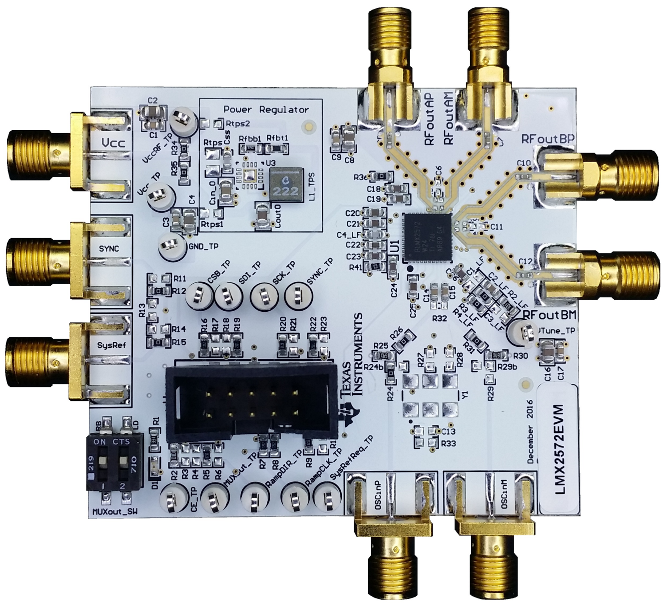
LMX2572EVM Evaluation Instructions

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.



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Trademarks

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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

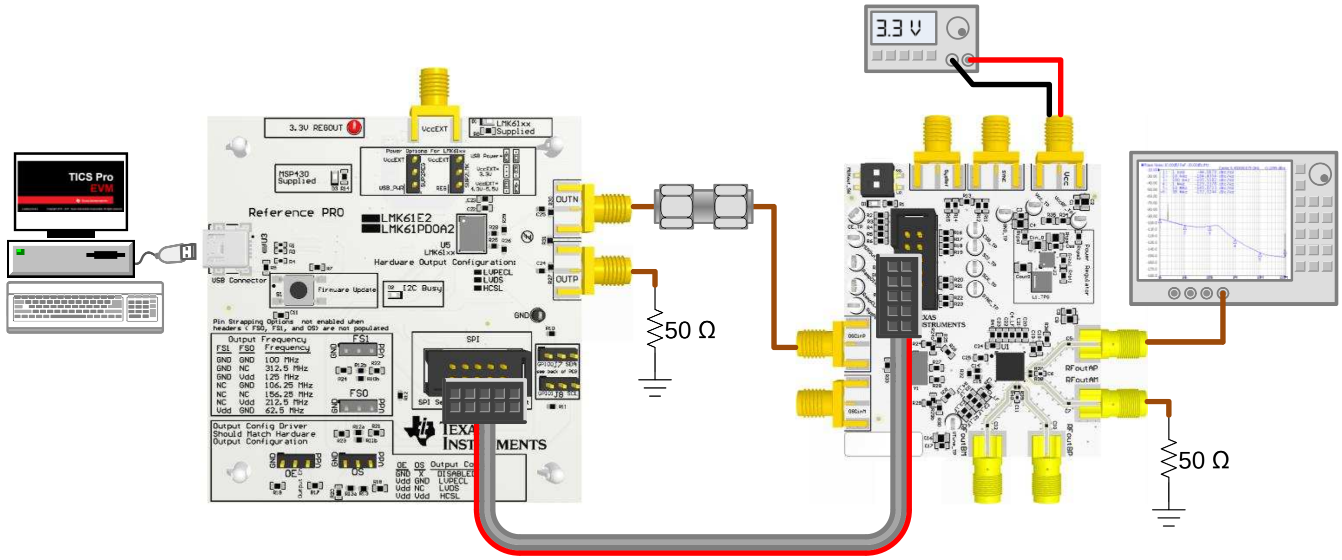


Figure 1. EVM Connection Diagram

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 adopter. 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.

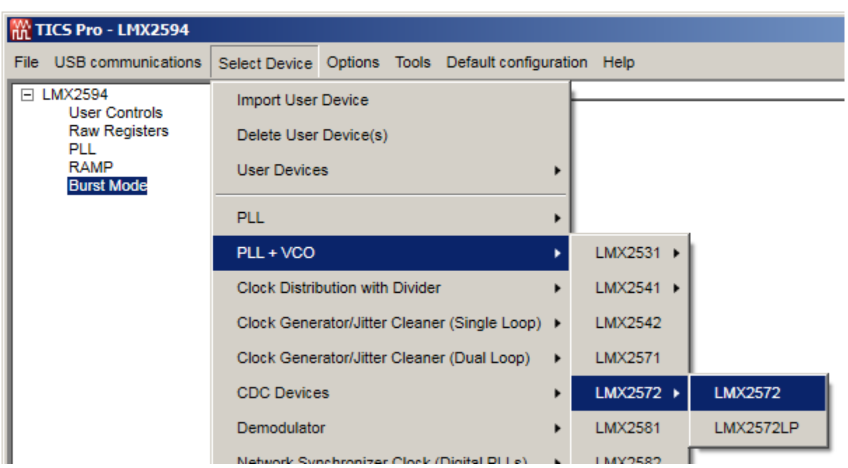


Figure 2. Select Device in TICS Pro

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

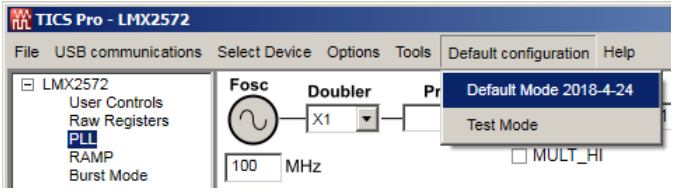


Figure 3. Default Mode

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.

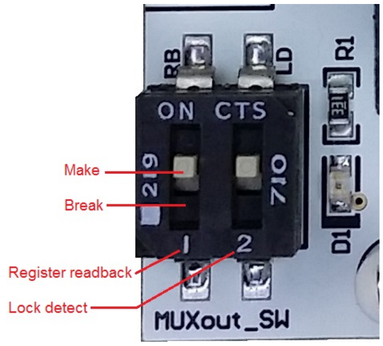


Figure 4. MUXout_SW Switch

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 µA
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

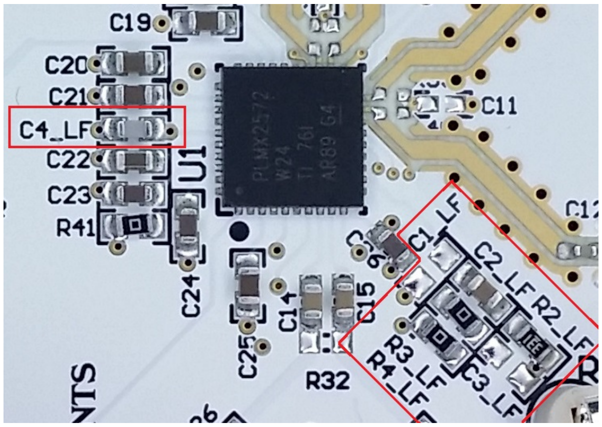


Figure 5. Loop Filter

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.

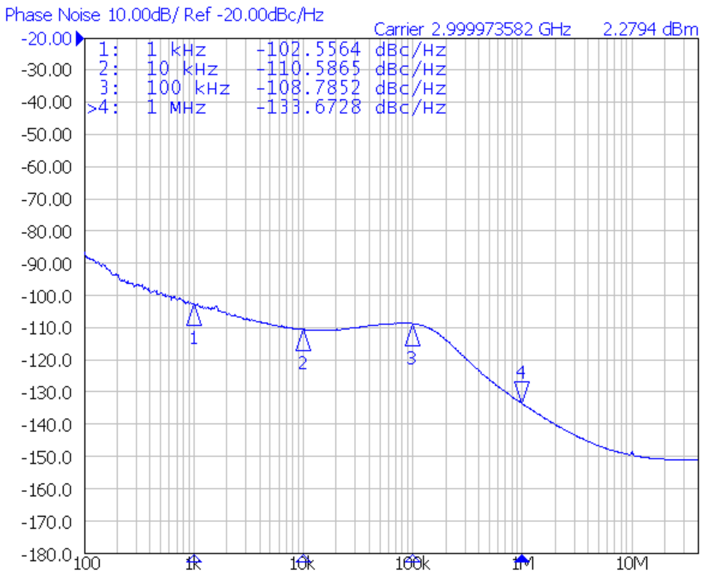


Figure 6. Default Output

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° × (MASH_SEED / PLL_DEN) × (P / 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° × (800 / 1000) × (1 / 32) = 9°. We can write 800 to MASH_SEED 40 times to get 360° phase shift.

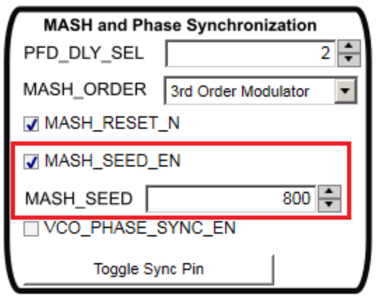


Figure 7. Phase Adjustment Setting

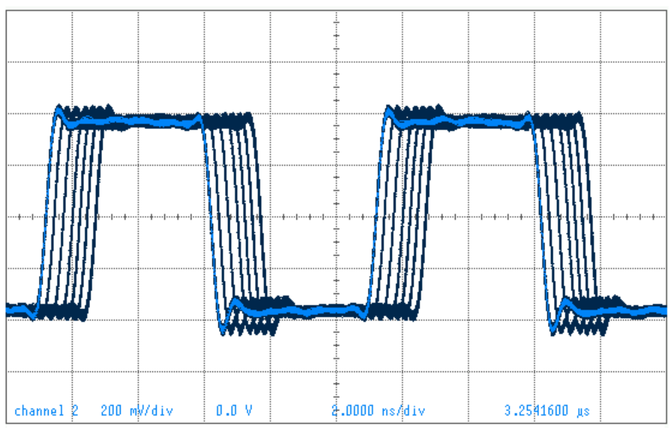


Figure 8. Phase Adjustment

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 µs
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.

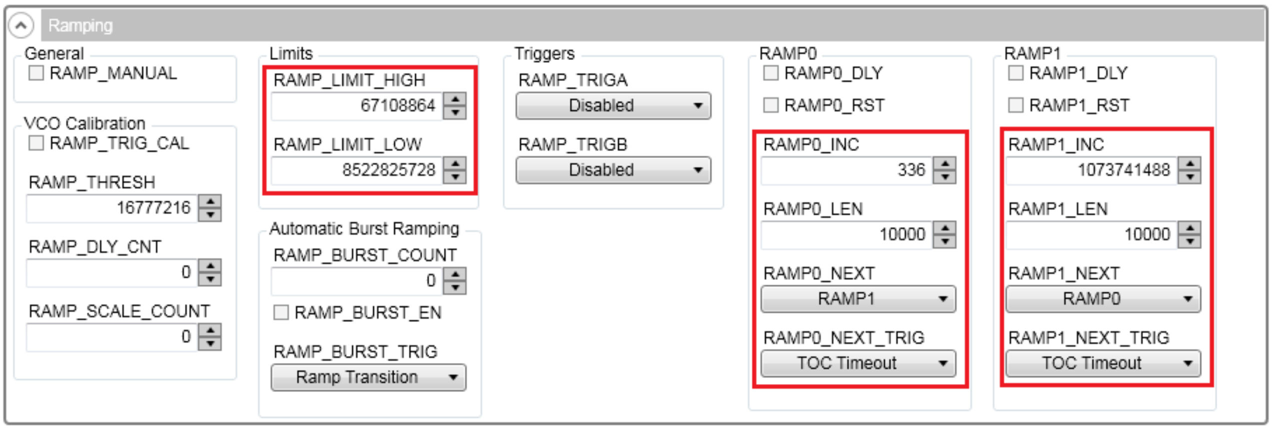


Figure 9. Calibration-Free Automatic Ramp Setting

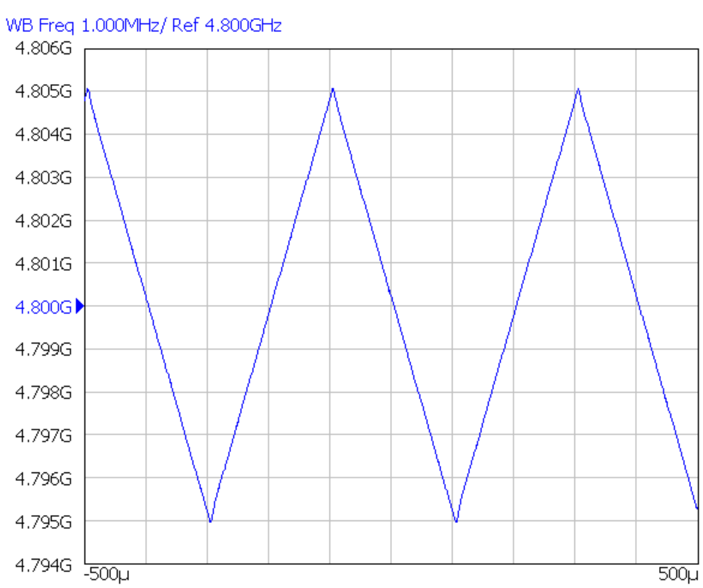


Figure 10. Calibration-Free Automatic Ramp

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 µs
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 µs

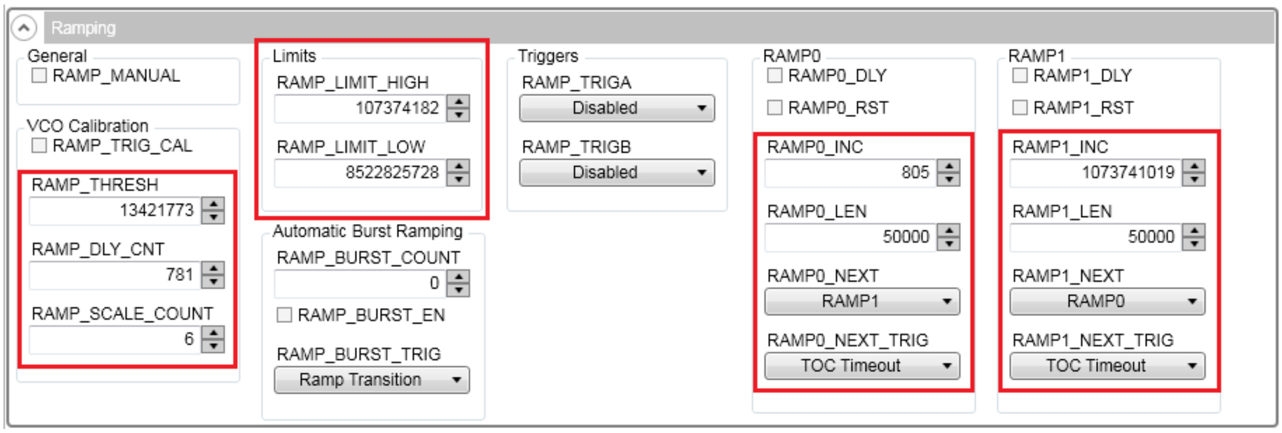


Figure 11. Automatic Ramp Setting

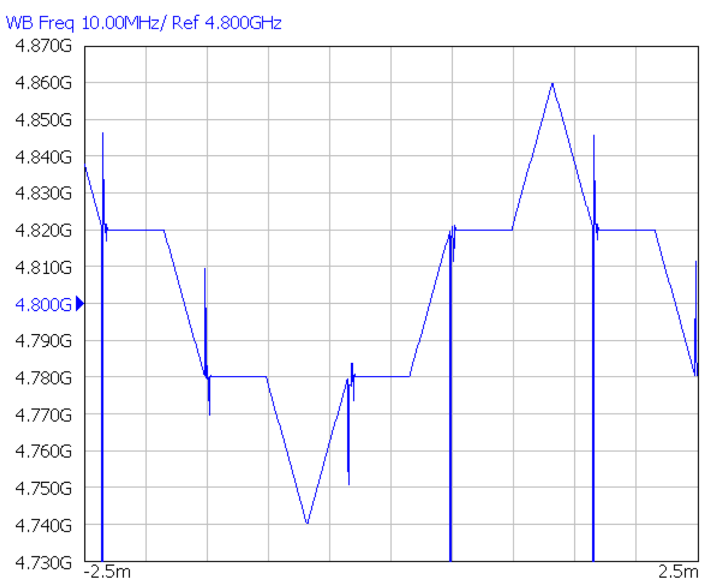


Figure 12. Automatic Ramp

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.

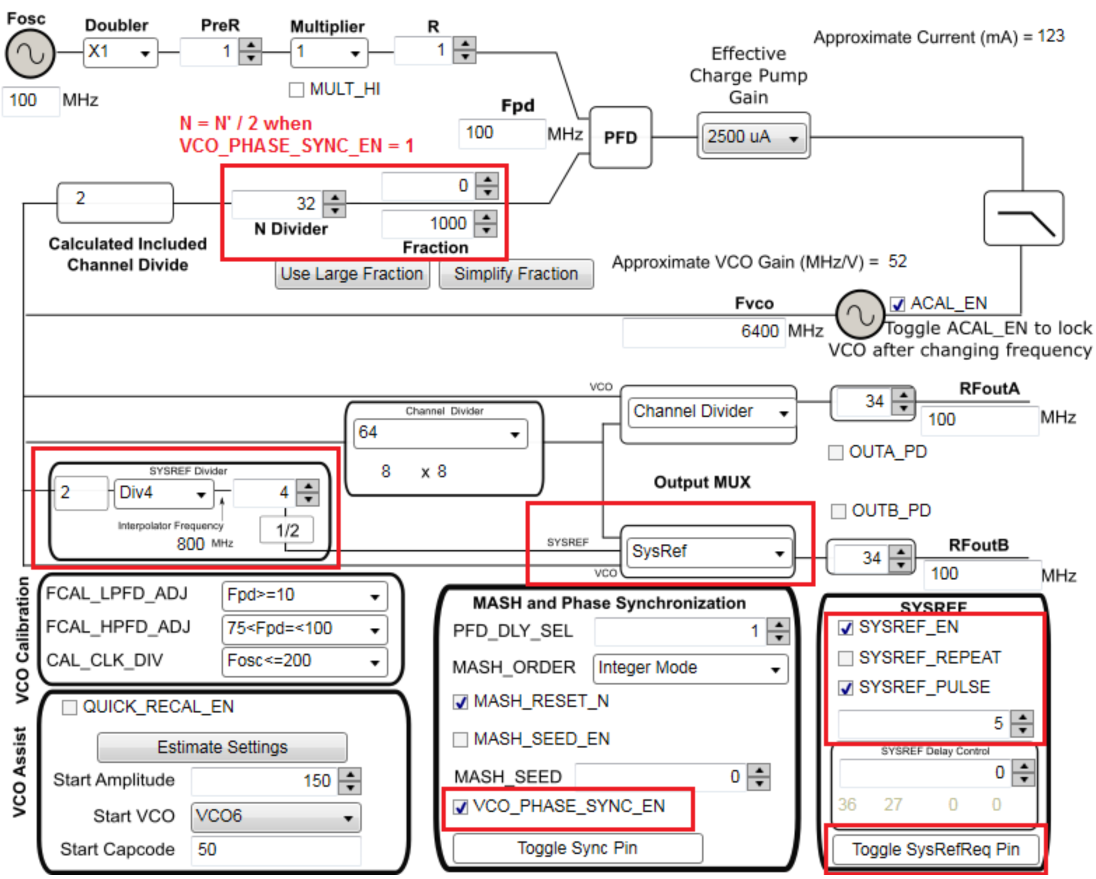


Figure 13. SYSREF Pulsed Mode Setting

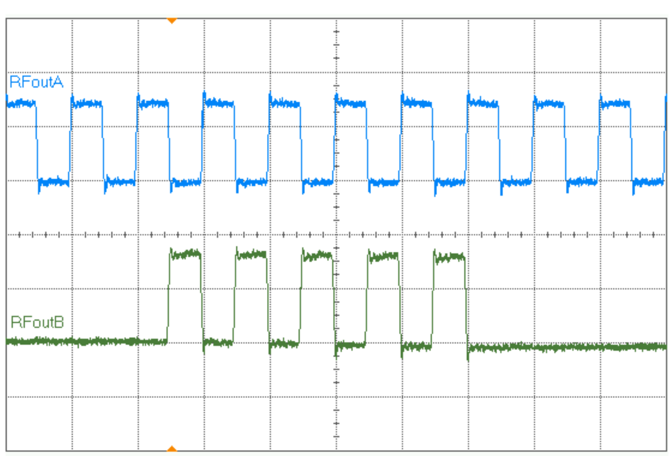


Figure 14. SYSREF Pulsed Mode

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.

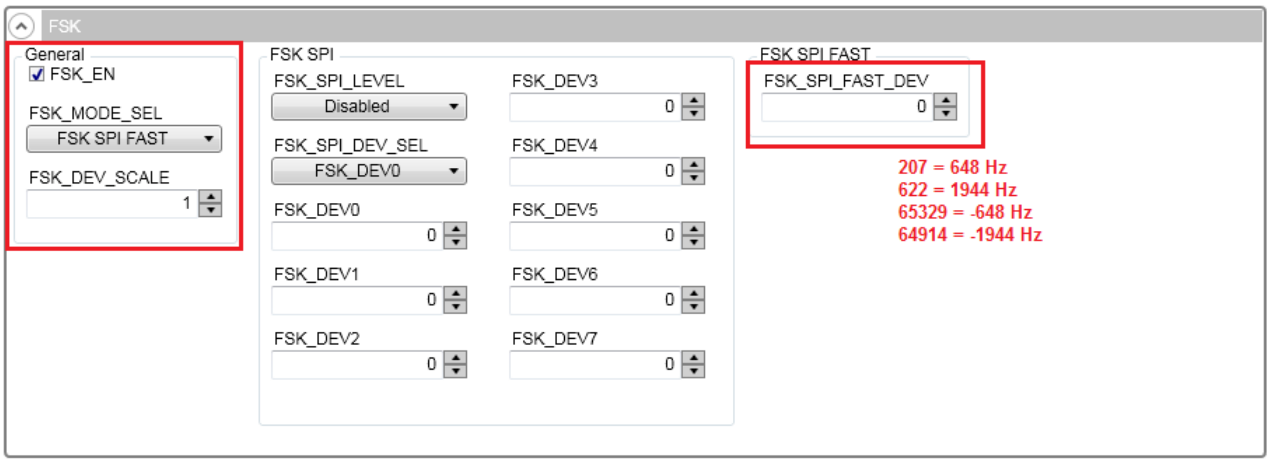


Figure 15. FSK SPI FAST Mode Setting

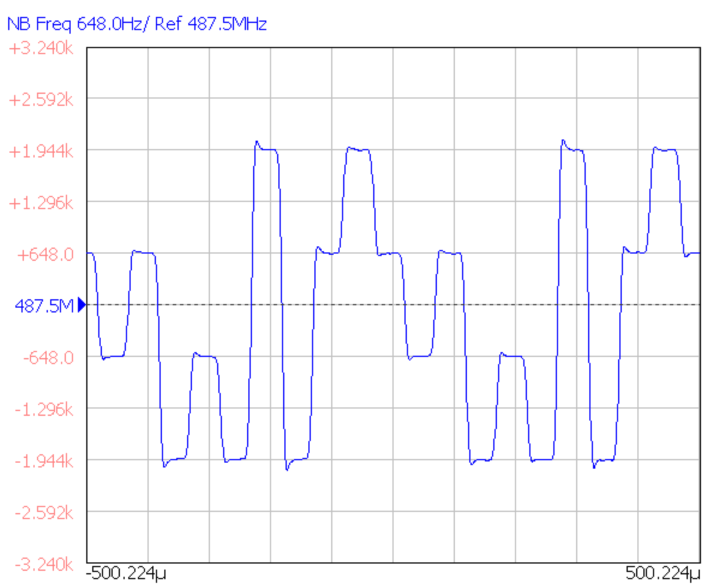


Figure 16. FSK SPI FAST Mode

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*.

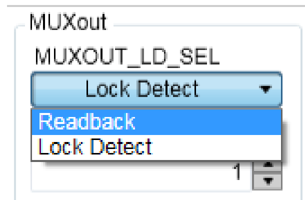


Figure 17. Readback Setting

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

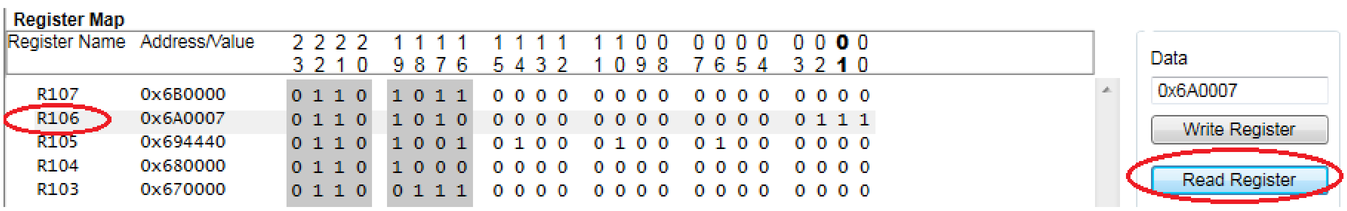


Figure 18. Register Readback

4 Schematic

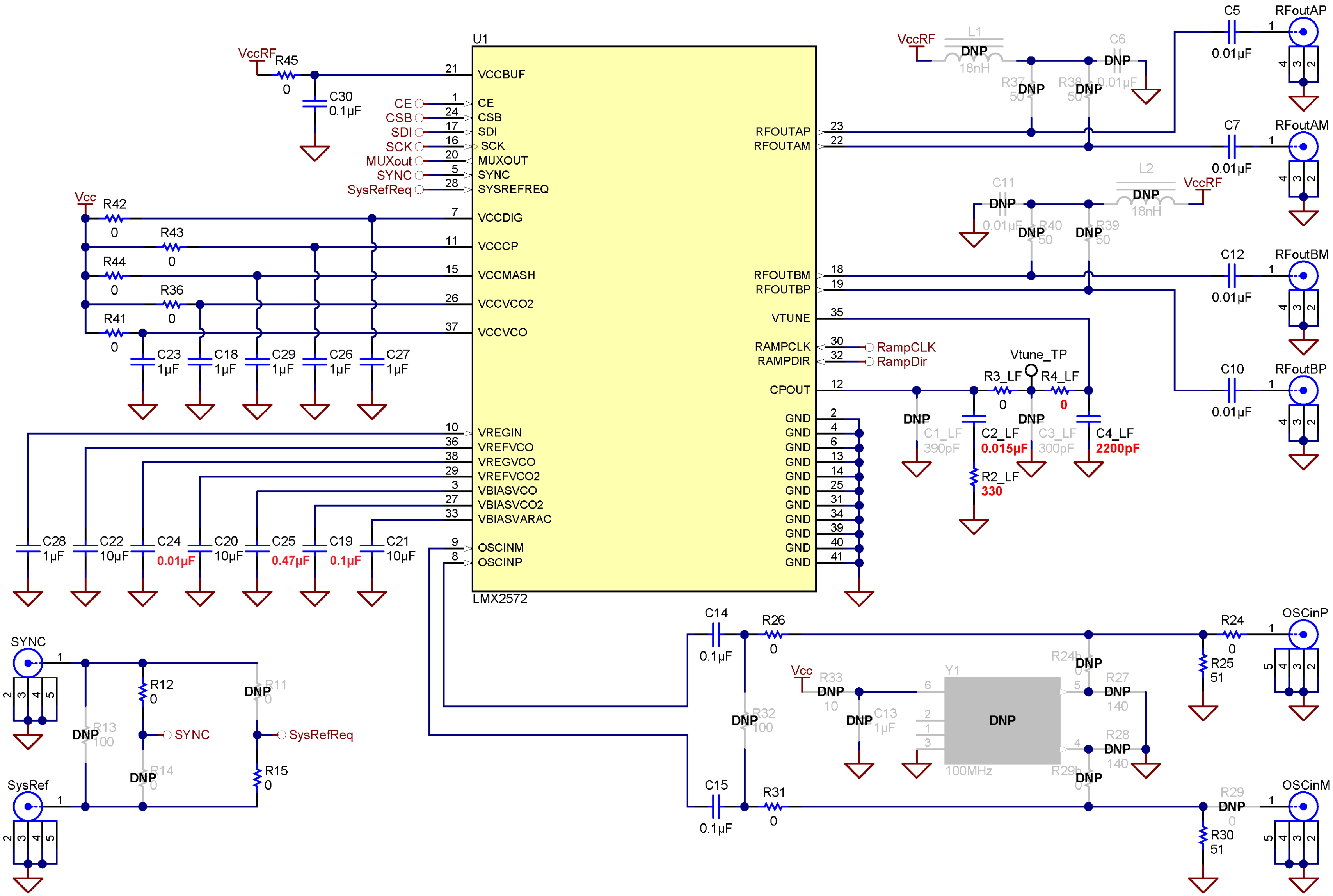


Figure 19. LMX2572EVM Schematic (Page 1)

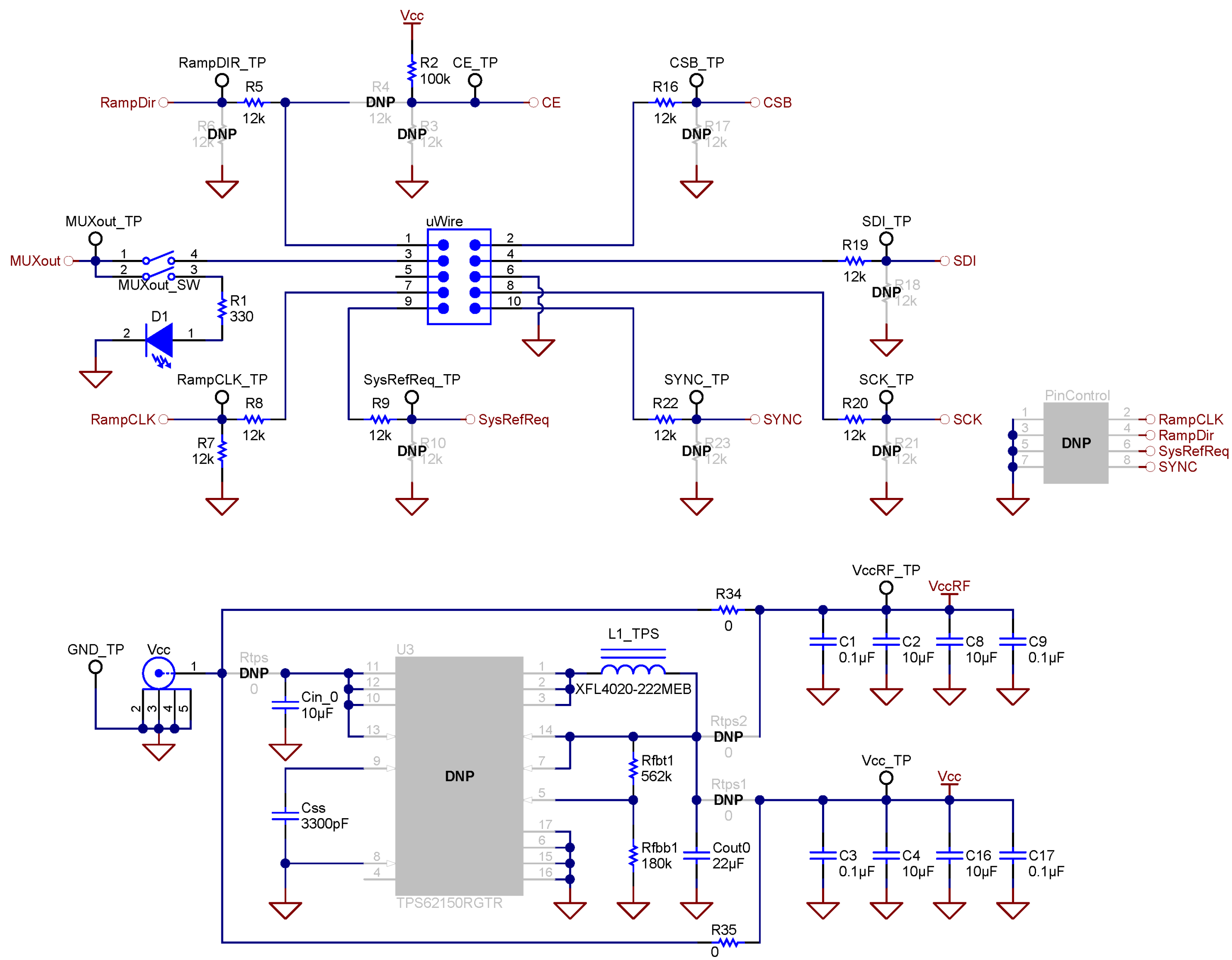


Figure 20. LMX2572EVM Schematic (Page 2)

5 PCB Layout and Layer Stack-up

5.1 PCB Layer Stack-up

The top layer is 1-oz. copper.

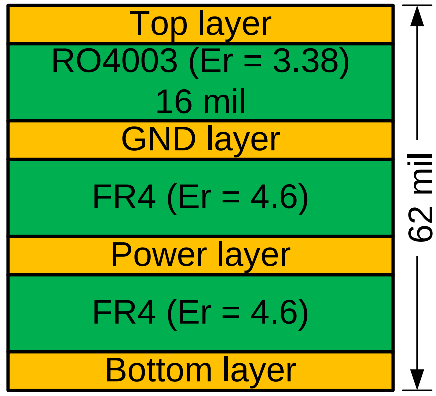


Figure 21. PCB Layer Stack-Up

5.2 PCB Layout

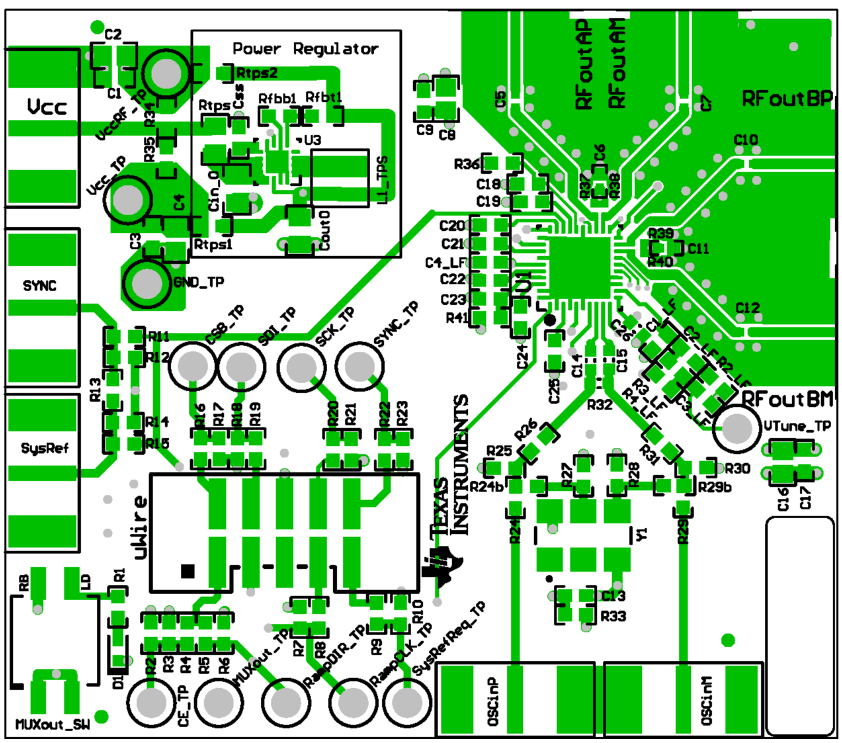


Figure 22. Top Layer

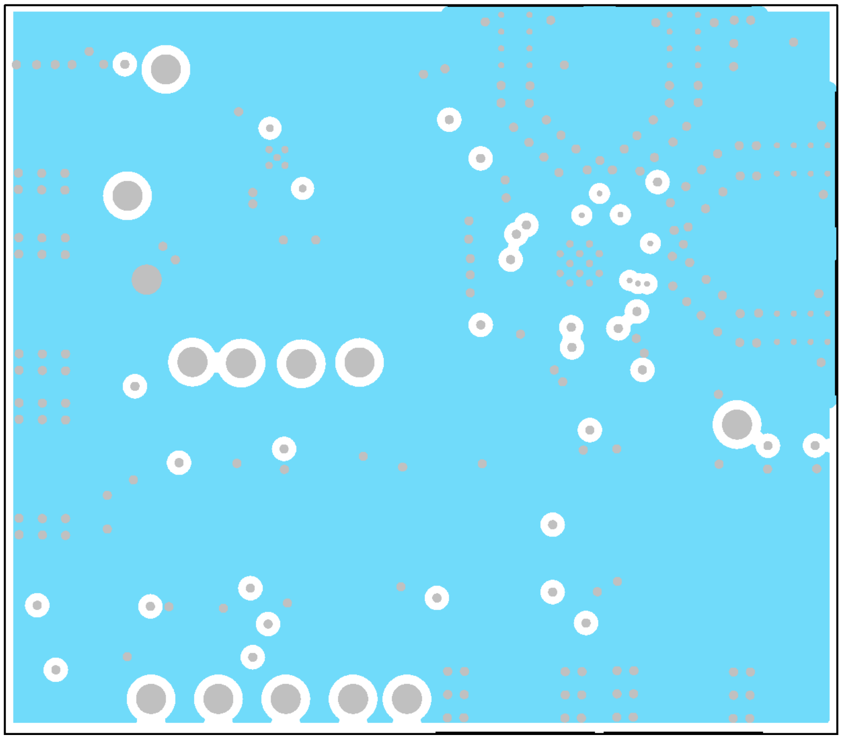


Figure 23. GND Layer

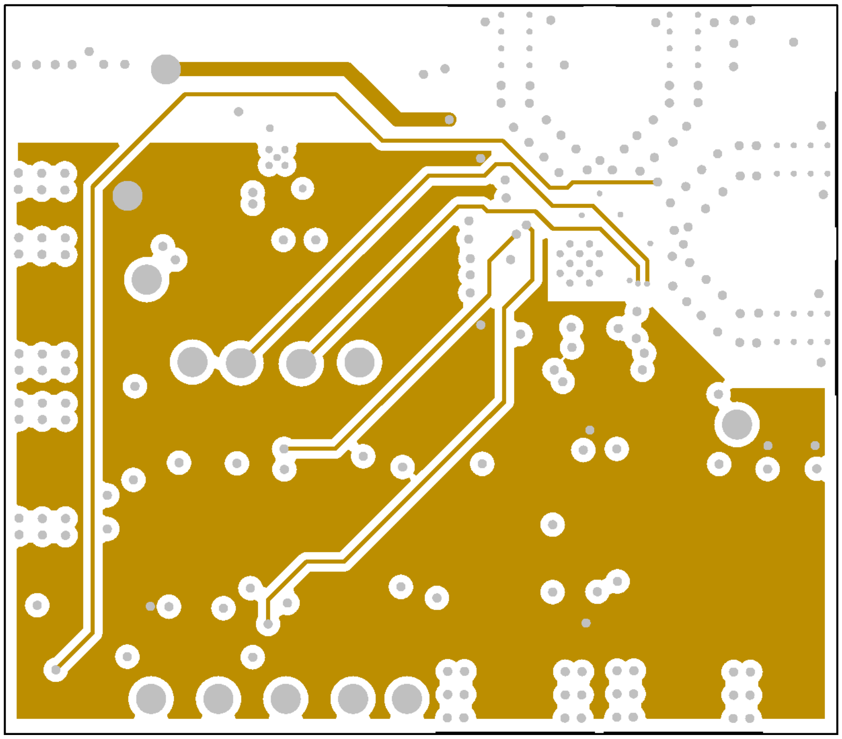


Figure 24. Power Layer

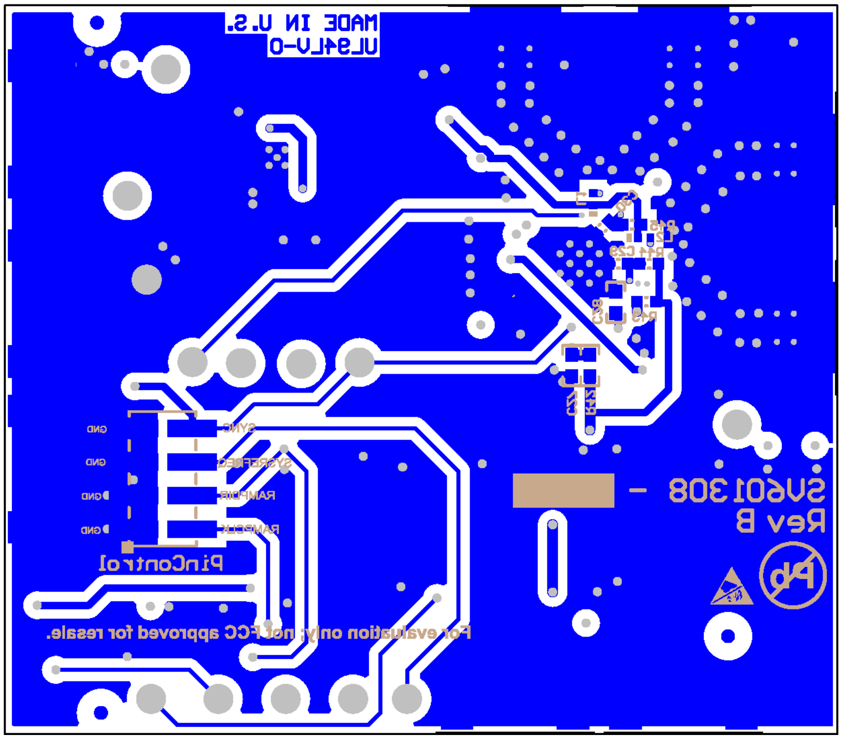


Figure 25. Bottom Layer

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 µF, 16 V, ±5%, X7R, 0603	0603YC104JAT2A	AVX
C2, C4, C8, C16	4	CAP, CERM, 10 µF, 10 V, ±10%, X5R, 0805	C0805C106K8PACTU	Kemet
C2_LF	1	CAP, CERM, 0.015 µF, 50 V, ±10%, X7R, 0603	GRM188R71H153KA01D	MuRata
C4_LF	1	CAP, CERM, 2200 pF, 50 V, ±5%, C0G/NP0, 0603	GRM1885C1H222JA01D	MuRata
C5, C7, C10, C12	4	CAP, CERM, 0.01 µF, 16 V, ±10%, X7R, 0402	520L103KT16T	AT Ceramics
C18, C23, C26, C27, C28, C29	6	CAP, CERM, 1 µF, 16 V, ±10%, X7R, 0603	C1608X7R1C105K080AC	TDK
C20, C21, C22	3	CAP, CERM, 10 µF, 10 V, ±20%, X5R, 0603	C1608X5R1A106M080AC	TDK
C24	1	CAP, CERM, 0.01 µF, 50 V, ±5%, X7R, 0603	C0603C103J5RACTU	MuRata
C25	1	CAP, CERM, 0.47 µF, 25 V, ±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 µF, 25 V, ±10%, X5R, 0805	GRM219R61E106KA12D	MuRata
Cout0	1	CAP, CERM, 22 µF, 16 V, ±10%, X5R, 0805	C2012X5R1C226K125AC	TDK
Css	1	CAP, CERM, 3300 pF, 50 V, ±5%, C0G/NP0, 0603	GRM1885C1H332JA01D	MuRata
D1	1	LED, Green, SMD	LTST-C190GKT	Lite-On
L1_TPS	1	Inductor, Shielded, Composite, 2.2 µH, 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 kΩ, 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 kΩ, 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 kΩ, 0.1%, 0.1 W, 0603	RT0603BRD07180KL	Yageo America
Rfbt1	1	RES, 562 kΩ, 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.

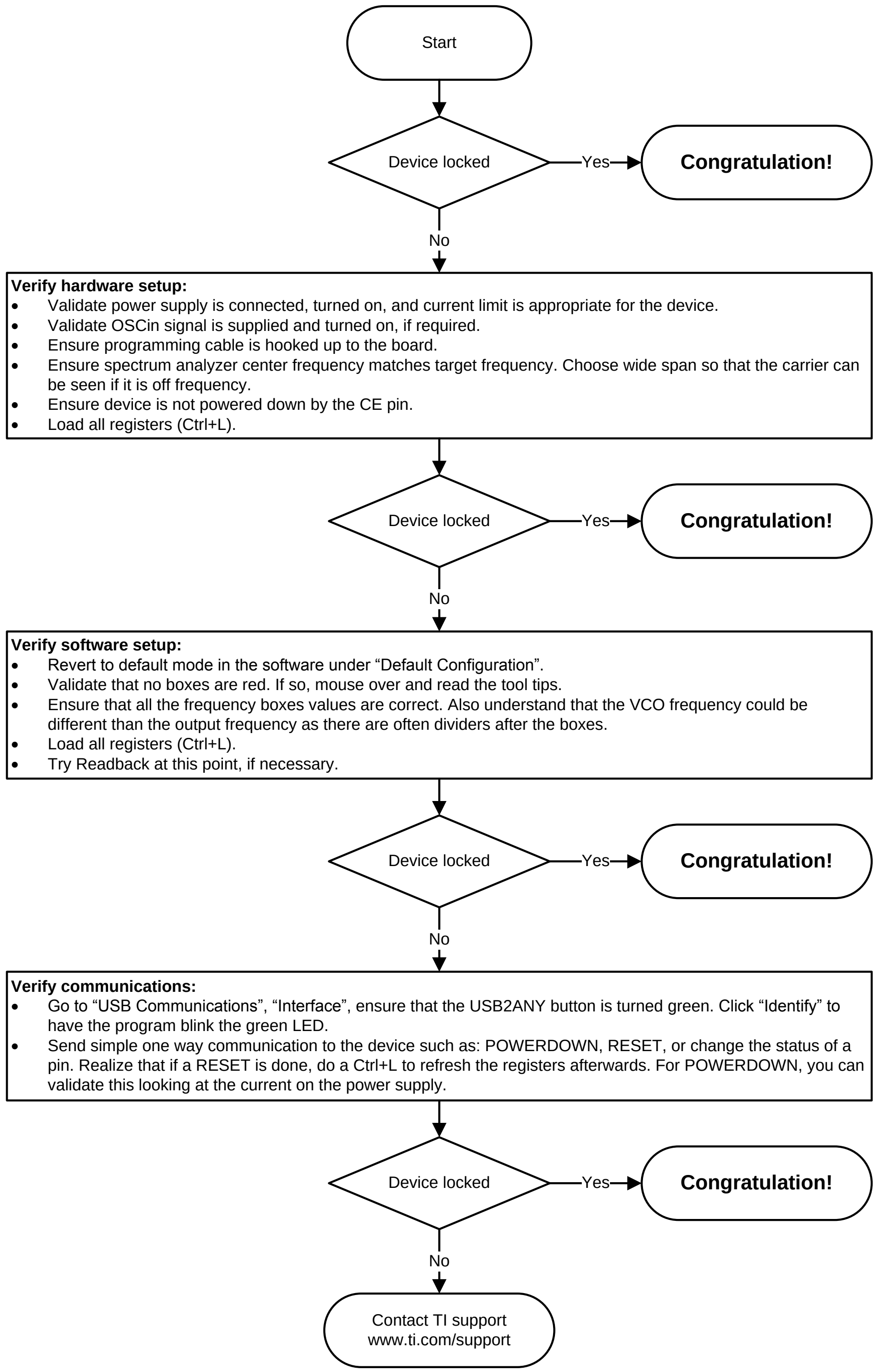
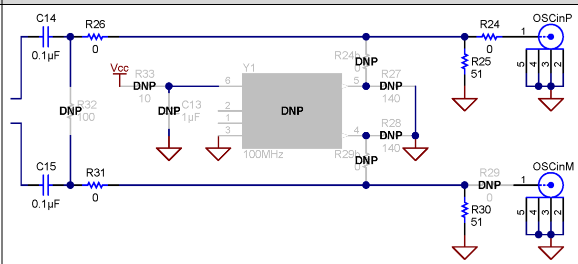
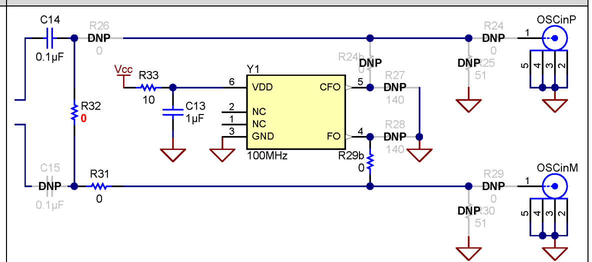
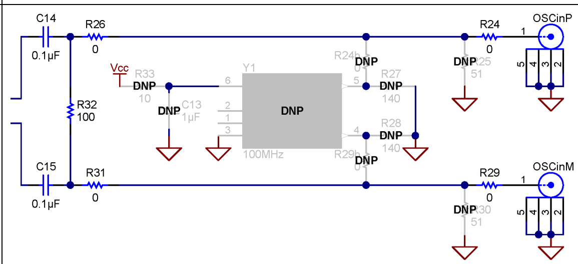
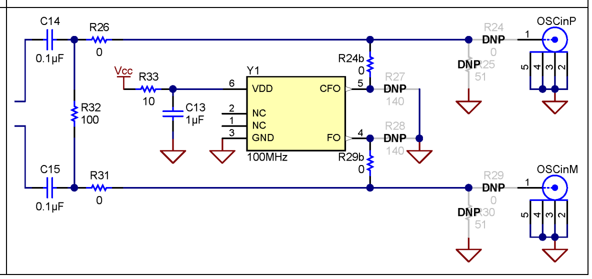


Figure 26. Troubleshooting Guide

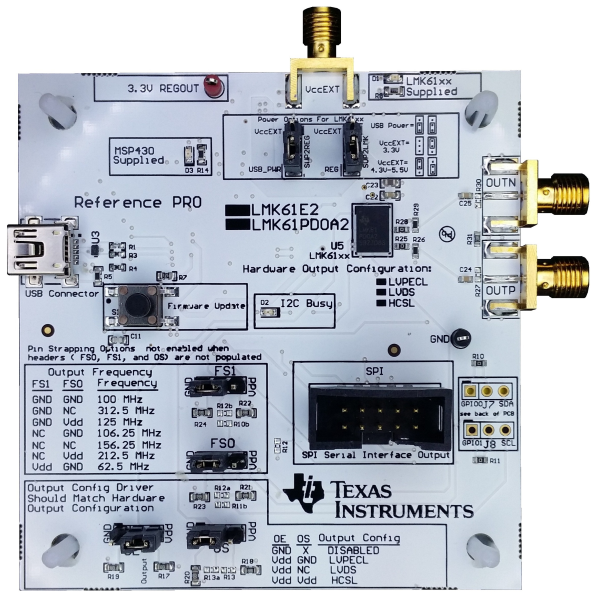
Using Different Reference Clock

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

INPUT	EXTERNAL CLOCK	CRYSTAL OSCILLATOR
Single-ended		
Differential (LVDS)		

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 inTable 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
HCSL	AC	R25, 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 V_{CC} – 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.

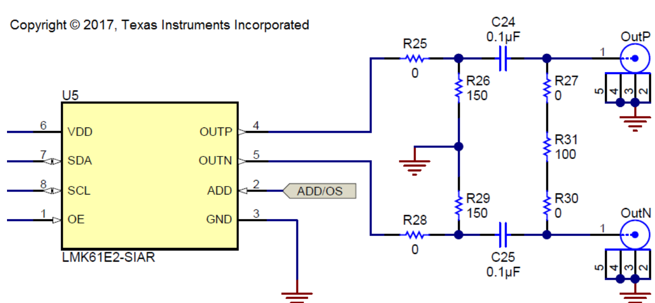


Figure 27. Output Termination Schematic

B.3 Typical Output Characteristics

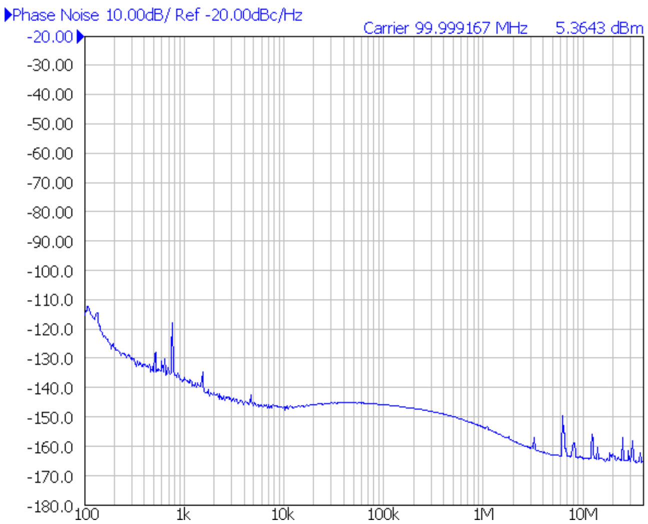


Figure 28. Default Output Phase Nosie

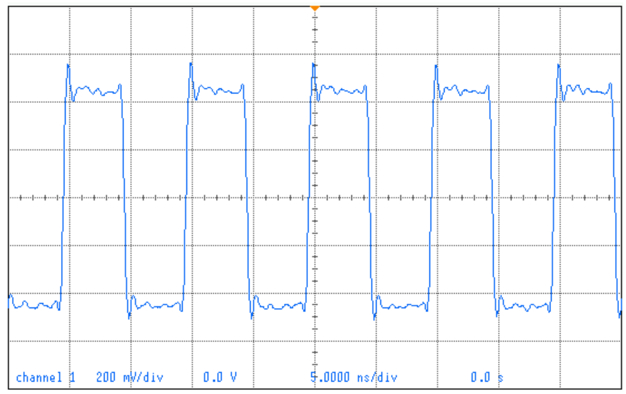


Figure 29. Default Output Waveform

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.

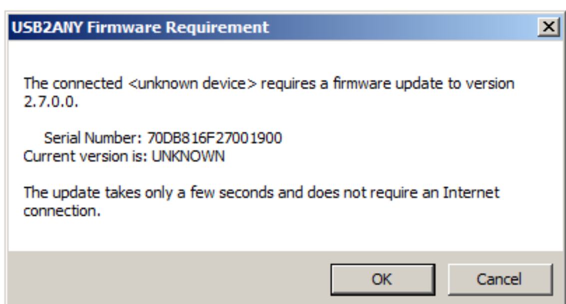


Figure 30. Firmware Requirement

2. Next, follow the on-screen procedure.

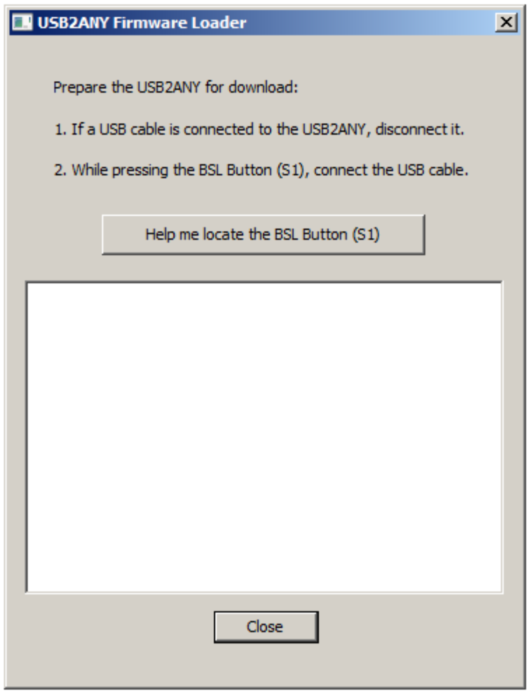


Figure 31. Firmware Loader

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

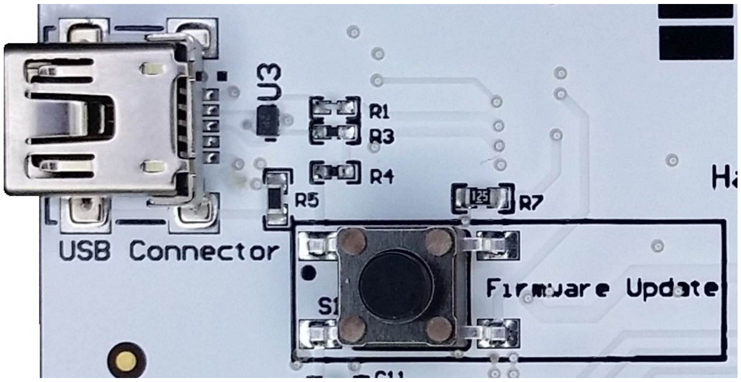


Figure 32. BSL Button

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

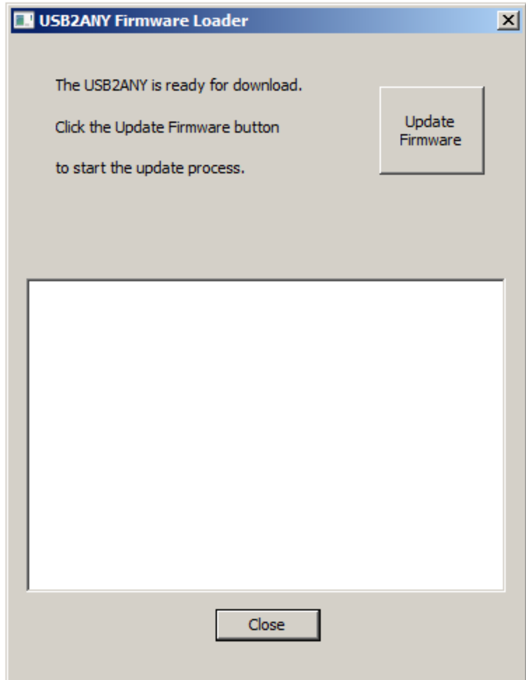


Figure 33. Update Firmware

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

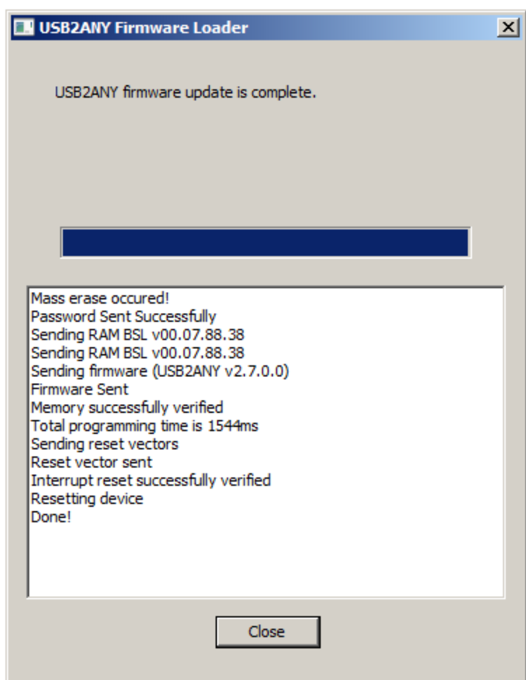


Figure 34. Firmware Update Completed

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

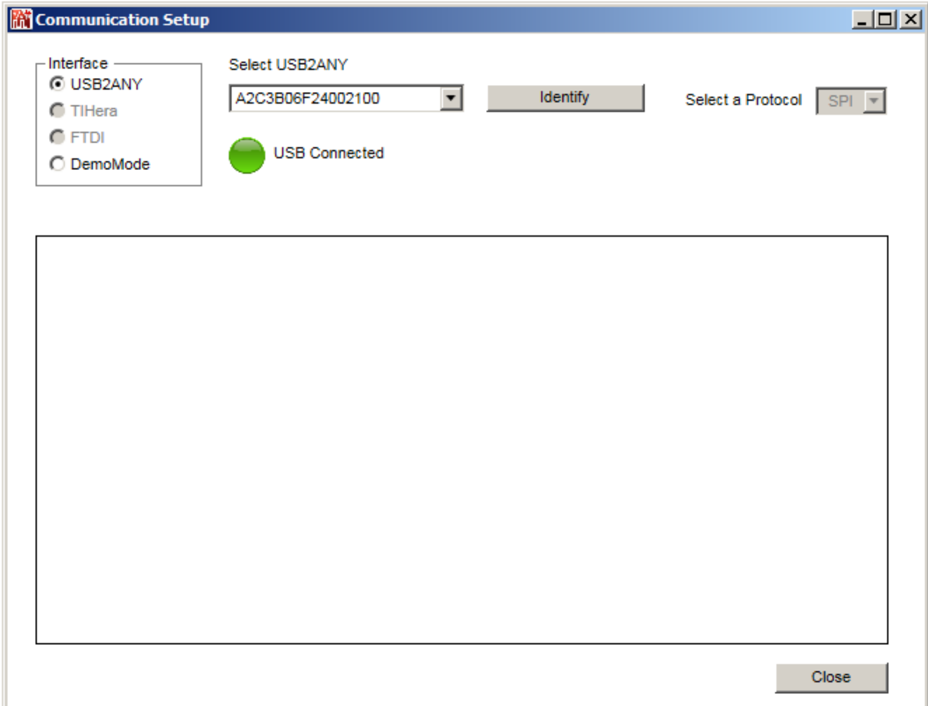


Figure 35. USB Communications

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

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NOTE:

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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

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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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.

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