User's Guide
LMX2594PSEVM Evaluation Instructions

TEXAS INSTRUMENTS

ABSTRACT

The LMX2594PSEVM uses two LMX2594 synthesizers to generate two phase-coherent outputs with very fine phase adjustment capability. The outputs of the synthesizers can also be combined to produce lower noise and jitter than is possible with just one.

The LMX2594 is a high-performance, wideband synthesizer that can generate any frequency from 10 MHz to 15 GHz without using an internal doubler, thus eliminating the need for sub-harmonic filters.
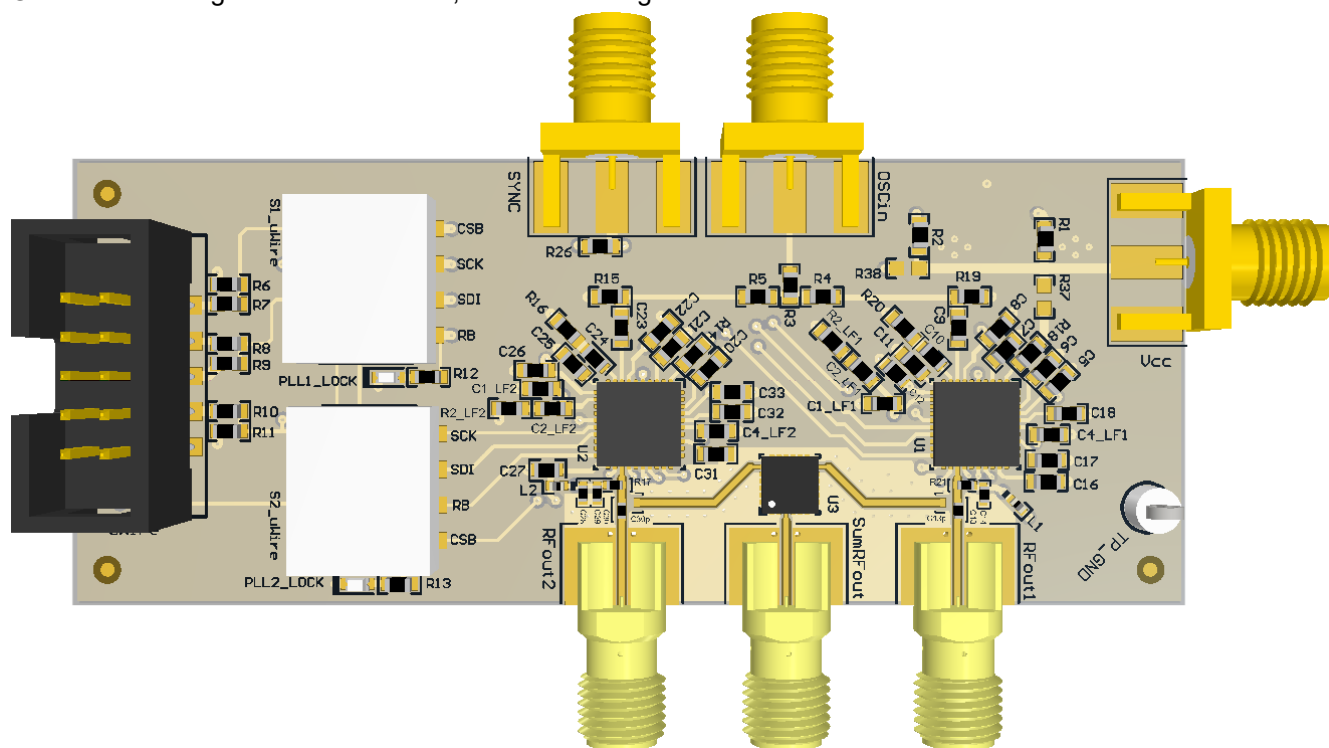
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1 LMX2594PSEVM Evaluation Module

1.1 Evaluation Module Contents

The following is included in the package:
- One LMX2594PSEVM board (DC193-001).
- One Reference PRO board (SV601349).
- One USB cable.
- One 10-pin ribbon cable.

1.2 Evaluation Setup Requirement

The evaluation requires the following hardware and software:
- A DC power supply
- A spectrum analyzer or a signal analyzer
- A PC running Windows® 7 or more recent version
- An oscilloscope
- A high quality signal generator
- Texas Instruments Clocks and Synthesizers TICS Pro software
- Texas Instruments PLLatinum™ Simulator Tool (optional)

1.3 Resources

Related evaluation and development resources include:
- LMX2594 data sheet
- TICS Pro software
- PLLatinum Simulator Tool (PLL Sim)
- Reference PRO design file
- Reference designs:
  - TIDA-01410
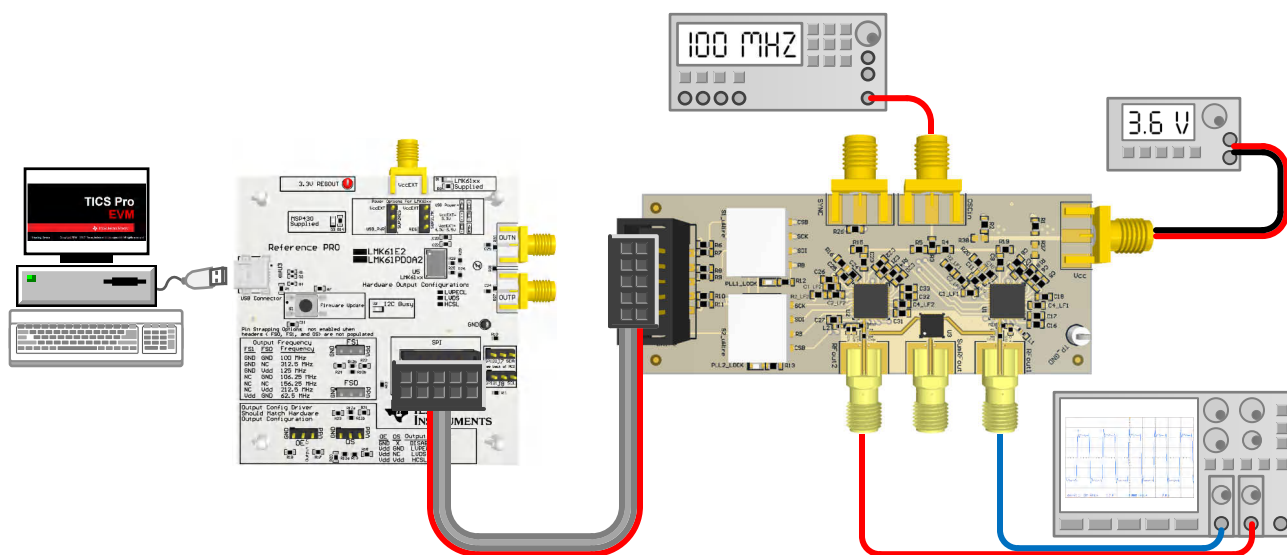 - TIDA-01346

2 Setup

2.1 Connection Diagram

Figure 2-1. Connection Diagram

2.2 Power Supply

Apply 3.6 V to Vcc SMA connector. Acceptable supply voltage range is 3.5 V to 5 V. The maximum current consumption in the most extreme configuration must not exceed 1200 mA. The onboard LDOs will provide a 3.3-V supply to the LMX2594 devices.

2.3 Reference Clock

Connect a low jitter reference clock to the OSCin SMA connector. This clock is evenly distributed to both LMX2594 devices. If a sine wave clock is used, 8 dBm or more input power is suggested.

2.4 SYNC Input

In category 1 and 2 phase synchronization, the timing of the SYNC signal is not critical. This SYNC signal can be generated from the Reference Pro board. In category 3 phase synchronization, the SYNC signal has to be carefully aligned with the reference clock of the synthesizers. This SYNC signal shall be provided externally to the SYNC SMA connector.

2.5 RF Output

Each LMX2594 device has two RF outputs, but only RFoutA is used. By default, RFoutAP pin is connected to the SMA connector while the RFoutAM pin is terminated onboard. This is the default configuration to measure the phases between the outputs of the LMX2594 devices. With some modification to the EVM, the sum of the two LMX2594 devices output can be obtained from the SumRFout SMA connector. See Section 7 for more information on EVM modification.

2.6 Programming

Connect the ribbon cable from the Reference PRO to the LMX2594PSEVM.

Connect the USB cable from a PC to the USB port on the Reference PRO board. This provides a power supply to the Reference PRO board and communication with the TICS Pro software. A firmware update may be required. See Section 9.4 for details.

The two LMX2594 devices share the uWIRE socket but only one device can be programmed at a time. Make sure that only one of the DIP switches is in the ON position at a time.

Figure 2-2. uWIRE Switches

2.7 Evaluation Software

Download and install TICS Pro to a PC. Run the software and follow the following steps to get started.

1. Go to *Select Device → PLL + VCO → LMX2594*.
2. Go to *Default Configuration → Default Mode*.

3 Typical Measurement

3.1 Category 3 Synchronization

Use the flow chart in the data sheet to determine the phase synchronization category. If it is a category 3 synchronization, there is limitation to the reference clock frequency and the timing of the SYNC signal with respect to the reference clock is critical. Shown below is a category 3 synchronization example.
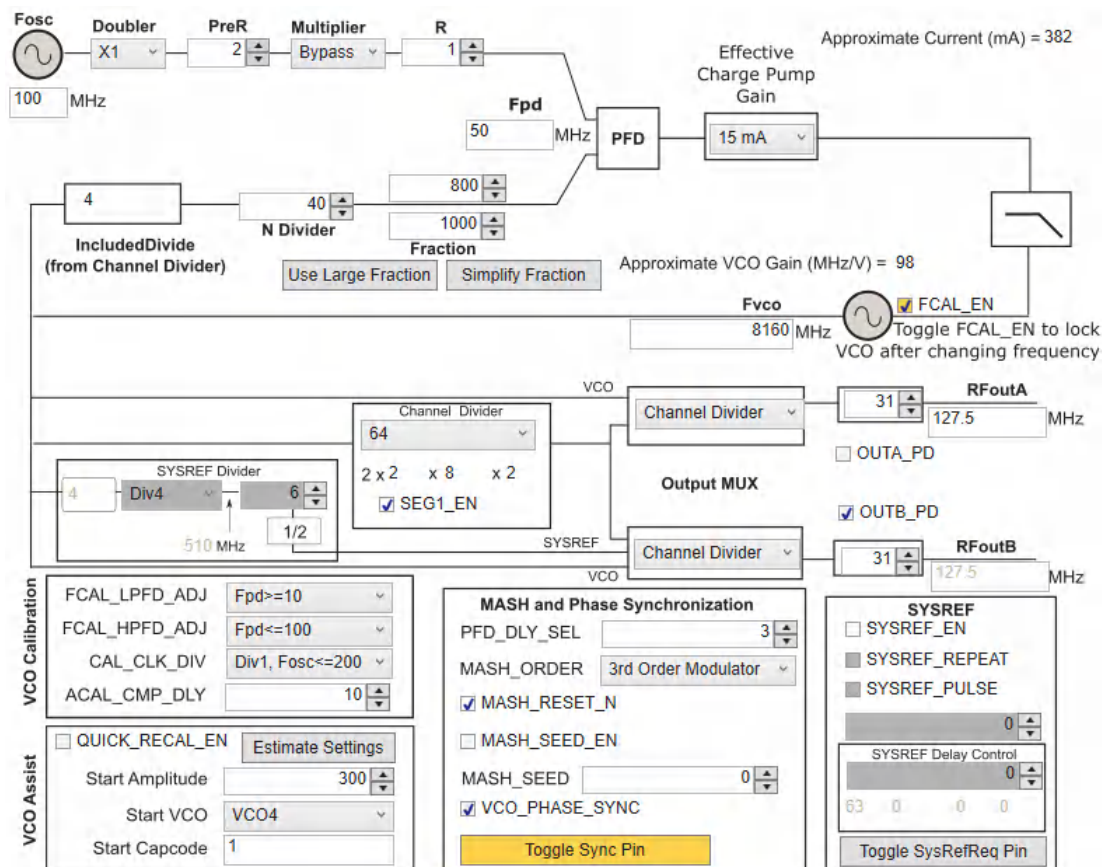

Figure 3-1. Category 3 TICS Pro Configuration

If it is a category 3 synchronization, VCO_PHASE_SYNC should be checked to put the devices in SYNC mode. After programming, the outputs from the two LMX2594 devices may not be phase-aligned.
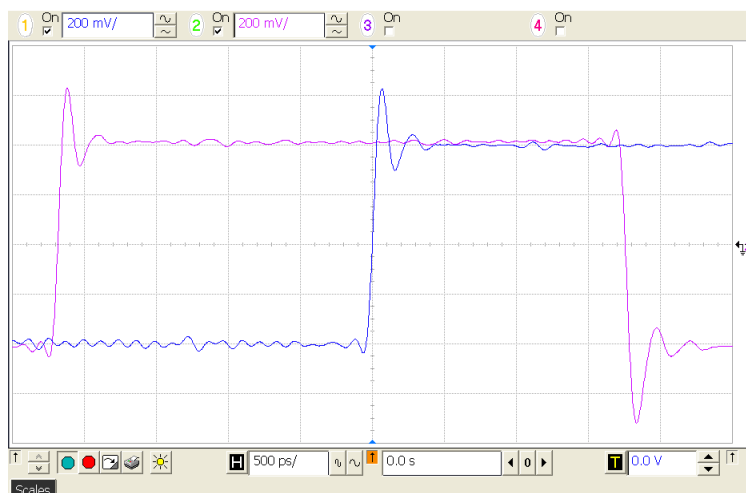

Figure 3-2. Output Phases Before Synchronization

A timing critical SYNC pulse is needed to trigger synchronization.
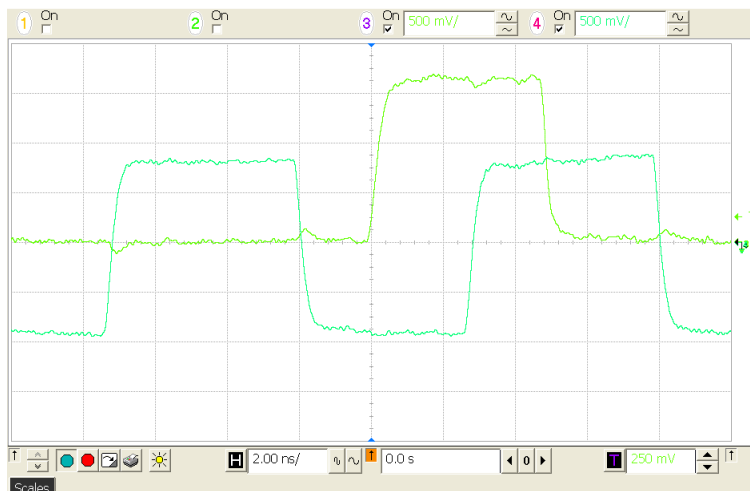
Figure 3-3. Timing Critical SYNC Pulse

Figure 3-4. Output Phases After Synchronization

3.2 Phase Noise Improvement

By combining the output of two synthesizers that are in-phase, a theoretical 3-dB phase noise benefit is possible due to the output power being 6-dB higher while the noise power is only 3-dB higher.

To measure the combined phase noise, some modification to the EVM is needed. See Section 7 for details.

In Figure 3-5, the blue trace shown the phase noise of individual LMX2594 device while the black trace respresented the phase noise of the combined signal.

Figure 3-5. Combined Phase Noise

4 Schematic

Figure 4-1. LMX2594PSEVM Schematic (Page 1)
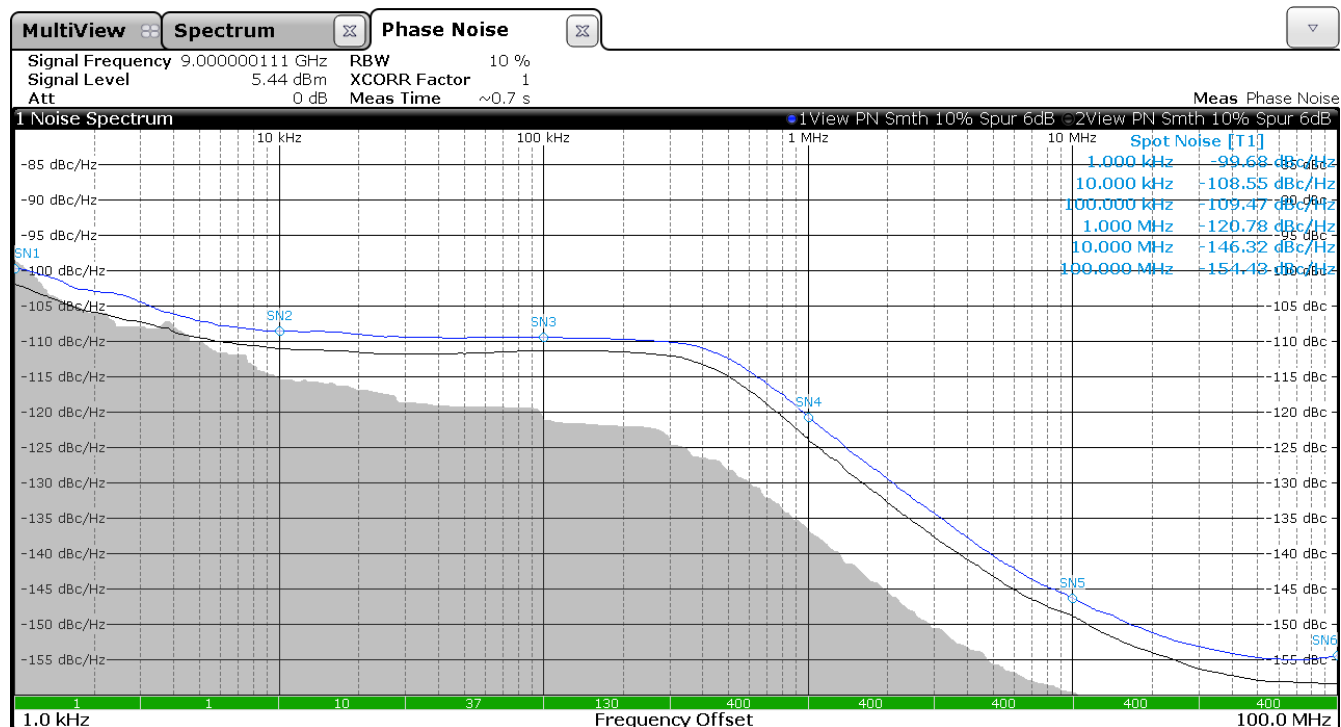

Figure 4-2. LMX2594PSEVM Schematic (Page 2)
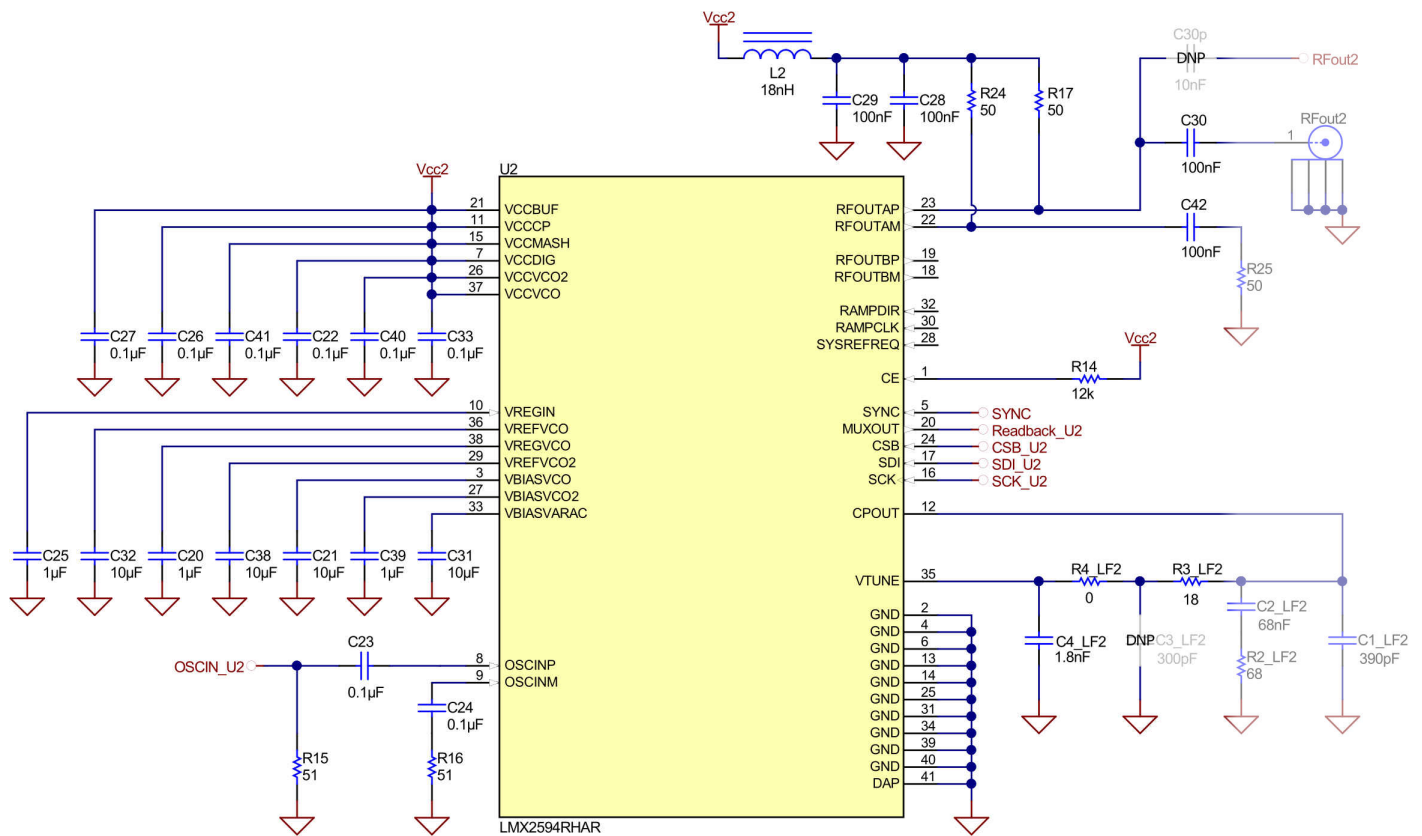
Figure 4-3. LMX2594PSEVM Schematic (Page 3)

5 PCB Layout and Layer Stack-up
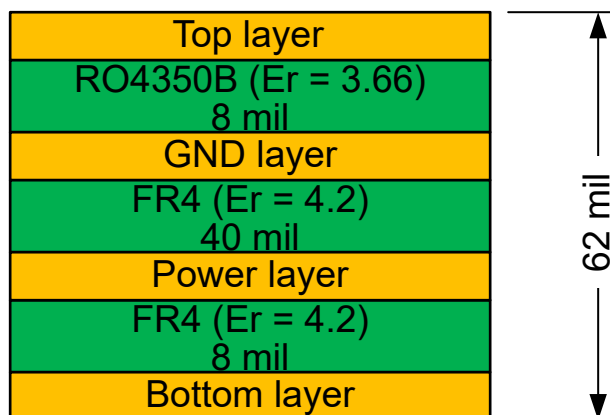
5.1 PCB Layer Stack-Up

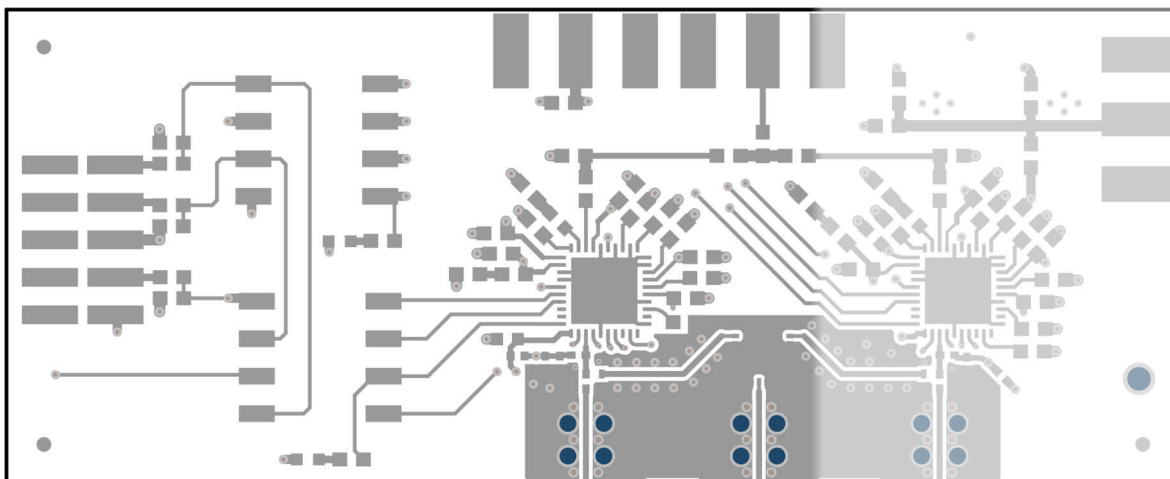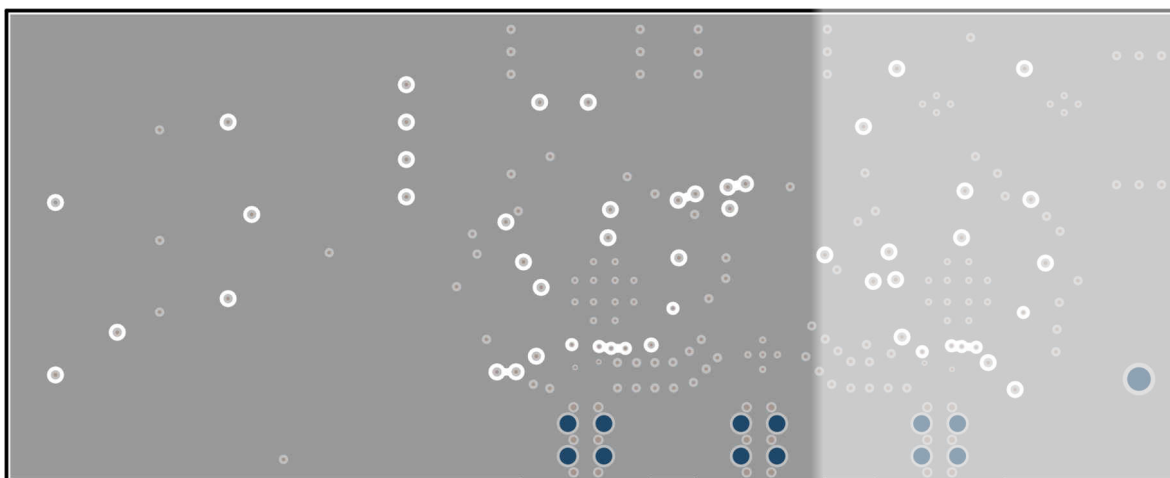**Figure 5-1. PCB Layer Stack-Up**

5.2 PCB Layout
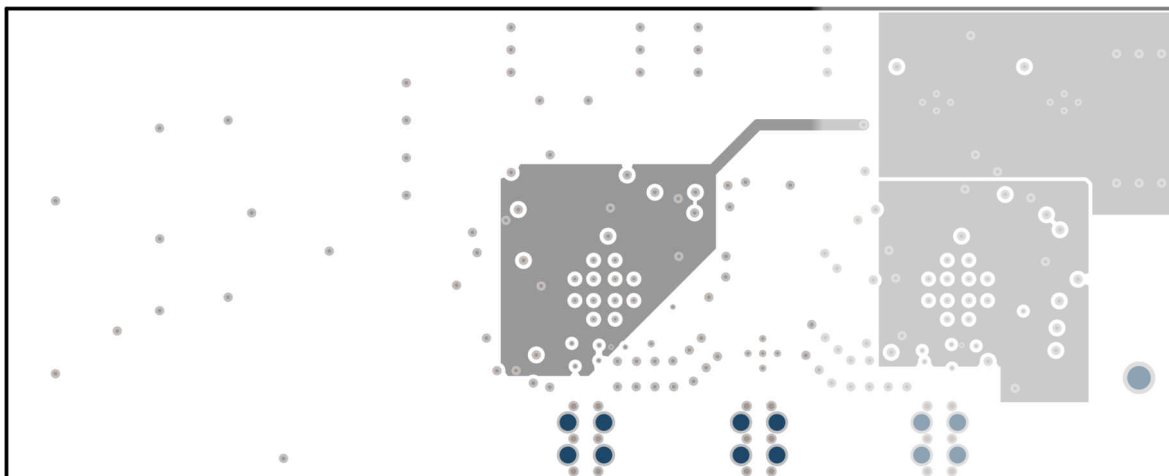

Figure 5-2. Top Layer

Figure 5-3. GND Layer
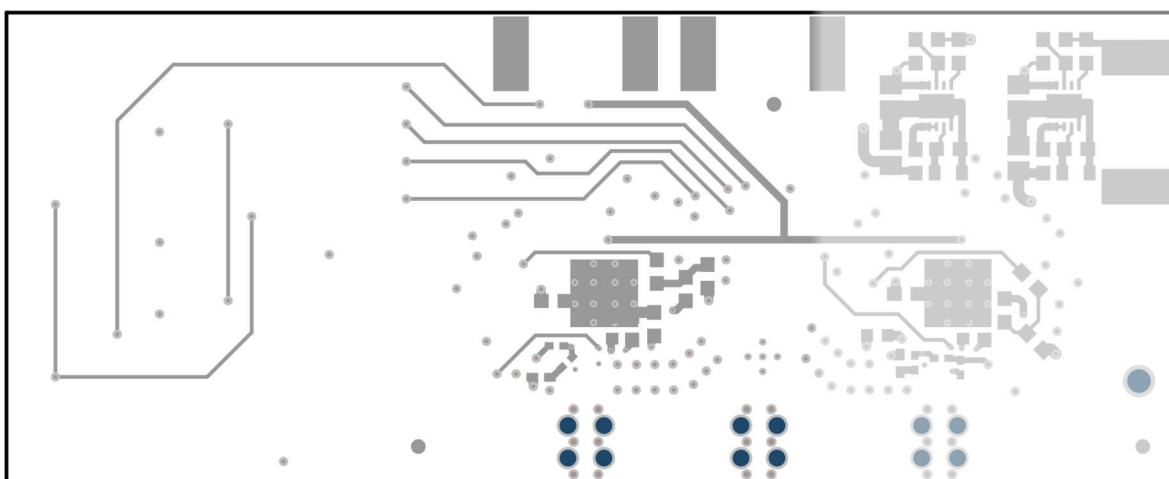
Figure 5-4. Power Layer

Figure 5-5. Bottom Layer

6 Bill of Materials

Table 6-1. Bill of Materials

DESIGNATOR	QUANTITY	DESCRIPTION	PART NUMBER	MANUFACTURER
C1, C2, C3, C4	4	CAP, CERM, 10 µF, 16 V, 10%, X7R, 0805	EMK212BB7106KG-T	Taiyo Yuden
C1_LF1, C1_LF2	2	CAP, CERM, 390 pF, 50 V, 5%, C0G/NP0, 0603	06035A391JAT2A	AVX
C2_LF1, C2_LF2	2	CAP, CERM, 0.068 µF, 25 V, 10%, X7R, 0603	885012206070	Wurth Elektronik
C4_LF1, C4_LF2	2	CAP, CERM, 1800 pF, 50 V, 5%, C0G/NP0, 0603	GRM1885C1H182JA01D	MuRata
C5, C8, C9, C10, C12, C22, C23, C24, C26, C27, C33, C35, C36, C37, C40, C41	16	CAP, CERM, 0.1 µF, 16 V, 5%, X7R, 0603	0603YC104JAT2A	AVX
C6, C11, C20, C25, C34, C39	6	CAP, CERM, 1 µF, 16 V, 10%, X7R, 0603	885012206052	Wurth Elektronik
C7, C16, C17, C18, C21, C31, C32, C38	8	CAP, CERM, 10 µF, 10 V, 10%, X5R, 0603	GRM188R61A106KAALD	MuRata
C13, C14, C15, C28, C29, C30, C42, C43	8	CAP, CERM, 0.1 µF, 16 V, 10%, X7R, 0402	530L104KT16T	AT Ceramics
C44, C45	2	CAP, CERM, 4.7 µF, 50 V, X7R, 10%, 0805	CGA4J1X7R1H475K125AC	TDK Corporation
D1, D2	2	LED, Green, SMD	LTST-C190GKT	Lite-On
J1, J2, J4	3	Connector, End launch SMA 50 ohm, TH	142-0761-881	Cinch Connectivity
J3, J5, J6	3	Connector, End launch SMA, 50 ohm, SMT	142-0701-851	Cinch Connectivity
L1, L2	2	Inductor, Multilayer, Air Core, 18 nH, SMD	LQG15HS18NJ02D	MuRata
R1, R2, R4_LF1, R4_LF2, R26, R30, R35	7	RES, 0, 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
R2_LF1, R2_LF2	2	RES, 68, 5%, 0.1 W, 0603	CRCW060368R0JNEA	Vishay-Dale
R3, R3_LF1, R3_LF2, R4, R5, R7, R8, R10	8	RES, 18, 5%, 0.1 W, 0603	CRCW060318R0JNEA	Vishay-Dale
R6, R9, R11, R14, R18, R27, R28, R31, R32, R33, R36	11	RES, 12 k, 5%, 0.1 W, 0603	CRCW060312K0JNEA	Vishay-Dale
R12, R13	2	RES, 330, 5%, 0.1 W, 0603	RC0603JR-07330RL	Yageo
R15, R16, R19, R20	4	RES, 51, 5%, 0.1 W, 0603	CRCW060351R0JNEA	Vishay-Dale
R17, R21, R22, R23, R24, R25	6	RES, 50, 0.1%, 0.05 W, 0402	FC0402E50R0BST1	Vishay-Dale
R29, R34	2	RES, 22.1 k, 1%, 0.1 W, 0603	CRCW060322K1FKEA	Vishay-Dale
S1, S2	2	Switch, SPST, Slide, Off-On, 4 Pos, SMD	219-4MST	CTS Electrocomponents
TP1	1	Test Point, White, TH	5007	Keystone Electronics
U1, U2	2	15 GHz RF Synthesizer	LMX2594RHAR	Texas Instruments
U3	1	Power Splitter/Combiner, 50Ohm, 1.8 to 12.5 GHz	EP2C+	Minicircuits
U4, U5	2	1-A, Ultra-Low Noise LDO	TPS7A9401DSCR	Texas Instruments
uWire	1	Header (shrouded), 100 mil, 5x2, Gold, SMT	52601-S10-8LF	FCI
C1, C2, C3, C4	4	CAP, CERM, 10 µF, 16 V, 10%, X7R, 0805	EMK212BB7106KG-T	Taiyo Yuden
C1_LF1, C1_LF2	2	CAP, CERM, 390 pF, 50 V, 5%, C0G/NP0, 0603	06035A391JAT2A	AVX

7 EVM Modification

The default EVM configuration has the outputs of the LMX2594 devices connected to the RFout1 and RFout2 SMA connectors. To evaluate the phase noise improvement by summing the two outputs together, do the following modifications.

- Move C13 to C13p
- Move C30 to C30p
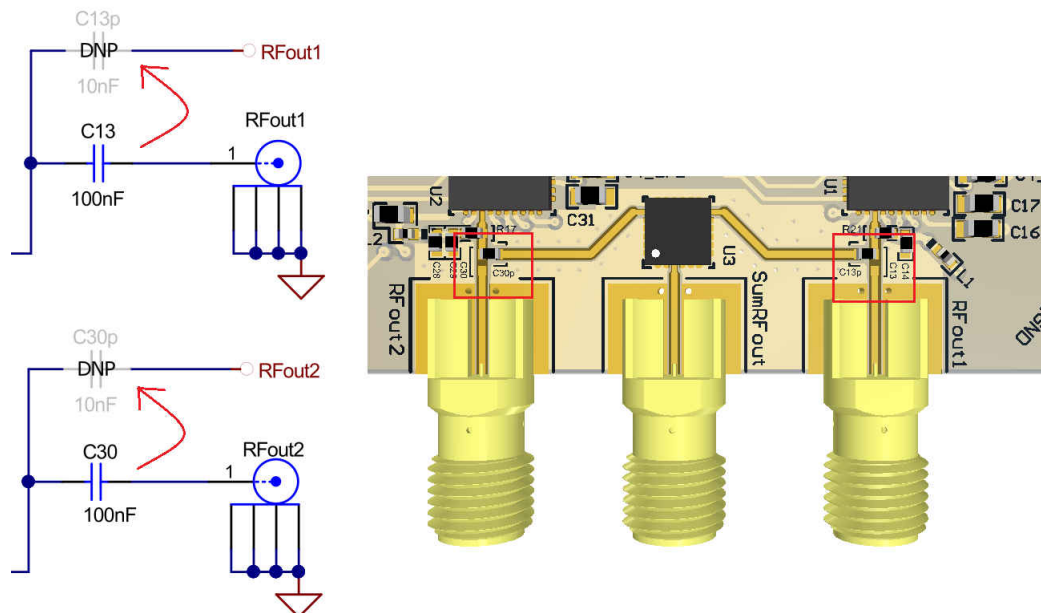
Figure 7-1. EVM Modification for Phase Noise Reduction

8 Troubleshooting Guide

If the EVM does not work as expected, use the following chart to identify potential root causes. Remember:
- Verify that the EVM is in working order before you make modifications to the EVM or change the default settings
- Register readback requires the correct hardware and software setup.
- The POR current of the LMX2594PSEVM is approximately 400 mA.

Figure 8-1. Trouble Shooting Guide

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9 Reference PRO

The Reference PRO board is used to program the LMX2594PSEVM and provide a clean reference clock to LMX2594PSEVM at the same time. The board has several control pins dedicated for control of output format, output frequency, and output enable control. These control pins are configurable through the jumpers by strapping the center pin to Vdd position or GND position. Connections from the Vdd position to the device supply or from the GND posi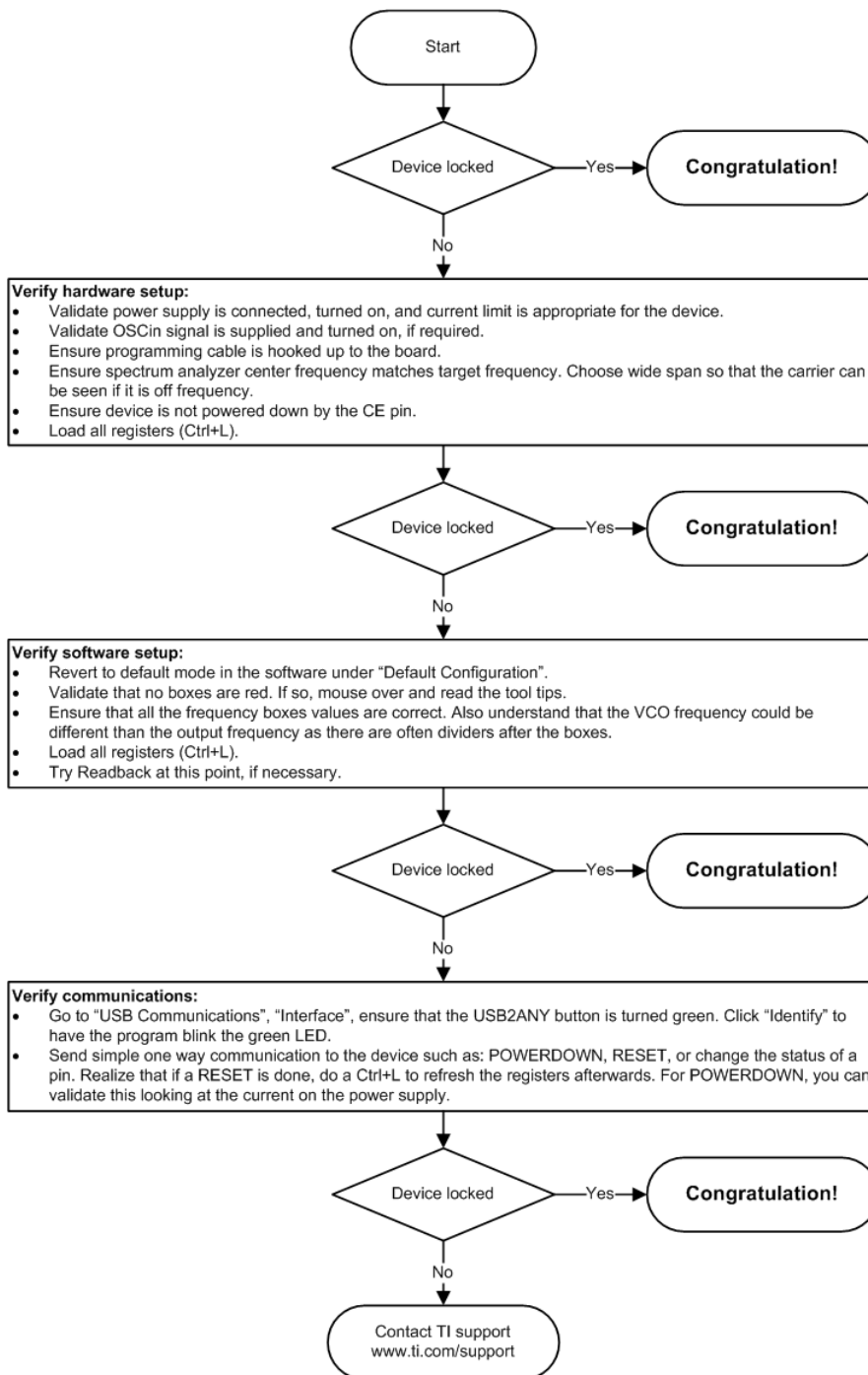tion to the ground plane are connected by 1.5-kΩ resistors. By default, the board is configured for 100-MHz LVPECL output. The power supply to Reference PRO is obtained from the PC through a USB connection.
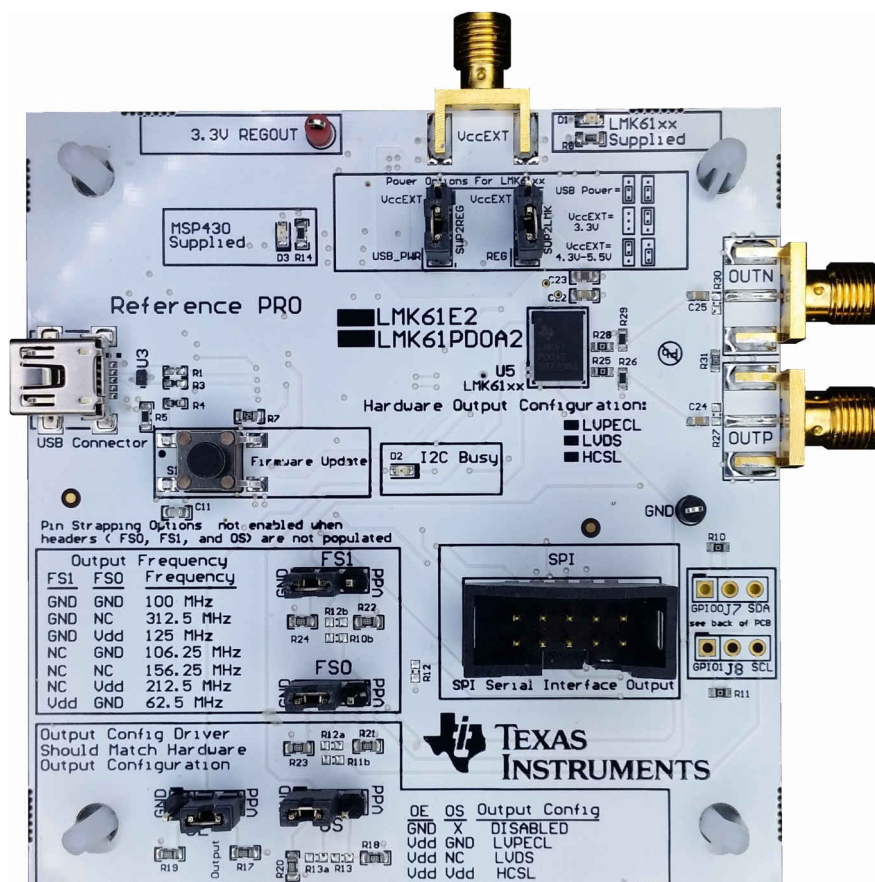

Figure 9-1. Reference PRO Board

9.1 Output Frequency Selection

Jumpers FS1 and FS0 are used to set the output frequency.

Table 9-1. Reference PRO Output Frequency Selection

FS1	FS0	OUTPUT FREQUENCY (MHz)
GND	GND	100
GND	NC	312.5
GND	Vdd	125
NC	GND	106.25
NC	NC	156.25
NC	Vdd	212.5
Vdd	GND	62.5

—

9.2 Output Format Selection

The OE pin is used to enable or disable the output.

The OS pin is used to bias internal drivers and change the output format.

Table 9-2. Reference PRO Output Format Selection

OE	OS	OUTPUT FORMAT
GND	Don't Care	Disabled
Vdd	GND	LVPECL
Vdd	NC	LVDS
Vdd	Vdd	HCSL

It is imperative to match the output termination passive components as shown in Table 9-3.

Table 9-3. Output Termination Configuration

OUTPUT FORMAT	COUPLING	COMPONENT	VALUE
LVPECL	AC (Default configuration)	R15, R28	0 Ω
		R26, R29	150 Ω
		C24, C25	0.01 µF
		R27, R30, R31	DNP
	DC[1]	R15, R28, C24, C25	0 Ω
		R26, R27, R29, R30, R31	DNP
LVDS[2]	AC	R25, R27, R28, R30	0 Ω
		R31	100 Ω
		C24, C25	0.01 µF
		R26, R29	DNP
	DC	R25, R27, R28, R30, C24, C25	0 Ω
		R31	100 Ω
		R26, R29	DNP
HCSL	AC	R15, R28	0 Ω
		R26, R29	50 Ω
		C24, C25	0.01 µF
		R27, R30, R31	DNP
	DC	R25, R28, C24, C25	0 Ω
		R26, R29	50 Ω
		R27, R30, R31	DNP

(1) 50-Ω to VCC – 2-V termination is required on receiver.
(2) 100-Ω differential termination (R31) is provided onboard. Removing this termination is possible if the differential termination is available on the receiver.
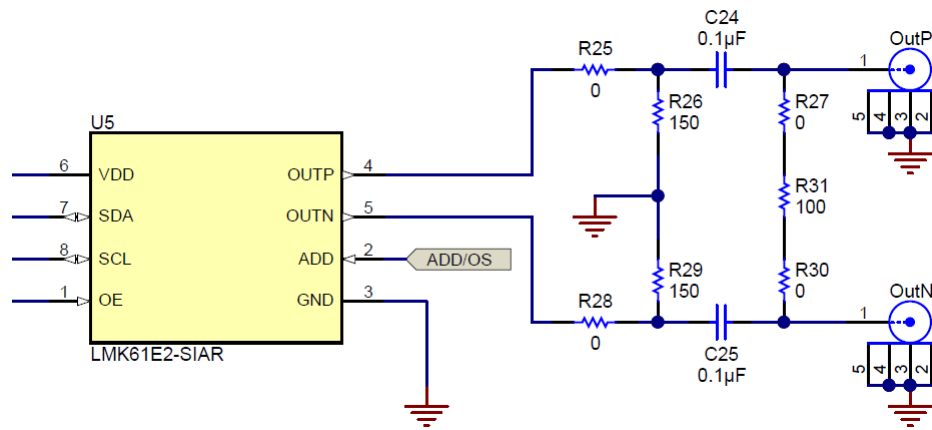
Figure 9-2. Output Termination Schematic

9.3 Typical Output Characteristics
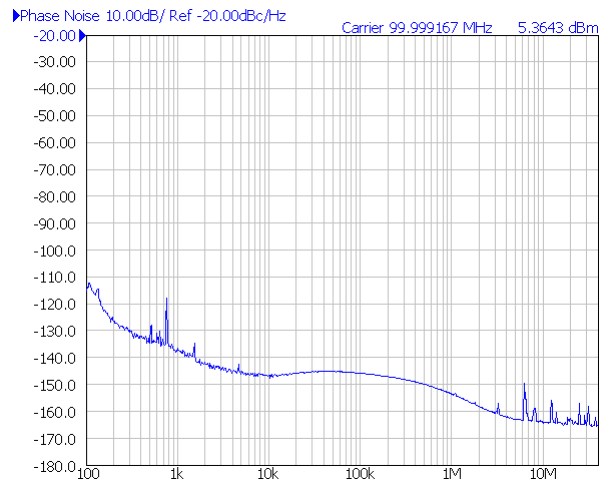
Figure 9-3. Default Output Phase Nosie
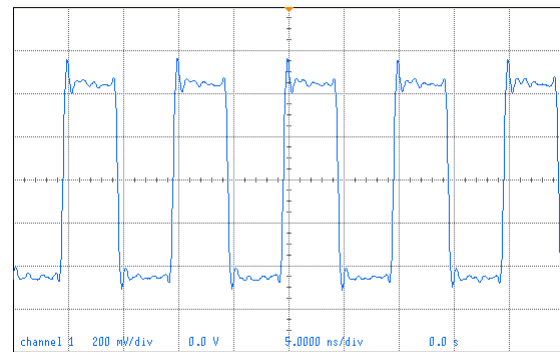
Figure 9-4. Default Output Waveform

9.4 Firmware Update

Usually when the Reference PRO board is used at the first time, TICS Pro will request for a firmware update. Simply follow the pop-up instructions to complete the update. This is necessary to ensure that the USB connection between the PC and the Reference PRO board is properly set up, otherwise the programming to LMX2594PSEVM will not be successful.

1. When you see this message, press the *OK* button.
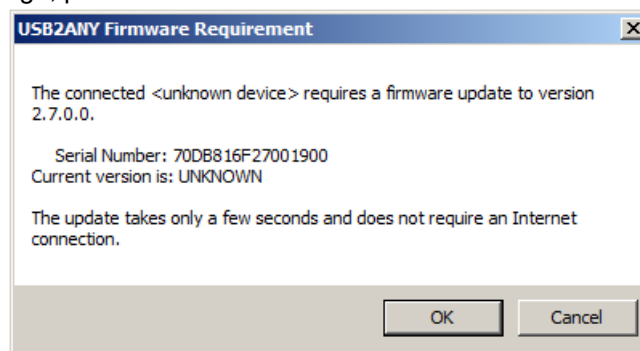
Figure 9-5. Firmware Requirement

2. Next, follow the on-screen procedure.
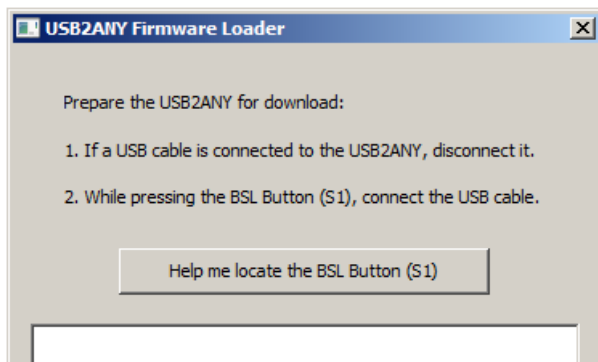
Figure 9-6. Firmware Loader

3. Find the BSL button next to the USB connector.
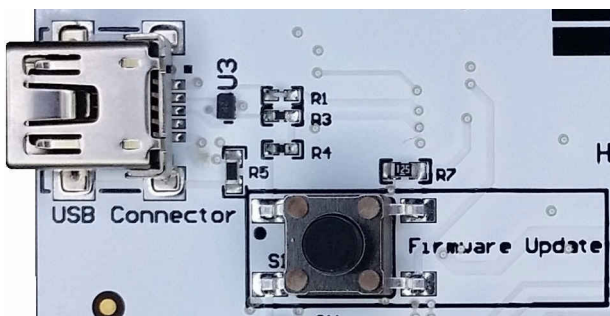
Figure 9-7. BSL Button

4. Follow the on-screen procedure until the Update Fireware pop-up appears.

Figure 9-8. Update Firmware

5. Press the *Upgrade Firmware* button to start the firmware upgrade. Press the *Close* button after the upgrade is complete.
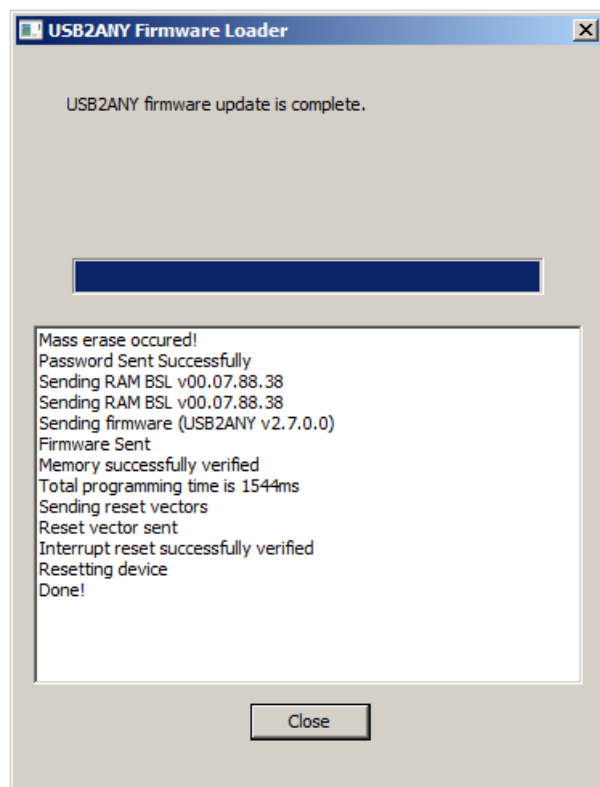
Figure 9-9. Firmware Update Completed

6. Go to *USB communications* → *Interface* to check the USB connection in TICS Pro. Make sure the *USB Connected* button is now green.
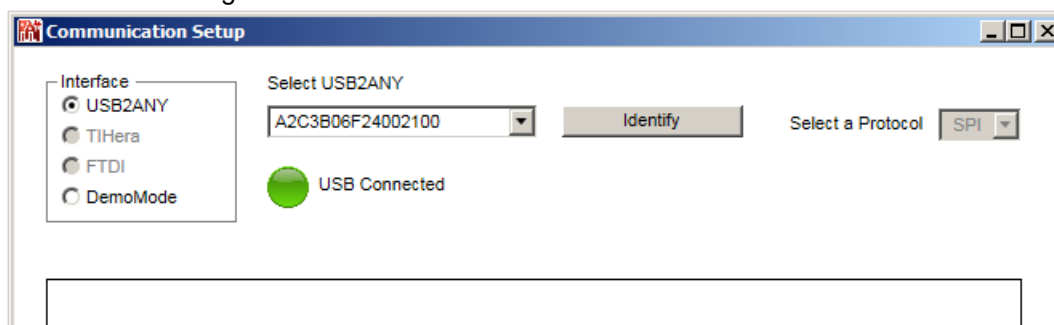
Figure 9-10. USB Communications

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    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.

<u>WARNING</u>

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。
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.

【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。

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

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

東京都新宿区西新宿６丁目２４番１号

西新宿三井ビル

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

6.   *Disclaimers:*

6.1   EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2   EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7.   *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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