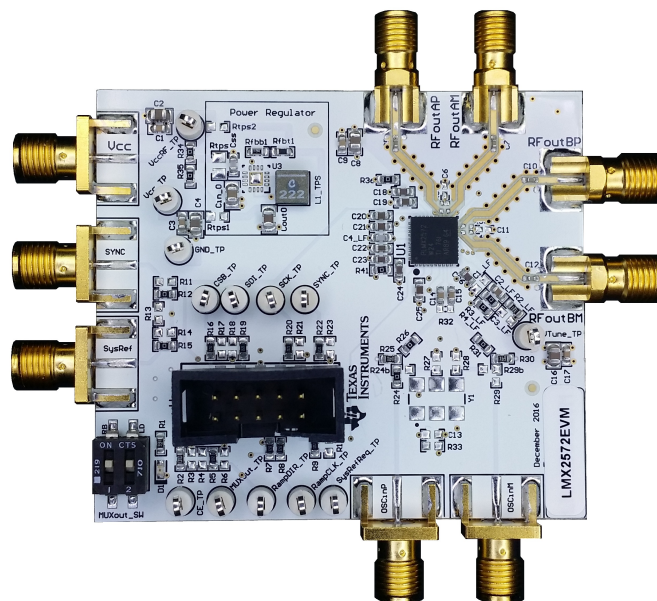


LMX2572EVM Evaluation Instructions

The LMX2572EVM is design to evaluate the performance of LMX2572. This board consists of a LMX2572 device.

The LMX2572 is a low-power, high-performance wideband synthesizer that can generate any frequency from 12.5 MHz to 6.4 GHz without using an internal VCO doubler. The PLL delivers excellent performance while consuming just 75 mA from a single 3.3-V supply.



Contents

1	LMX2572EVM Evaluation Module	3
2	Setup	3
3	Typical Measurement	5
4	Schematic	13
5	PCB Layout and Layer Stack-up	15
6	Bill of Materials	18
7	Troubleshooting Guide	19
Appendix A	Using Different Reference Clock	20
Appendix B	Reference PRO.....	21

List of Figures

1	EVM Connection Diagram	3
2	Select Device in TICS Pro.....	4
3	Default Mode	5
4	MUXout_SW Switch	5
5	Loop Filter	6
6	Default Output.....	6
7	Phase Adjustment Setting	7

8	Phase Adjustment	7
9	Calibration-Free Automatic Ramp Setting.....	8
10	Calibration-Free Automatic Ramp	8
11	Automatic Ramp Setting	9
12	Automatic Ramp	9
13	SYSREF Pulsed Mode Setting	10
14	SYSREF Pulsed Mode	10
15	FSK SPI FAST Mode Setting.....	11
16	FSK SPI FAST Mode	11
17	Readback Setting	12
18	Register Readback.....	12
19	LMX2572EVM Schematic (Page 1).....	13
20	LMX2572EVM Schematic (Page 2).....	14
21	PCB Layer Stack-Up.....	15
22	Top Layer	15
23	GND Layer	16
24	Power Layer	16
25	Bottom Layer.....	17
26	Troubleshooting Guide	19
27	Output Termination Schematic	22
28	Default Output Phase Noise	23
29	Default Output Waveform	23
30	Firmware Requirement	23
31	Firmware Loader	24
32	BSL Button	24
33	Update Firmware	25
34	Firmware Update Completed	25
35	USB Communications	26

List of Tables

1	Loop Filter Configuration.....	5
2	Phase Adjustment Setting	7
3	Calibration-free Automatic Ramp Example.....	8
4	Automatic Ramp Example	9
5	FSK SPI FAST Mode Example.....	11
6	Bill of Materials	18
7	Reference Clock Input Configuration	20
8	Reference PRO Output Frequency Selection	21
9	Reference PRO Output Format Selection	22
10	Output Termination Configuration.....	22

Trademarks

All trademarks are the property of their respective owners.

1 LMX2572EVM Evaluation Module

1.1 Evaluation Module Contents

In the box, there are:

- One LMX2572EVM board (SV601308-003).
- One Reference PRO board (SV601349).
- Two SMA Male-to-Male adaptors (132168).
- One USB cable.
- One 10-pin ribbon cable.

1.2 Evaluation Setup Requirement

The evaluation will require 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 (optional)
- A high quality signal generator (optional)
- Texas Instruments Clocks and Synthesizers TICS Pro software
- Texas Instruments PLLatinum Simulator Tool (optional)

1.3 Resources

Related evaluation and development resources are as follows:

- [LMX2572 data sheet](#)
- [TICS Pro software](#)
- [PLLatinum Simulator Tool](#) (PLL Sim)

2 Setup

2.1 Connection Diagram

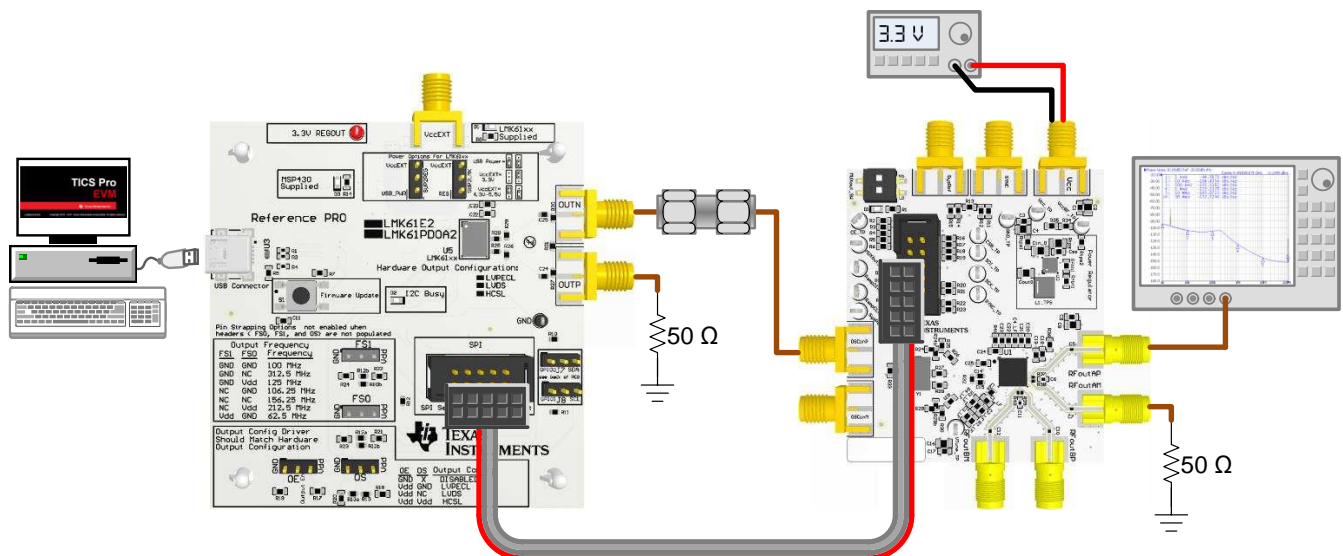


Figure 1. EVM Connection Diagram

2.2 Power Supply

Apply 3.3 V to V_{CC} SMA connector. Acceptable supply voltage range is 3 V to 3.6 V. The maximum current consumption in the most extreme configuration must not exceed 150 mA.

By default, the onboard DC-DC converter is not used.

2.3 Reference Clock

Connect OSCinP SMA connector with one of the outputs from Reference PRO using the SMA Male-to-male adapter. OSCinM SMA connector is not connected to LMX2572 so it could be left open.

The EVM is configured for single-ended input with OSCin pin connected to OSCinP SMA connector and OSCinM pin 50- Ω terminated onboard. If required, the EVM can be modified to operate with different clock source in different configuration, see [Appendix A](#) for details.

Terminate the unused output of the Reference PRO board with a 50- Ω resistor or SMA load. By default, the output clock from Reference PRO is a 100-MHz LVPECL clock. [Appendix B](#) has the details of Reference PRO.

2.4 RF Output

Connect either RFoutAP or RFoutAM SMA connector to a signal analyzer. The unused connector must be terminated with a 50- Ω resistor or SMA load. Output frequency is 3 GHz and the amplitude is about +2.5 dBm.

By default, the evaluation software, TICS Pro, has RFoutB power down. These SMA connectors could be left open.

2.5 Programming

Connect ribbon cable from Reference PRO to LMX2572EVM.

Connect USB cable from a PC to USB port in Reference PRO. This provides power supply to Reference PRO board and communication with TICS Pro. A firmware update may be required, see [Appendix B](#) for details.

2.6 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" → LMX2572 → LMX2572.

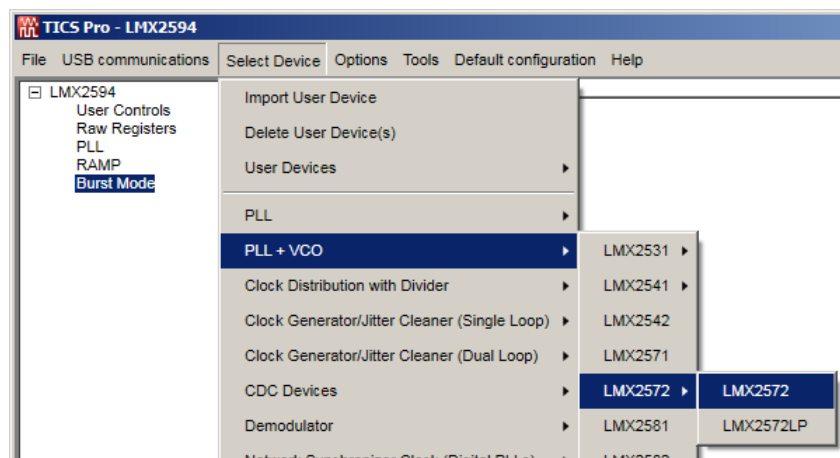


Figure 2. Select Device in TICS Pro

2. Go to "Default Configuration" → "Default Mode YYYY-MM-DD".

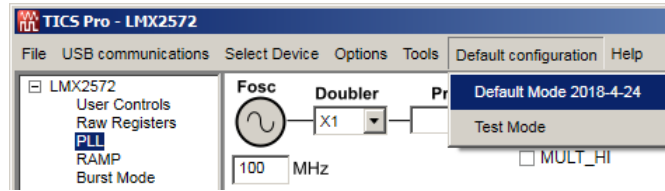


Figure 3. Default Mode

2.7 EVM Strap Options

2.7.1 MUXout_SW

There are two switches in MUXout_SW. Switch 1 is used for register readback. Switch 2 is used to provide a visual PLL lock status through the LED D1. By default, both switches are in the Make position. To read back register in TICS Pro, set Switch 2 to the Break position.

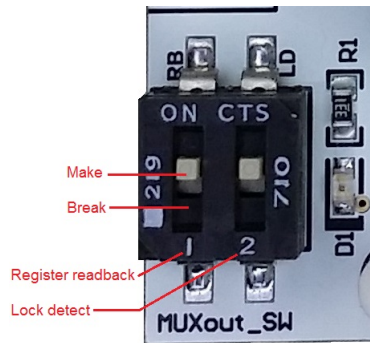


Figure 4. MUXout_SW Switch

3 Typical Measurement

3.1 Default Configuration

3.1.1 Loop Filter

The parameters for the loop filter are:

Table 1. Loop Filter Configuration

PARAMETER	VALUE
VCO frequency	Designed for 6 GHz, but works over the whole frequency range
VCO gain	66 MHz/V
Effective charge pump gain	2500 μ A
Phase detector frequency	100 MHz
Loop bandwidth	115 kHz
Phase margin	48 degrees
C1_LF, C3_LF	Open
C2_LF	15 nF
C4_LF	2.2 nF
R2_LF	330 Ω
R3_LF, R4_LF	0 Ω

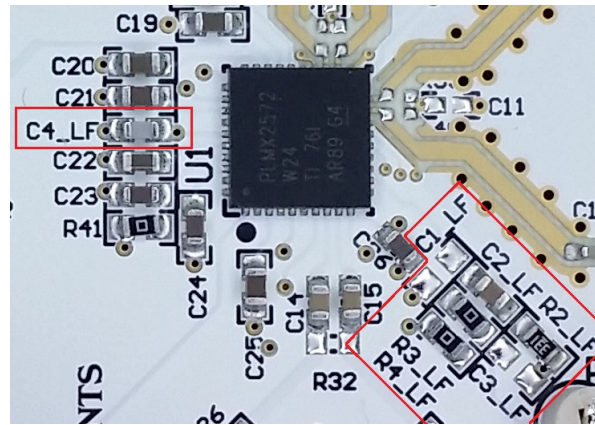


Figure 5. Loop Filter

3.1.2 Typical Output

1. Follow [Section 2](#) to setup the evaluation.
2. Click "Write All Registers" to write all the registers to LMX2572.

Default output is 3 GHz.

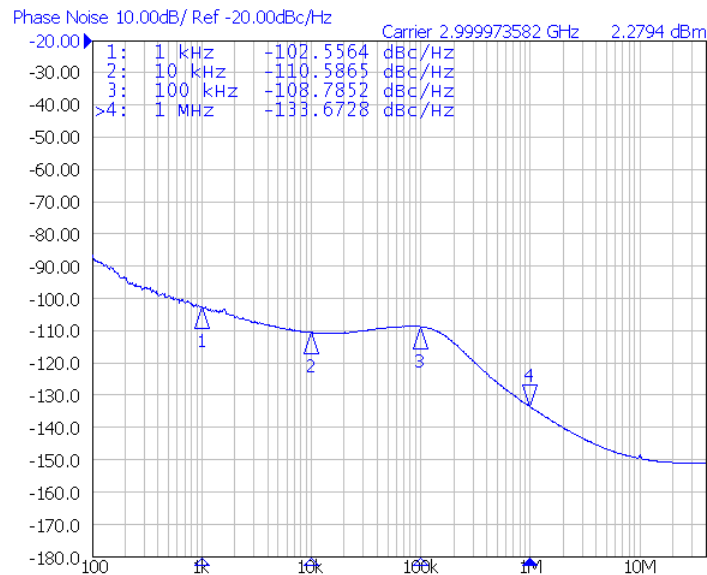


Figure 6. Default Output

3.2 Additional Tests

3.2.1 Phase Adjustment

The phase of the RF output signal can be adjusted as follows:

Phase shift in degree = $360^\circ \times (\text{MASH_SEED} / \text{PLL_DEN}) \times (\text{P} / \text{CHDIV})$, where P = 2 when VCO_PHASE_SYNC_EN = 1, else P = 1.

Here is an example.

Table 2. Phase Adjustment Setting

PARAMETER	EXAMPLE VALUE
MASH_SEED	800
PLL_DEN	1000
CHDIV	32
VCO_PHASE_SYNC_EN	0

Phase shift = $360^\circ \times (800 / 1000) \times (1 / 32) = 9^\circ$. We can write 800 to MASH_SEED 40 times to get 360° phase shift.

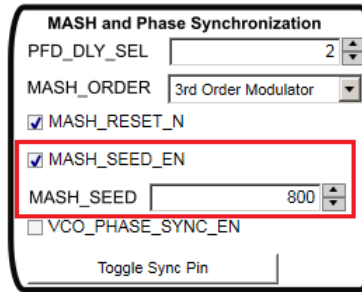


Figure 7. Phase Adjustment Setting

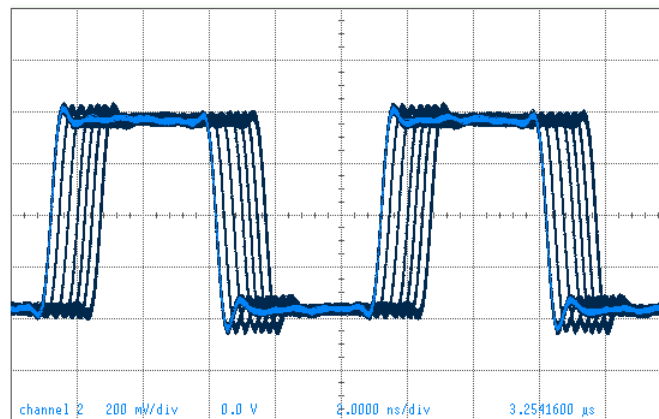


Figure 8. Phase Adjustment

3.2.2 Calibration-free Automatic Ramping

LMX2572 supports linear frequency ramp without the need of VCO calibration in the middle of the ramp. The output waveform is a continuous frequency sweep between the start and the end frequencies. However, the frequency ramp range is limited. When using ramp, the followings need to be set accordingly:

- OUT_FORCE = 1
- LD_DLY = 0
- PLL_DEN = $2^{32} - 1$

Table 3. Calibration-free Automatic Ramp Example

PARAMETER	EXAMPLE VALUE
Ramping start frequency	4795 MHz
Ramping stop frequency	4805 MHz
Phase detector frequency	50 MHz
Ramp up / down time	200 μ s
RAMP_LIMIT_HIGH	4995 MHz
RAMP_LIMIT_LOW	4595 MHz

This is a triangular ramp example. Ramp up is defined by RAMP0 while ramp down is defined by RAMP1. RAMP_THRESH, RAMP_DLY_CNT, and RAMP_SCALE_COUNT are "don't care" because we are not going to trigger any VCO calibration. RAMP_MANUAL = 0 means Automatic Ramping mode.

Set RAMP_EN = 1 to start ramping. Set RAMP_EN = 0 to turn off ramping.

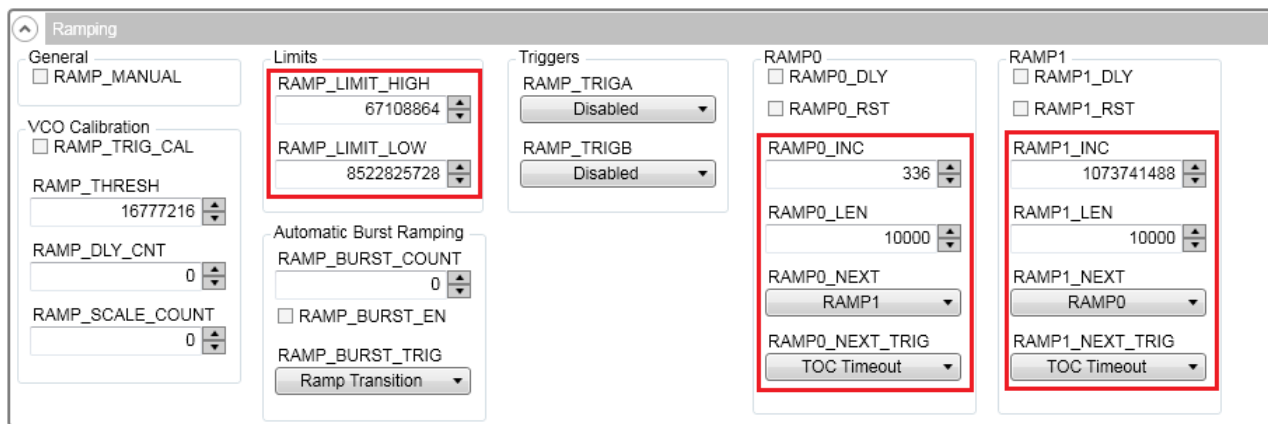


Figure 9. Calibration-Free Automatic Ramp Setting

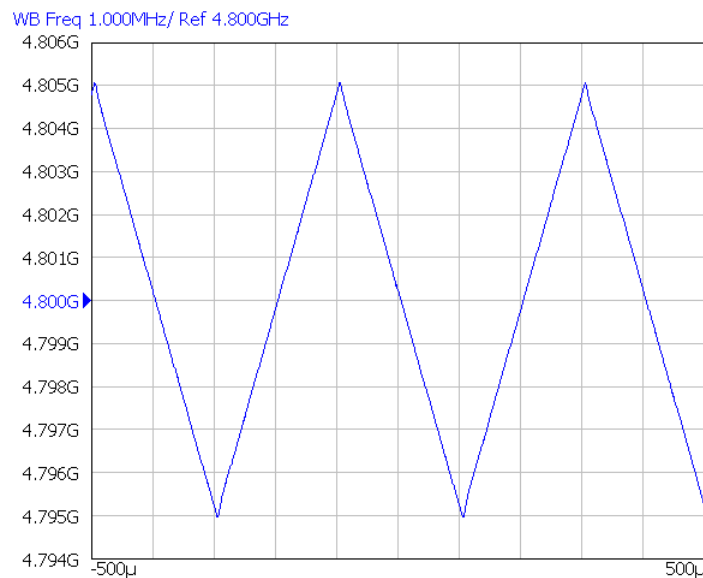


Figure 10. Calibration-Free Automatic Ramp

3.2.3 Automatic Ramping

This ramping mode supports wider ramp frequency, however there are glitches in the middle of the ramp because of VCO calibrations which are required so as to ensure the continuity of the ramp.

Table 4. Automatic Ramp Example

PARAMETER	EXAMPLE VALUE
Ramping start frequency	4740 MHz
Ramping stop frequency	4860 MHz
Phase detector frequency	50 MHz
Ramp up / down time	1000 μ s
RAMP_LIMIT_HIGH	5060 MHz
RAMP_LIMIT_LOW	4540 MHz
f_{OSCin}	100 MHz
CAL_CLK_DIV	0
RAMP_THRESH	40 MHz
Pause time for VCO calibration	500 μ s

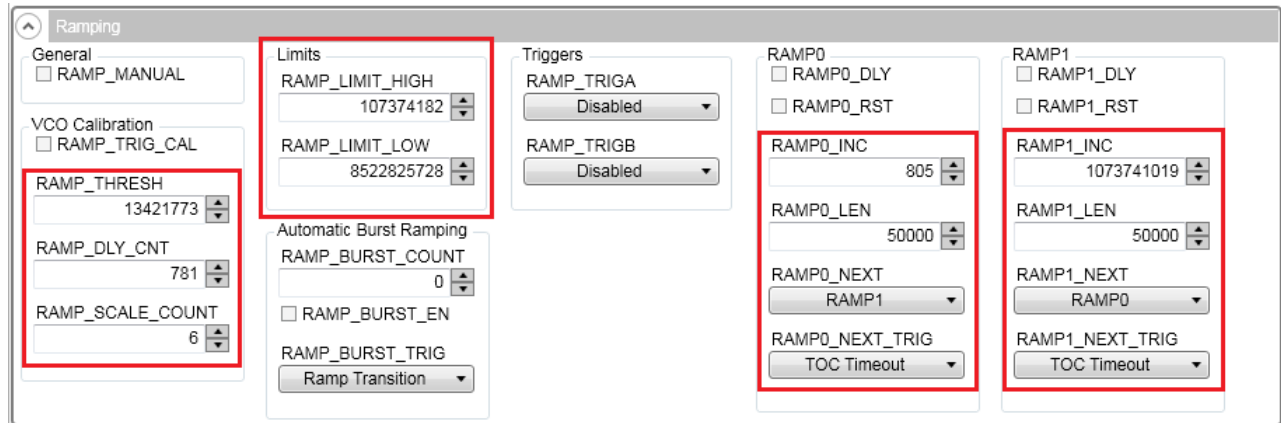


Figure 11. Automatic Ramp Setting

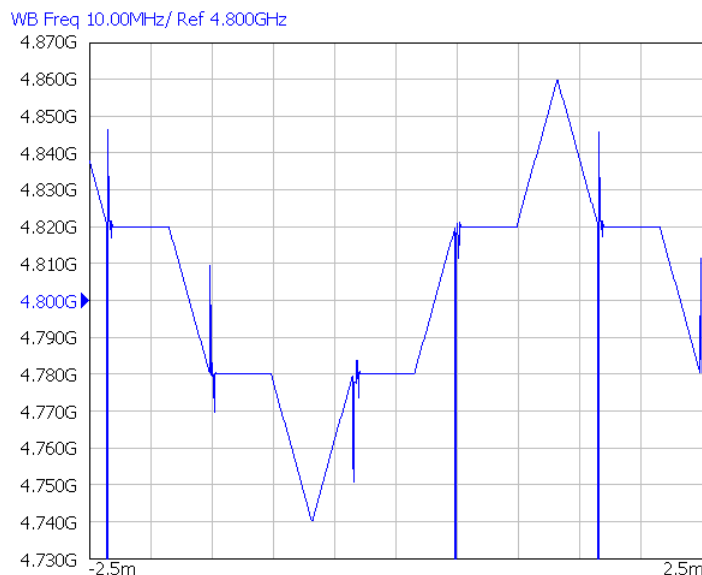


Figure 12. Automatic Ramp

3.2.4 SYSREF Example

RFoutB of LMX2572 can be used to generate or duplicate SYSREF signal. The output of RFoutB can be a single pulse, series of pulse, or a continuous stream of pulses. These pulses are synchronous with the RFoutA signal with an adjustable delay. To use the SYSREF capability, the PLL must be in SYNC mode with VCO_PHASE_SYNC_EN = 1. Here is an example of Pulsed mode.

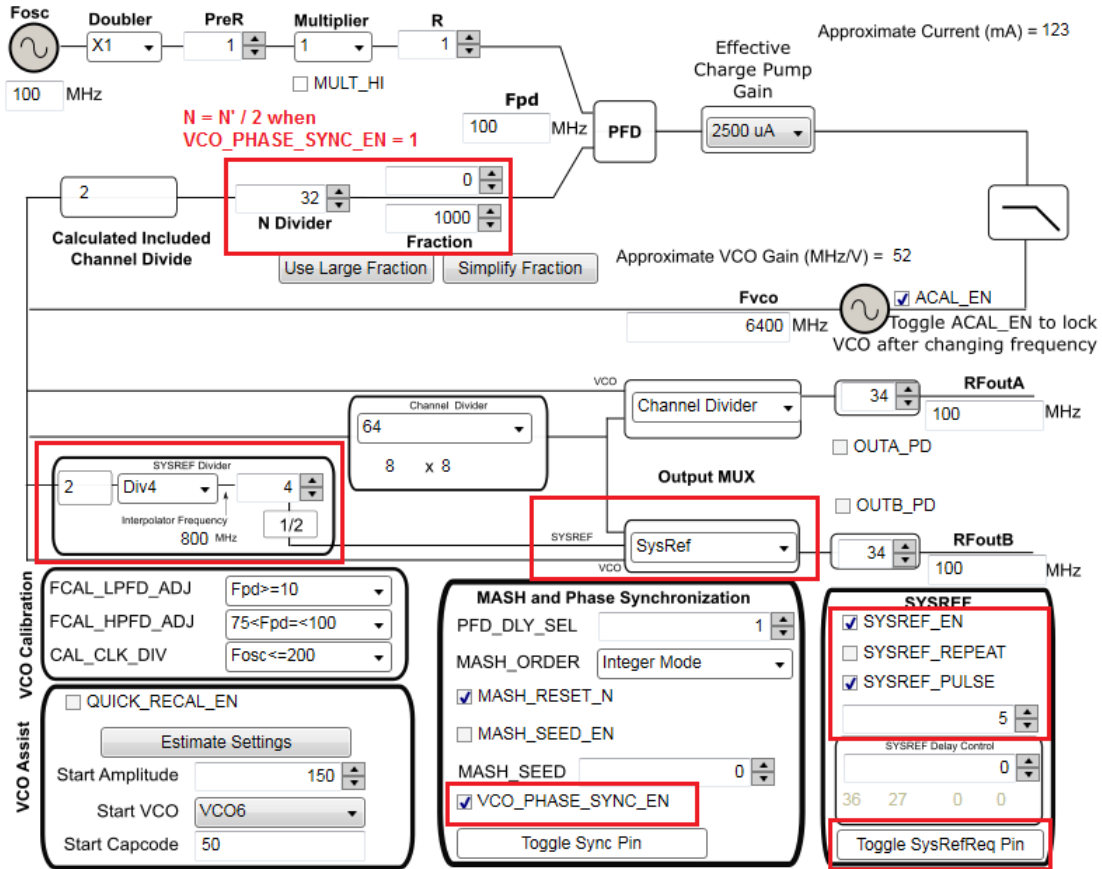


Figure 13. SYSREF Pulsed Mode Setting

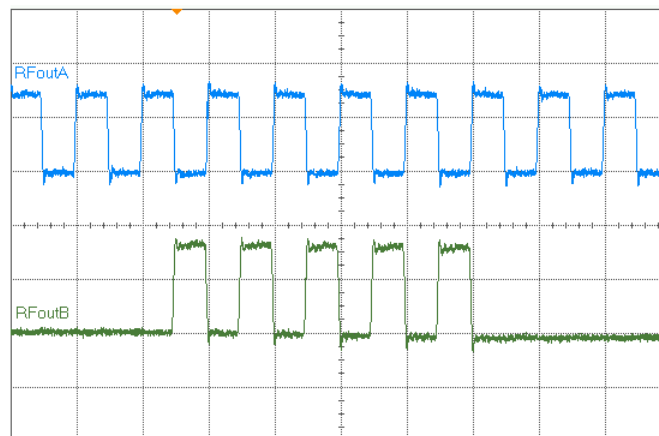


Figure 14. SYSREF Pulsed Mode

3.2.5 FSK Modulation

Direct digital FSK modulation is supported in LMX2572. FSK SPI mode supports discrete 2-, 4-, or 8-level FSK modulation while FSK SPI FAST mode supports arbitrary level FSK modulation. The followings is an FSK SPI FAST mode example.

Table 5. FSK SPI FAST Mode Example

PARAMETER	EXAMPLE VALUE
Phase detector frequency	100 MHz
CHDIV	8
PLL_DEN	8000000
FSK_DEV_SCALE	1
Frequency deviation	±648 Hz; ±1944 Hz

Keep writing to the FSK_SPI_FAST_DEV register field the correct values, the output of LMX2572 is a discrete 4-level FSK modulation signal.

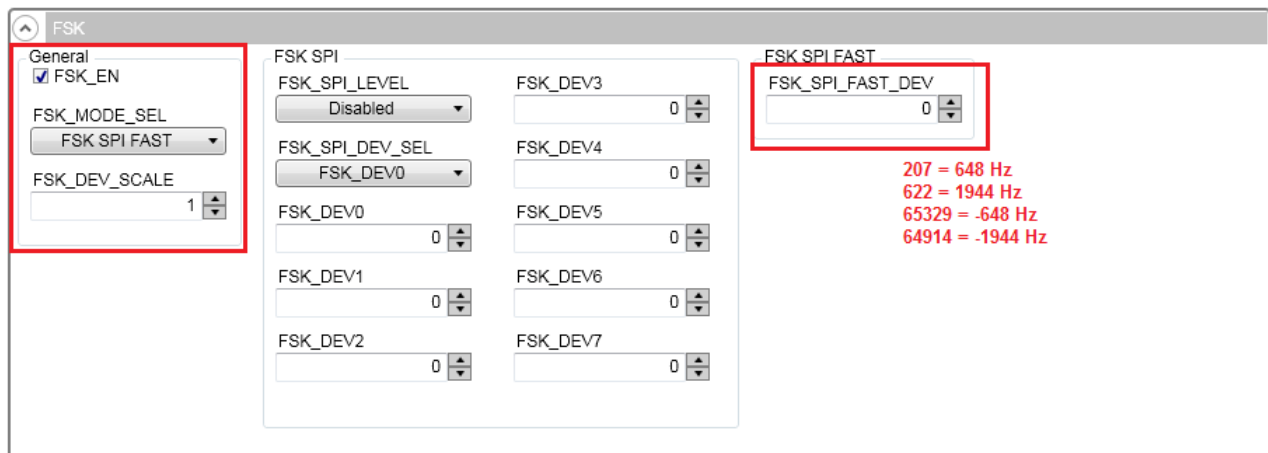


Figure 15. FSK SPI FAST Mode Setting

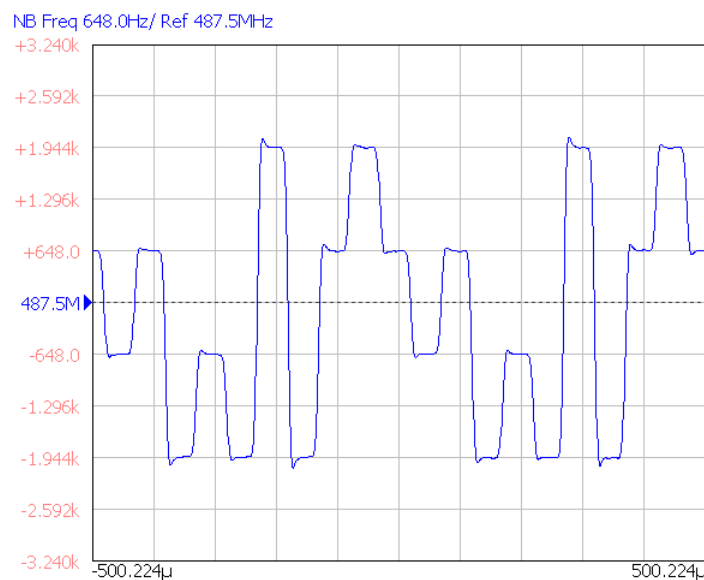


Figure 16. FSK SPI FAST Mode

3.2.6 Register Readback

To read back the written register values,

1. Set MUXout_SW Switch 2 to Break position. See [Section 2.7.1](#) for details.
2. In TICS Pro, set MUXOUT_LD_SEL to *Readback*.

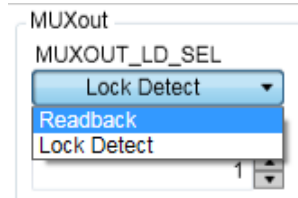


Figure 17. Readback Setting

3. Click on the Register Name that you want to read back.
4. Click the Read Register button to read back the register value.

Register Map		2 2 2 2	1 1 1 1	1 1 1 1	1 1 0 0	0 0 0 0	0 0 0 0
Register Name	Address/Value	3 2 1 0	9 8 7 6	5 4 3 2	1 0 9 8	7 6 5 4	3 2 1 0
R107	0x6B0000	0 1 1 0	1 0 1 1	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
R106	0x6A0007	0 1 1 0	1 0 1 0	0 0 0 0	0 0 0 0	0 0 0 0	0 1 1 1
R105	0x694440	0 1 1 0	1 0 0 1	0 1 0 0	0 1 0 0	0 1 0 0	0 0 0 0
R104	0x680000	0 1 1 0	1 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
R103	0x670000	0 1 1 0	0 1 1 1	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0

Data: 0x6A0007

Write Register

Read Register

Figure 18. Register Readback

4 Schematic

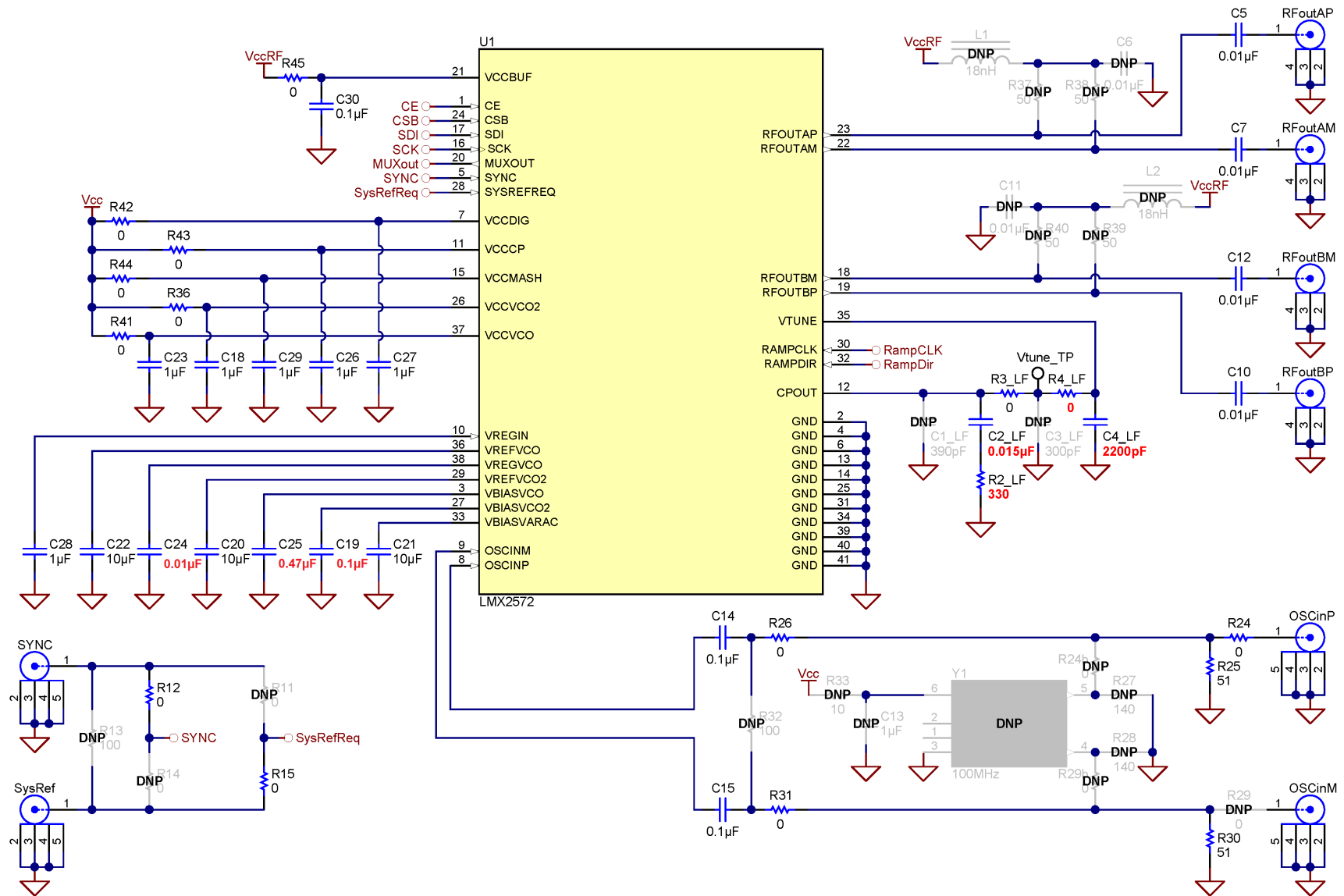


Figure 19. LMX2572EVM Schematic (Page 1)

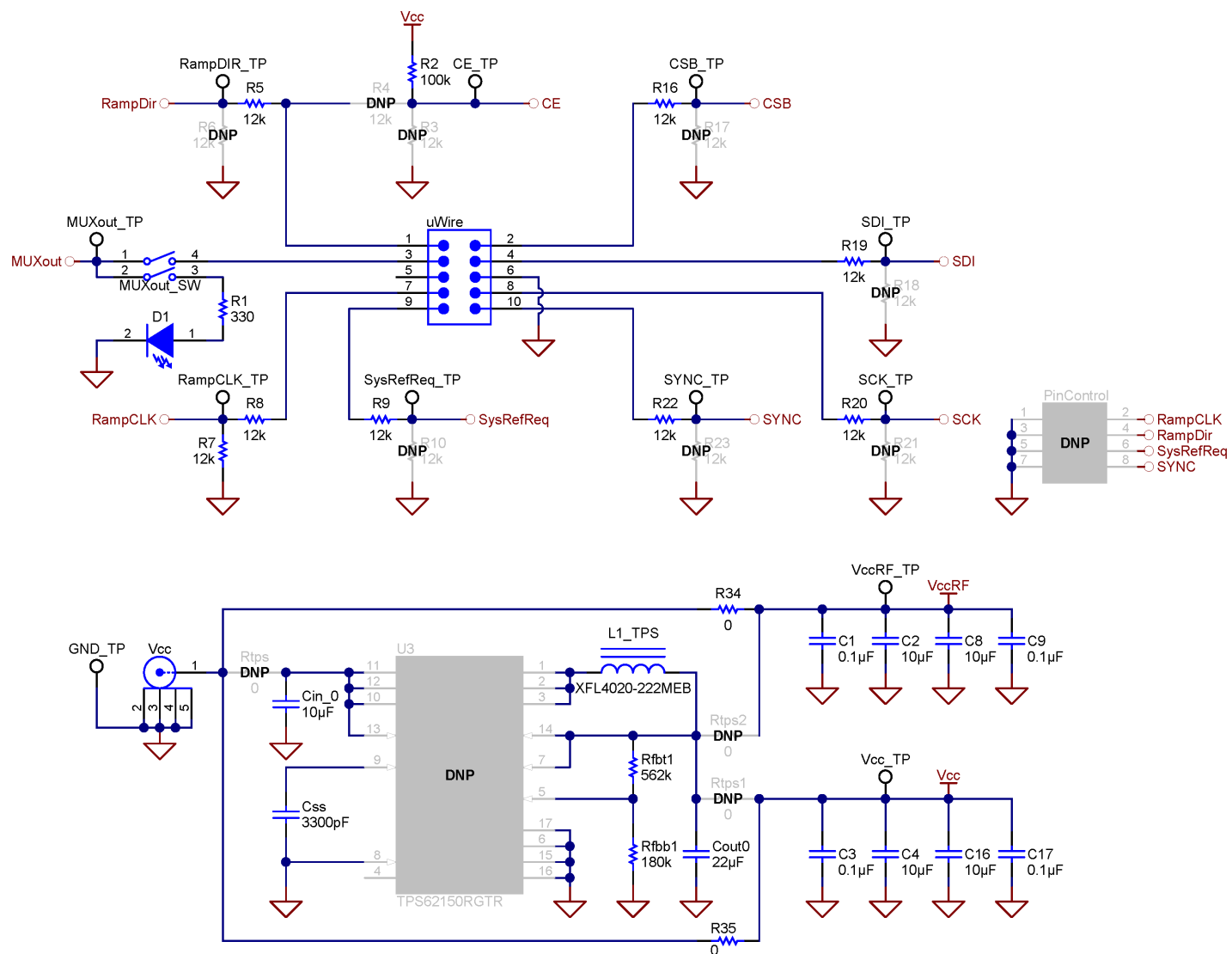


Figure 20. LMX2572EVM Schematic (Page 2)

5 PCB Layout and Layer Stack-up

5.1 PCB Layer Stack-up

The top layer is 1-oz. copper.

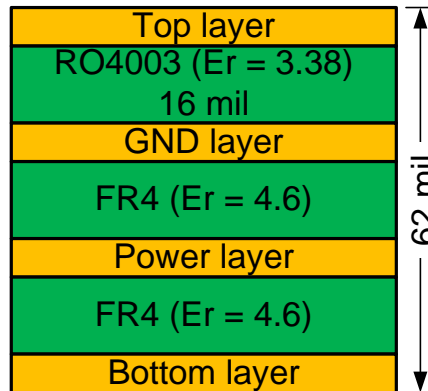


Figure 21. PCB Layer Stack-Up

5.2 PCB Layout

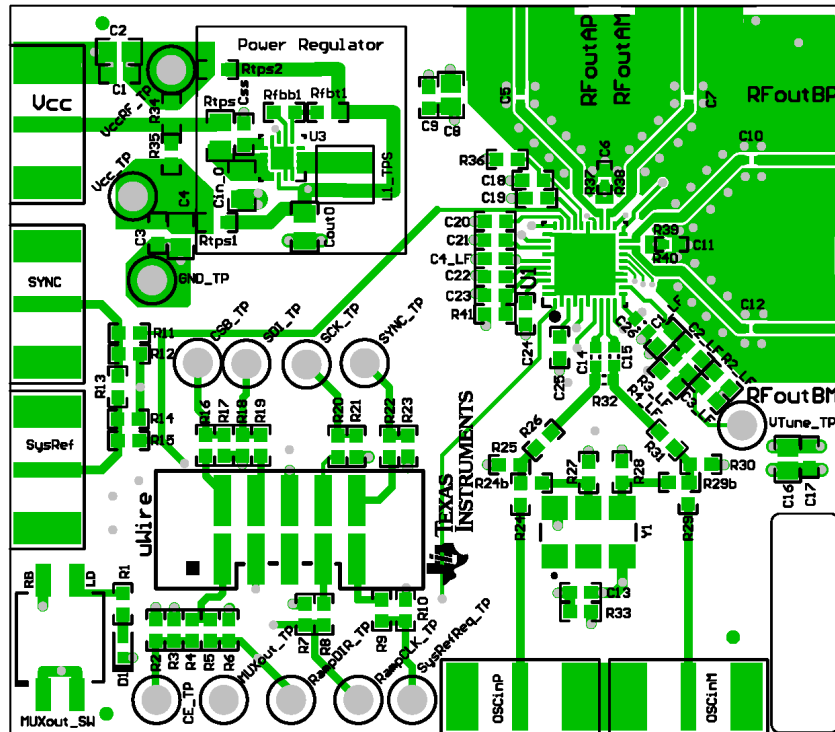


Figure 22. Top Layer

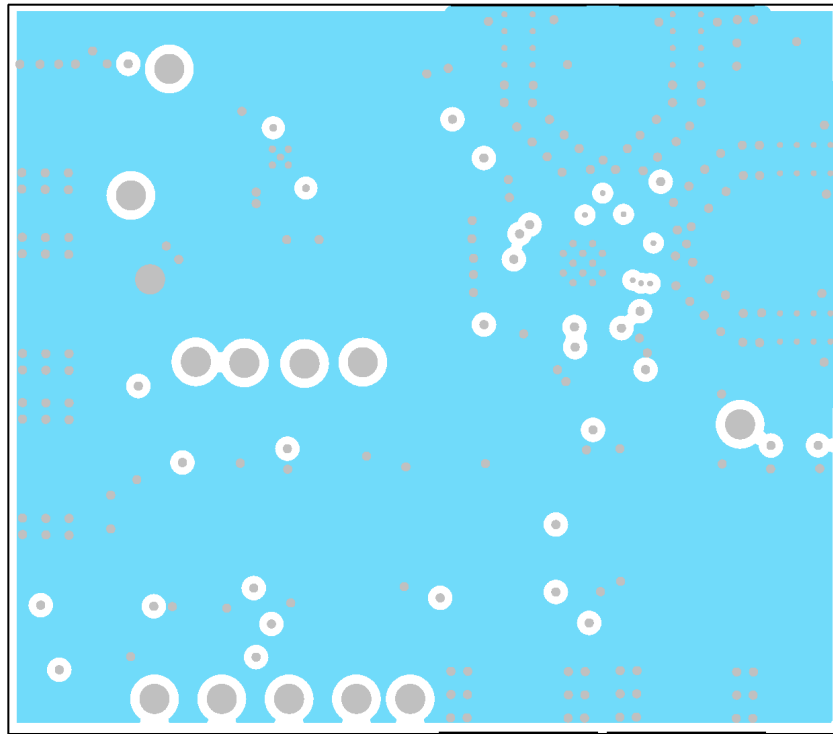


Figure 23. GND Layer

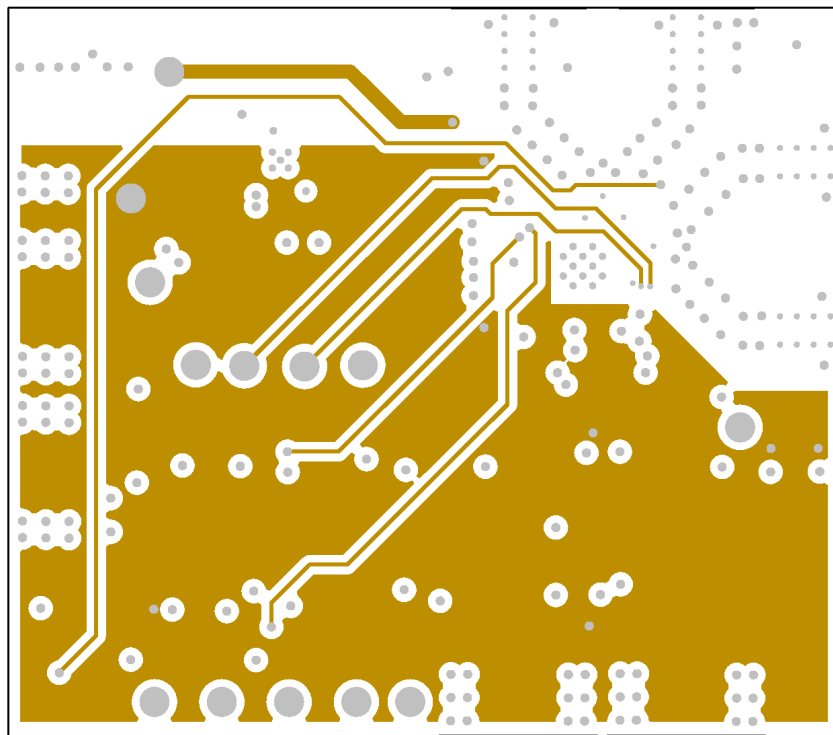


Figure 24. Power Layer

6 Bill of Materials
Table 6. Bill of Materials

DESIGNATOR	QUANTITY	DESCRIPTION	PART NUMBER	MANUFACTURER
C1, C3, C9, C14, C15, C17, C19, C30	8	CAP, CERM, 0.1 μ F, 16 V, \pm 5%, X7R, 0603	0603YC104JAT2A	AVX
C2, C4, C8, C16	4	CAP, CERM, 10 μ F, 10 V, \pm 10%, X5R, 0805	C0805C106K8PACTU	Kemet
C2_LF	1	CAP, CERM, 0.015 μ F, 50 V, \pm 10%, X7R, 0603	GRM188R71H153KA01D	MuRata
C4_LF	1	CAP, CERM, 2200 pF, 50 V, \pm 5%, COG/NP0, 0603	GRM1885C1H222JA01D	MuRata
C5, C7, C10, C12	4	CAP, CERM, 0.01 μ F, 16 V, \pm 10%, X7R, 0402	520L103KT16T	AT Ceramics
C18, C23, C26, C27, C28, C29	6	CAP, CERM, 1 μ F, 16 V, \pm 10%, X7R, 0603	C1608X7R1C105K080AC	TDK
C20, C21, C22	3	CAP, CERM, 10 μ F, 10 V, \pm 20%, X5R, 0603	C1608X5R1A106M080AC	TDK
C24	1	CAP, CERM, 0.01 μ F, 50 V, \pm 5%, X7R, 0603	C0603C103J5RACTU	MuRata
C25	1	CAP, CERM, 0.47 μ F, 25 V, \pm 10%, X7R, 0603	GRM188R71E474KA12D	Kemet
CE_TP, CSB_TP, GND_TP, MUXout_TP, RampCLK_TP, RampDIR_TP, SCK_TP, SDI_TP, SYNC_TP, SysRefReq_TP, Vcc_TP, VccRF_TP, Vtune_TP	13	Test Point, Compact, White, TH	5007	Keystone
Cin_0	1	CAP, CERM, 10 μ F, 25 V, \pm 10%, X5R, 0805	GRM219R61E106KA12D	MuRata
Cout0	1	CAP, CERM, 22 μ F, 16 V, \pm 10%, X5R, 0805	C2012X5R1C226K125AC	TDK
Css	1	CAP, CERM, 3300 pF, 50 V, \pm 5%, COG/NP0, 0603	GRM1885C1H332JA01D	MuRata
D1	1	LED, Green, SMD	LTST-C190GKT	Lite-On
L1_TPS	1	Inductor, Shielded, Composite, 2.2 μ H, 3.7 A, 0.02 Ω , SMD	XFL4020-222MEB	Coilcraft
MUXout_SW	1	Switch, SPST, Slide, Off-On, 2 Pos, 0.1 A, 20 V, SMD	219-2MST	CTS Electrocomponents
OSCinM, OSCinP, SYNC, SysRef, Vcc	5	Connector, SMT, End launch SMA 50 Ω	142-0701-851	Emerson Network Power Connectivity
R1	1	RES, 330 Ω , 5%, 0.1 W, 0603	RC0603JR-07330RL	Yageo America
R2	1	RES, 100 k Ω , 5%, 0.1 W, 0603	CRCW0603100KJNEA	Vishay-Dale
R2_LF	1	RES, 330 Ω , 5%, 0.1 W, 0603	CRCW0603330RJNEA	Vishay-Dale
R3_LF, R4_LF, R12, R15, R24, R26, R31	7	RES, 0 Ω , 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
R5, R7, R8, R9, R16, R19, R20, R22	8	RES, 12 k Ω , 5%, 0.1 W, 0603	CRCW060312K0JNEA	Vishay-Dale
R25, R30	2	RES, 51 Ω , 5%, 0.1 W, 0603	CRCW060351R0JNEA	Vishay-Dale
R34, R35, R36, R41, R42, R43, R44, R45	8	RES, 0 Ω , 5%, 0.1 W, 0603	CRCW06030000Z0EA	Vishay-Dale
Rfbb1	1	RES, 180 k Ω , 0.1%, 0.1 W, 0603	RT0603BRD07180KL	Yageo America
Rfbt1	1	RES, 562 k Ω , 1%, 0.1 W, 0603	CRCW0603562KFKEA	Vishay-Dale
RFoutAM, RFoutAP, RFoutBM, RFoutBP	4	JACK, SMA, 50 Ω , Gold, Edge Mount	142-0771-831	Johnson
U1	1	High Performance, Wideband PLLatinum RF Synthesizer	LMX2572RHAR	Texas Instruments
uWire	1	Header (shrouded), 100 mil, 5x2, Gold plated, SMD	52601-S10-8LF	FCI

7 Troubleshooting Guide

If the EVM does not work as expected, use the following chart to identify potential root causes. Couples of thing to note:

- Make modifications to the EVM or change the default settings until AFTER it is verified to be working.
- Register readback requires the correct hardware and software setup. See [Section 3.2.6](#) for details.
- The POR current of the LMX2572EVM is approximately 30 mA.
- The powerdown current of the LMX2572EVM is approximately 2.5 mA.

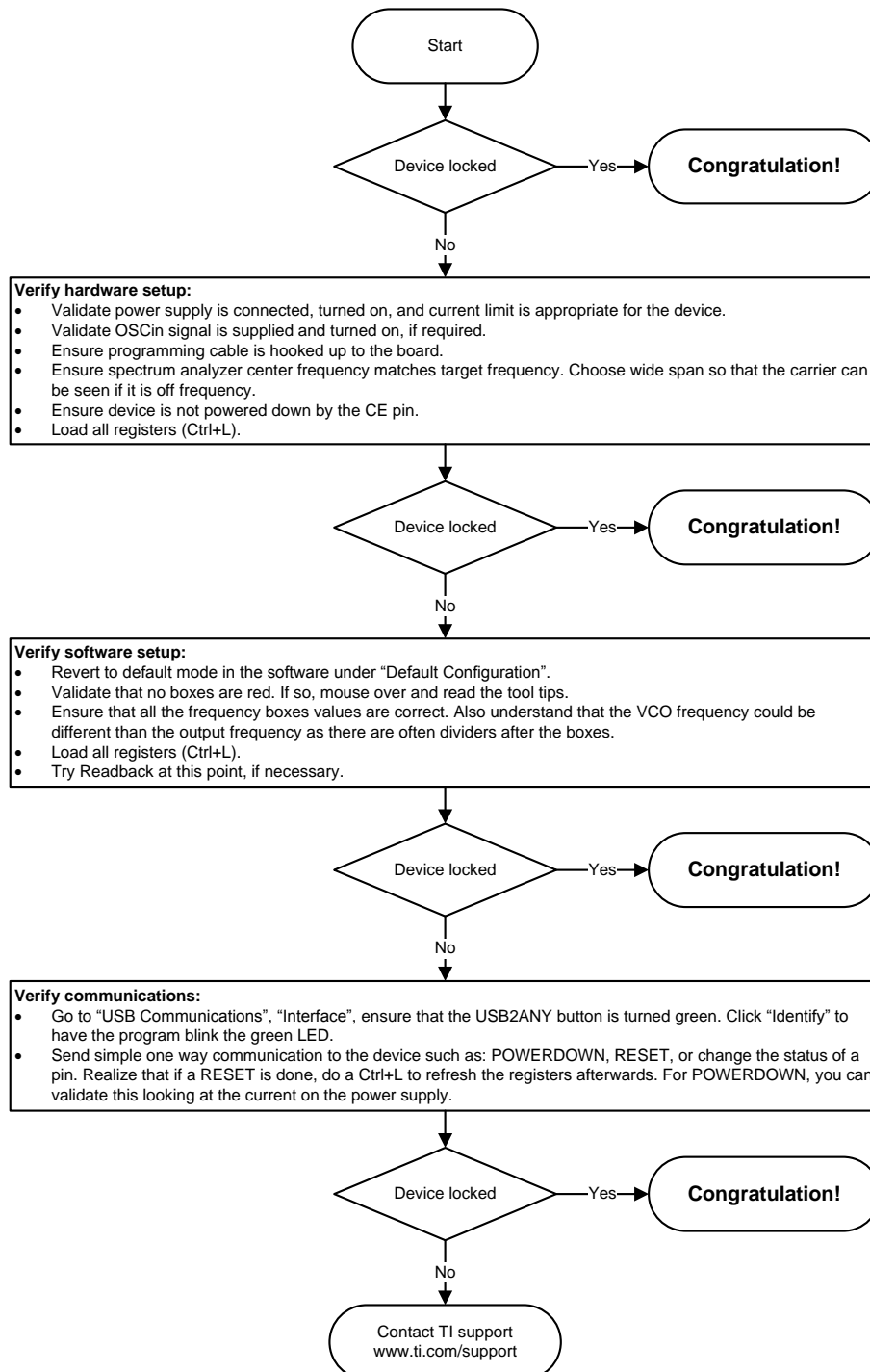
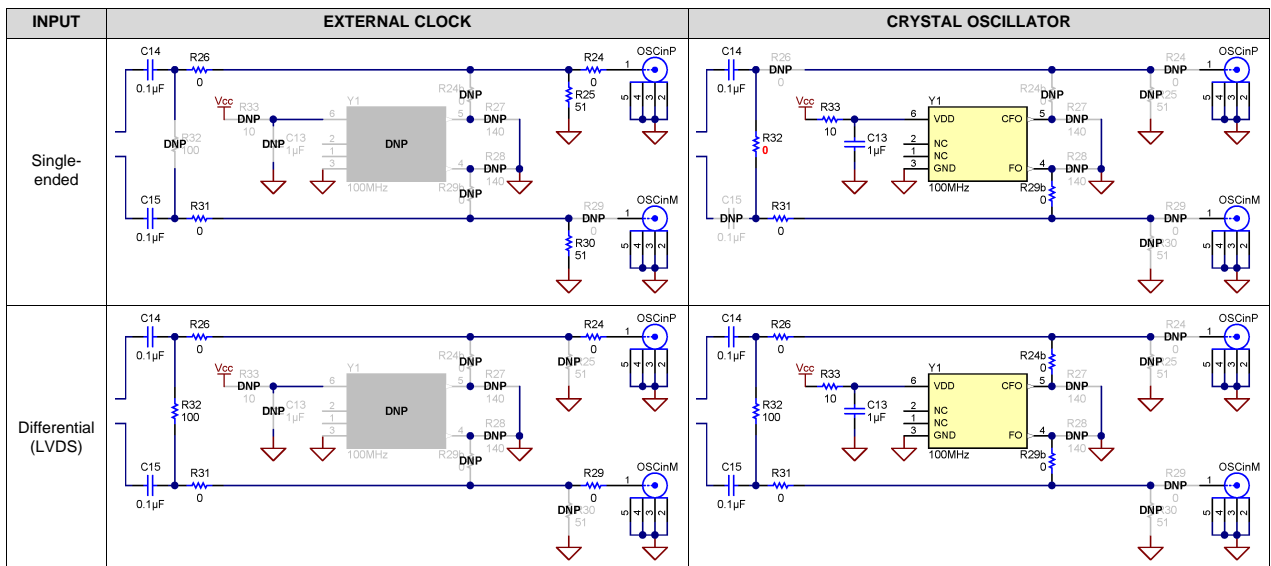


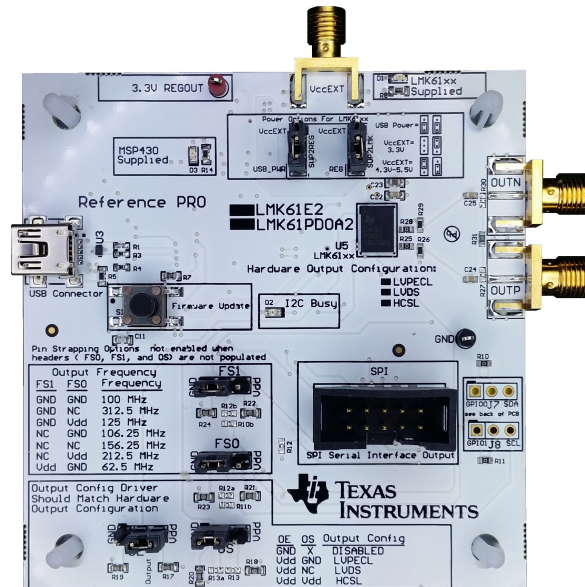
Figure 26. Troubleshooting Guide

Using Different Reference Clock

There are different options to provide a reference clock to LMX2572EVM. By default, the EVM is configured for an external single-ended clock.

Table 7. Reference Clock Input Configuration


Reference PRO



The Reference PRO board is used to program the LMX2572EVM and at the same time, provide a clean reference clock to LMX2572EVM. 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 position 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 that is connecting to Reference PRO through the USB interface.

B.1 Output Frequency Selection

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

Table 8. 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

B.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. 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 10](#).

Table 10. 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
		R25, R28	0 Ω
HCSL	AC	R26, R29	50 Ω
		C24, C25	0.01 μF
		R27, R30, R31	DNP
		R25, R28, C24, C25	0 Ω
	DC	R26, R29	50 Ω
		R27, R30, R31	DNP

⁽¹⁾ 50-Ω to $V_{CC} - 2\text{-V}$ 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.

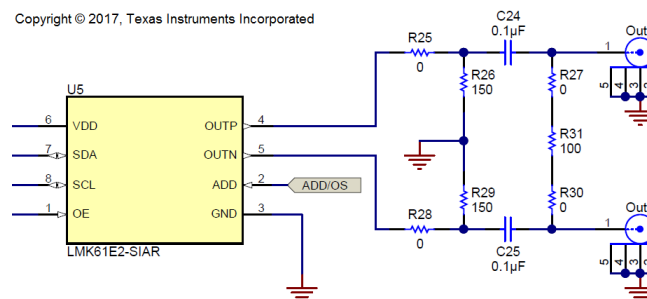


Figure 27. Output Termination Schematic

B.3 Typical Output Characteristics

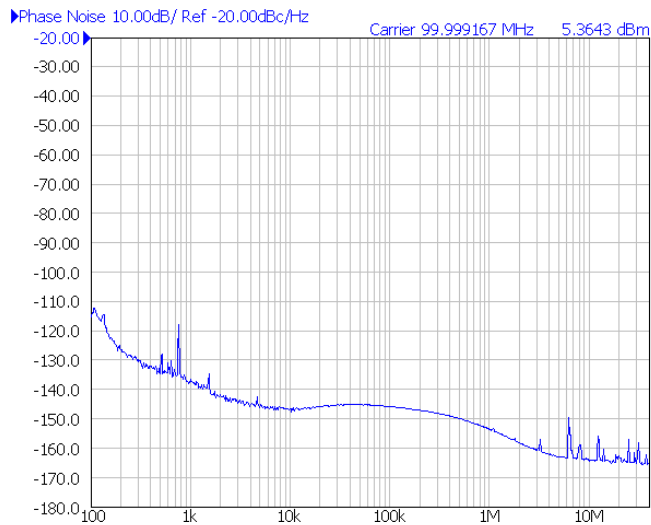


Figure 28. Default Output Phase Noise

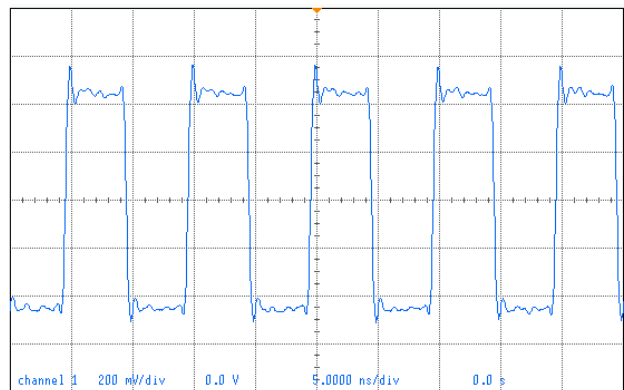


Figure 29. Default Output Waveform

B.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 setup, otherwise the programming to LMX2572EVM will not be successful.

1. When you see this message, click the "OK" button.

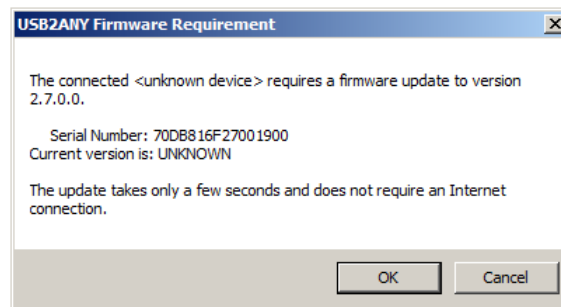


Figure 30. Firmware Requirement

2. Next, follow the on-screen procedure.

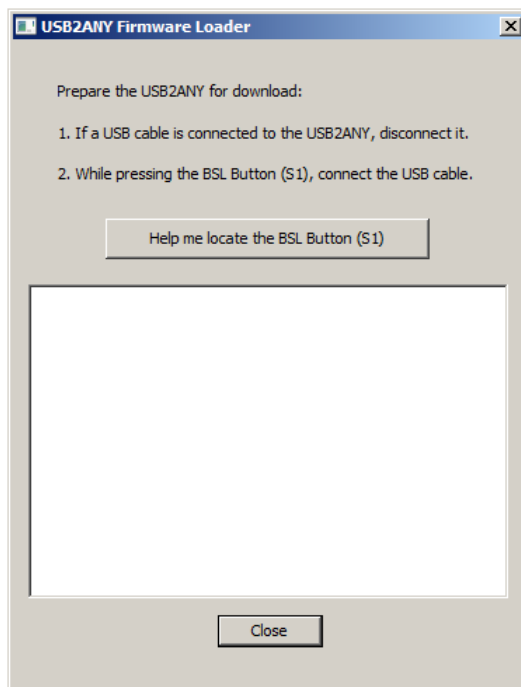


Figure 31. Firmware Loader

3. The BSL button is located next to the USB connector.

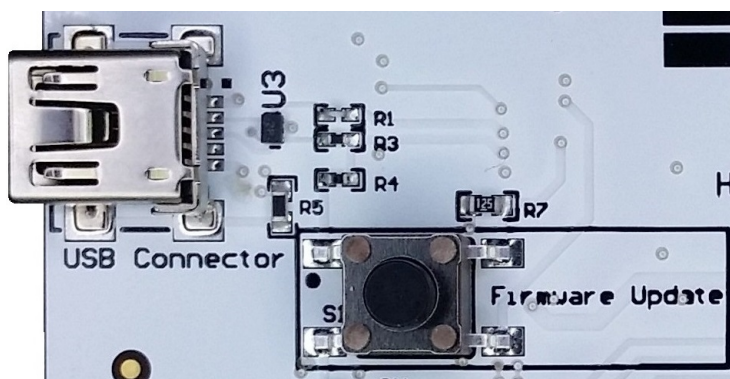


Figure 32. BSL Button

4. Follow the on-screen procedure until the below screen is pop-up.

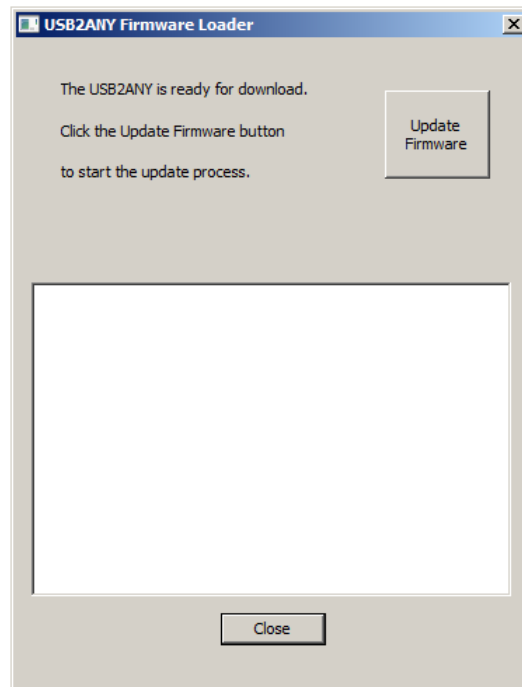


Figure 33. Update Firmware

5. Click the "Upgrade Firmware" button, the firmware will be upgrading. Click the "Close" button after it is done.

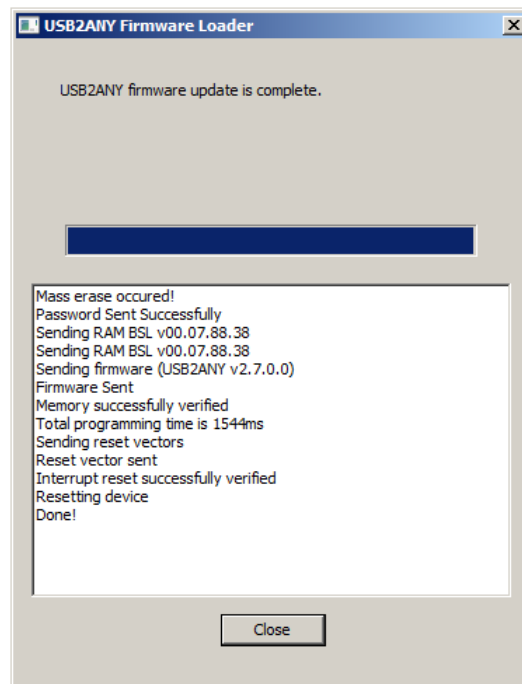


Figure 34. Firmware Update Completed

6. Check the USB connection in TICS Pro by clicking USB communications → Interface. Make sure the USB Connected button is turned green.

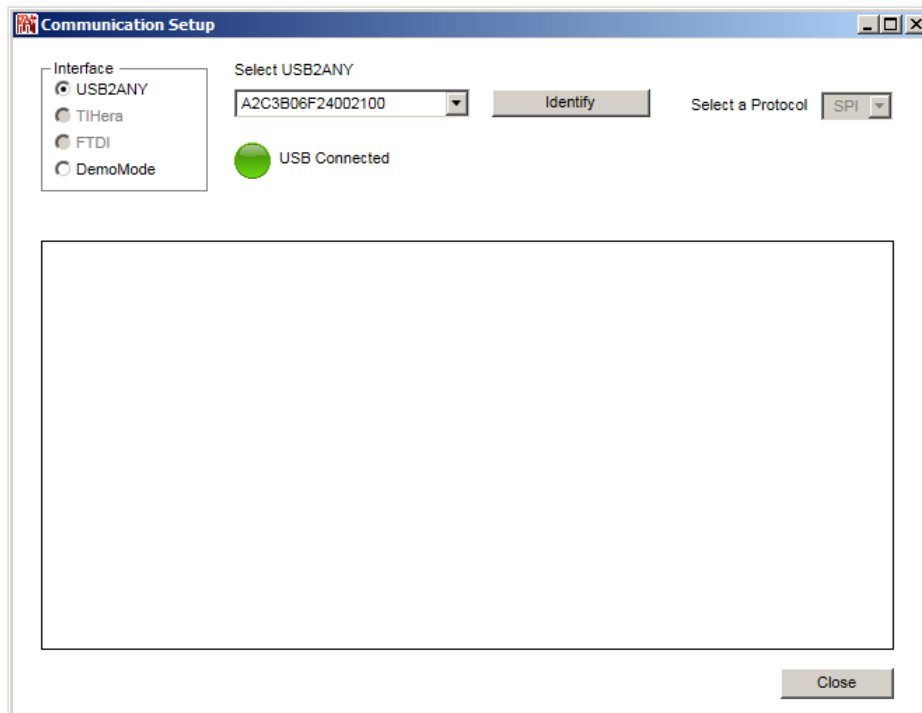


Figure 35. USB Communications

Revision History

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

Changes from A Revision (November 2017) to B Revision	Page
• Changed C19, C24 and C25 values in schematic.....	13
• Changed C19, C24 and C25 values in BOM.....	18

Changes from Original (August 2017) to A Revision	Page
• Added phase adjustment example.....	6
• Added calibration-free ramping example.....	7
• Added automatic ramp example	9
• Added SYSREF example	10
• Added FSK modulation example	11
• Added register readback example.....	12
• Added troubleshooting guide	19
• Changed the graphic of single-ended input with crystal oscillator	20

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.

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 DEGRADATION 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/lstds/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/lstds/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 2 4 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/lstds/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/lstds/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, INDEMNITY 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.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2019, Texas Instruments Incorporated