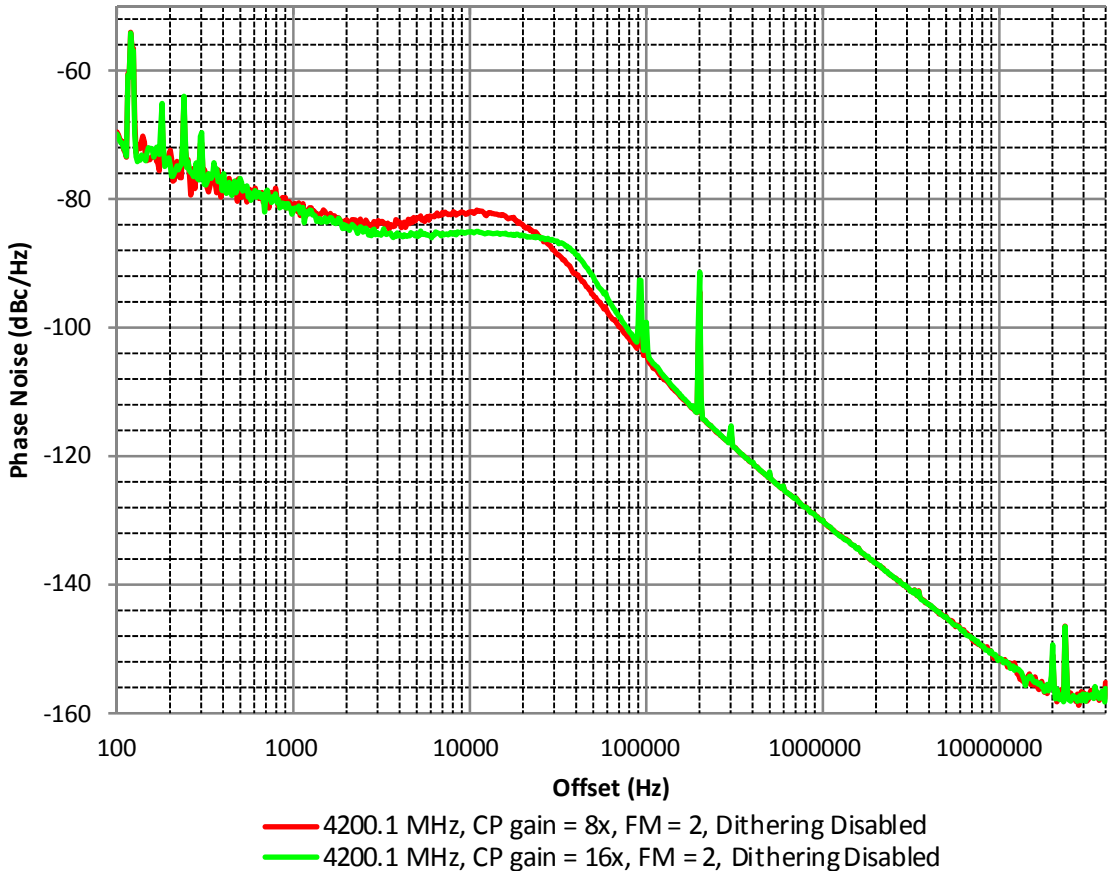

Figure 12. LMX2487E Impact of CPG on Phase Noise

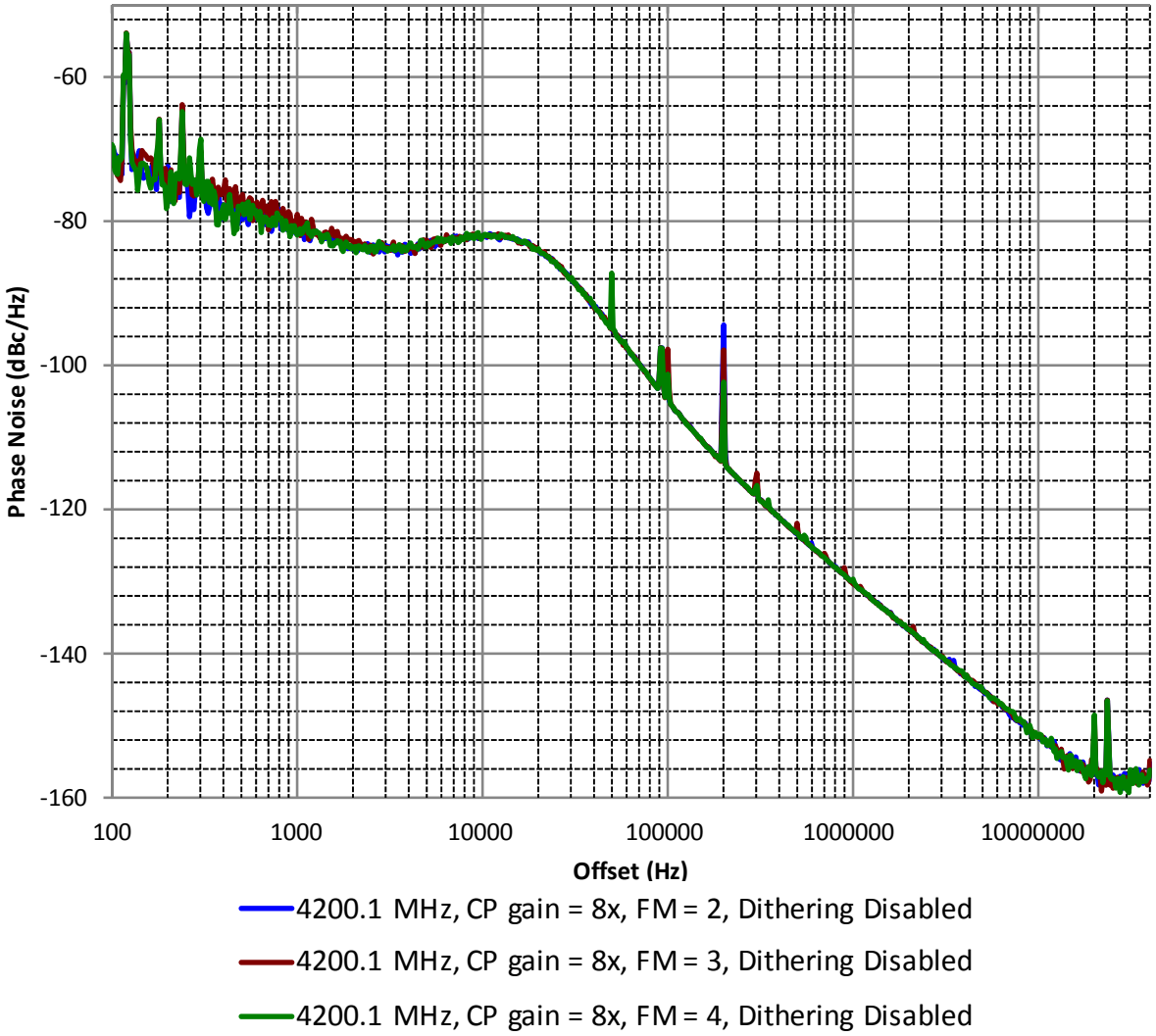

Figure 13. LMX2487E Impact on Fractional Modulator

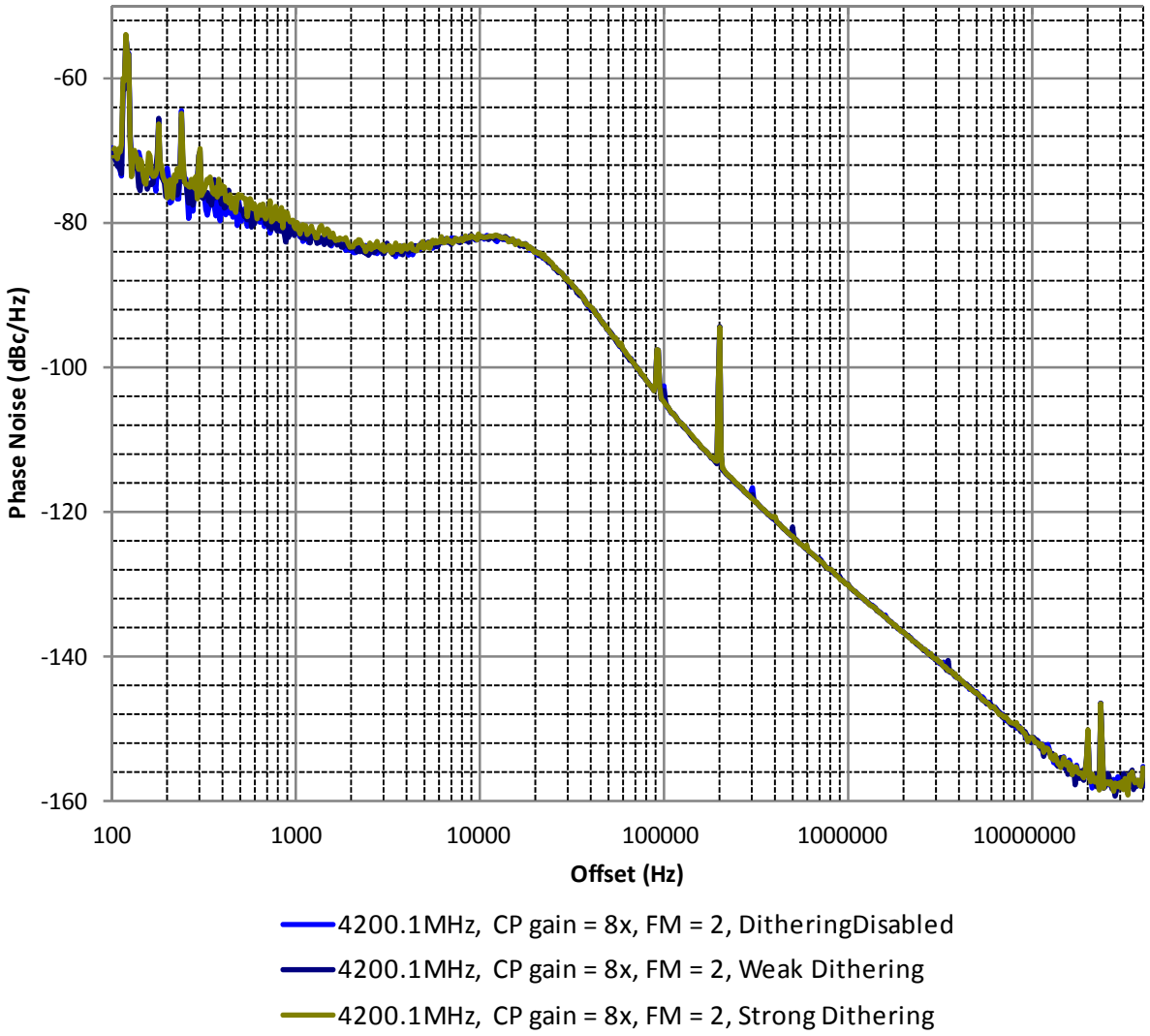

Figure 14. LMX2487E Impact of Dithering

Revision History

Changes from B Revision (April 2015) to C Revision	Page
• Changed schematic.	5

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

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.

   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 and conditions 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*:

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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 any defects that are 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. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.

   2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, 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:*

      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*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). 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 by Radio Law of Japan to follow the instructions below with respect to EVMs:

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.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

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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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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

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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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