EVM User's Guide: LMX2831EVM

LMX2831 Evaluation Module With 18GHz Synthesizer

Description

LMX2831EVM is used to evaluate the performance of the LMX2831 device. This device is a high performance RF synthesizer in 7mm x 7mm LGA package. LMX2831 is able to generate continuous wave signals up to 18GHz. The evaluation module provides all the hardware interface to enable users to quickly evaluate and develop with this RF synthesizer.

Get Started

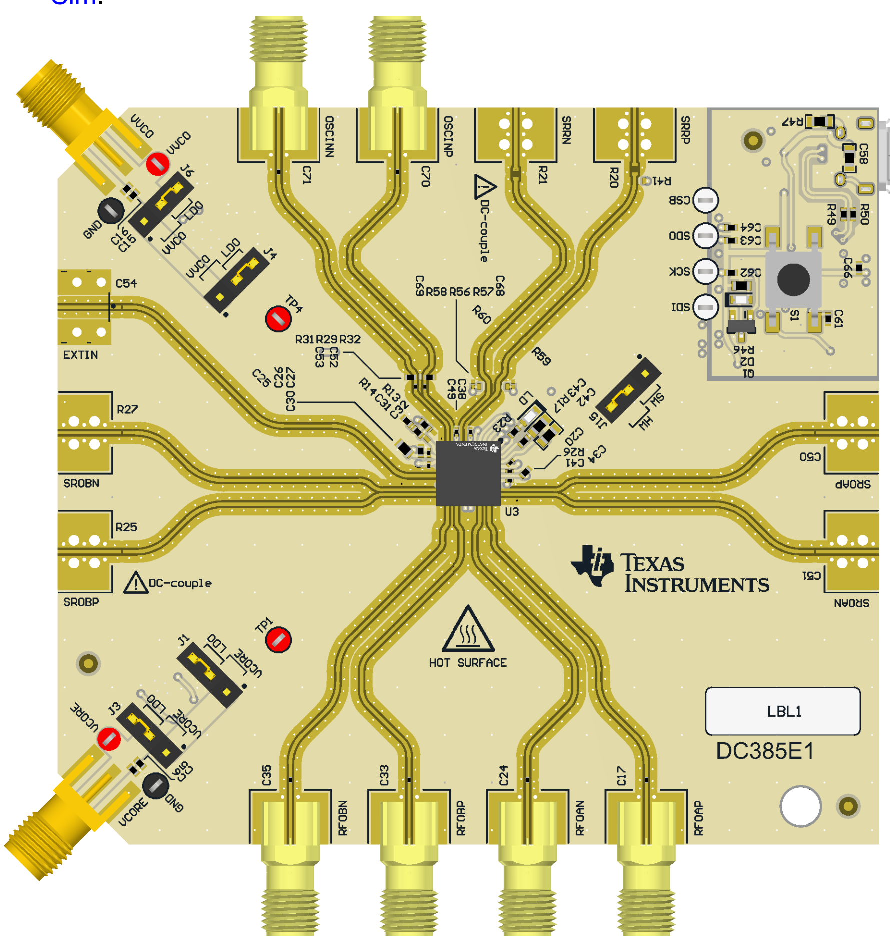
1. Order the EVM, LMX2831EVM.
2. Download the latest programming GUI, TICS Pro 2.
3. Download the PLL simulation tool, PLLatinum Sim.
4. Learn more about VCO calibration, SNAA336.
5. Ping-pong architecture overview, SNAA357.

Features

- Up to 9GHz direct VCO output
- Up to 18GHz doubler output at channel B
- Onboard USB interface for SPI control

Applications

- Radar and electronic warfare
- MC-GSM base station, 5G and mm-wave wireless infrastructure
- Microwave backhaul
- Test and measurement equipment
- High speed data converter clocking



ADVANCE INFORMATION

1 Evaluation Module Overview

1.1 Introduction

LMX2831EVM board contains a LMX2831 RF synthesizer (Test chip), two low noise LDOs and a microcontroller (also referred to as *USB2ANY*). The board has two RF outputs, RFOUTA and RFOUTB. RFOUTB can output divided down, direct VCO or VCO doubler output up to 18GHz. RFOUTA supports direct VCO output only, the maximum output frequency is 9GHz.

Configuration to the LMX2831 device is made through the onboard USB2ANY to a PC. TICS Pro 2 is used to configure and program the LMX device.

1.2 Kit Contents

Included within each evaluation kit is:

- One LMX2831 EVM board with integrated USB2ANY controller
- One USB cable

1.3 Specification

Table 1-1. EVM Specification

Parameter	Value	Conditions
Supply voltage	VCORE: 3.0V VVCO: 6.5V	VCORE LDO output is 2.5V VVCO LDO output is 6.0V
	VCORE: 2.5V VVCO: 6.0V	Onboard LDOs are bypassed
Supply current	VCORE: 1A maximum VVCO: 300mA maximum	Configuration dependent
OSCIN input frequency	5MHz to 1.1GHz	4dBm
RF output frequency	4.5GHz to 9GHz	RFOUTA
	1.125GHz to 18GHz	RFOUTB

1.4 Device Information

LMX2831 device (Test chip) is a high performance, wideband phase-locked loop (PLL) with integrated voltage controlled oscillator (VCO) that can generate any frequency from 1.125MHz to 18GHz. The core supply voltage of this device is 2.5V while the supply voltage for the internal VCO is 6V.

This device has two output channels. Channel B supports direct VCO output, divided down output and VCO doubler output. Channel A supports direct VCO output only. Output can be quickly muted through pin control, response time is as short as 10ns. This feature is especially useful for ping-pong switching application. See SNAA357 for details.

With a new Full Assist operation, VCO lock time is greatly reduced to within 20µs.

Configuration to this device is made through SPI programming.

This device is fabricated in Texas Instruments' advanced BiCMOS process and is available in a 48-lead 7mm × 7mm LGA package.

2 Hardware

2.1 Setup

2.1.1 Evaluation Setup Requirement

- At a minimum, evaluation of the EVM requires:
- Two DC power supply capable of at least 3V, 1.5A and 6.5V, 500mA
- A high quality signal source, such as an SMA100B
- A spectrum analyzer or phase noise analyzer up to 26GHz
- A PC running Windows 7 or a more recent version with TICS Pro 2 software installed

2.1.2 Connection Diagram

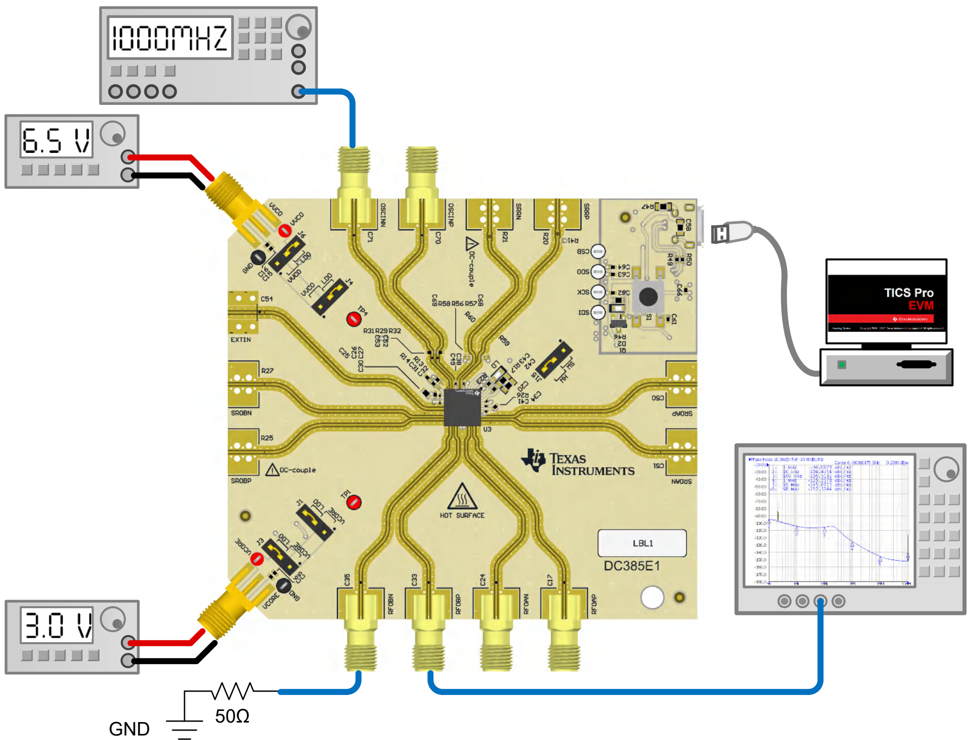


Figure 2-1. Connection Diagram

2.2 Jumper Information

Jumper J1, J3, J4 and J6 determine the supply voltage to the board.

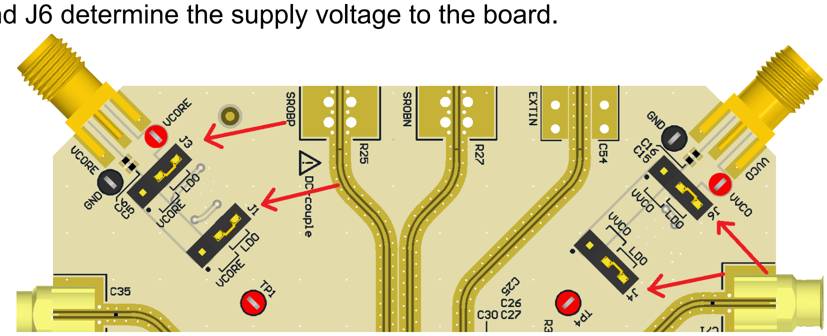


Figure 2-2. Power Supply Jumpers

To bypass the LDOs, set jumper J4 and J6 to the VVCO position; set jumper J1 and J3 to the VCORE position.

To use the LDOs, set jumper J1, J3, J4 and J6 to the LDO position. This is the EVM default configuration.

2.3 Power Requirements

When LDOs are bypassed. Apply 2.5V to VCORE SMA connector and 6.0V to VVCO SMA connector.

When using the LDOs (EVM default configuration), apply 3.0V to VCORE SMA connector and 6.5V to VVCO SMA connector.

VCORE can draw up to 1A during operation, so the resistance of the power cable is matter.

2.4 Reference Clock

Connect OSCINP or OSCINN SMA connector to a high quality signal source such as an SMA100B signal generator. Set the output power of the signal generator to 4dBm.

Input can be driven differentially. Connect both OSCINP and OSCINN SMA connectors to a balun or a differential clock source. Populate R29, R31 or R32 properly to match the input signal termination requirement.

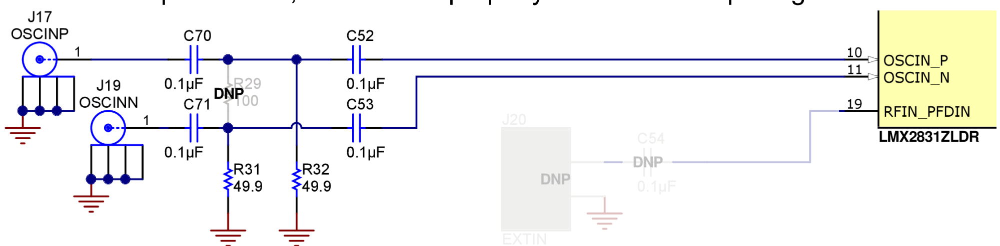


Figure 2-3. Reference Clock

2.5 Output Connections

Connect either RFOBP or RFOBN SMA connector to a signal analyzer. The unused connector must be terminated with a 50Ω resistor or a SMA load. Default TICS Pro 2 evaluation software configuration has RFOB output 6GHz signal and RFOA powered down. RFOA SMA connectors can be left open.

2.6 Test Points

Table 2-1. SPI Test Points

Test point	Designator	Property
TP10	SDO	Serial data output (Register read back)
TP7	CSB	SPI chip select input
TP8	SCK	SPI clock input
TP9	SDI	SPI data input

Table 2-2. Power Supply Test Point

Test point	Designator	Property
TP3	VCORE	2.5V (LDO bypassed) 2.8V to 3.0V (use onboard LDO)
TP1	VCC25	2.5V
TP6	VVCO	6.0V (LDO bypassed) 6.3V to 6.5V (use onboard LDO)
TP4	VCC6	6.0V
TP2, TP5	GND	0V

3 Software

3.1 Software Description

Texas Instruments Clocks and Synthesizers (TICS) Pro 2 software is used to program this evaluation module (EVM) through the on-board USB2ANY interface.

3.2 Software Installation

Download and install TICS Pro 2 software from www.ti.com/tool/ticspro-sw.

ADVANCE INFORMATION

4 Implementation Results

4.1 Evaluation Setup

Default EVM configuration is operated with the onboard LDOs. Setup the connection as shown in Figure 2-1. Run TICS Pro evaluation software and follow these steps to start the program.

1. Go to **Select Device** → **RF Synthesizers** → **LMX2830** → **LMX2830-TC (v0.0.2)**.

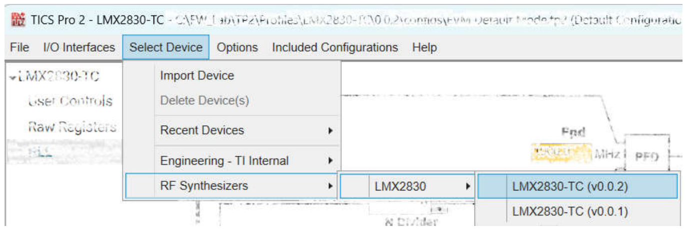


Figure 4-1. Select Device in TICS Pro

2. Go to **Included Configurations** → **EVM Default Mode**.

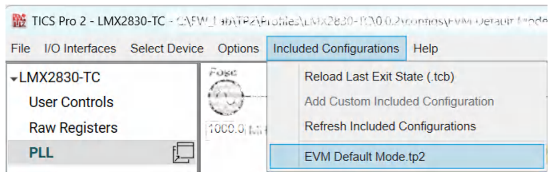


Figure 4-2. Default Mode

3. Go to **I/O Interfaces** → **Write All Registers** to write all the registers to LMX2831.

4.2 Performance Data and Results

4.2.1 RF Output

With EVM Default Mode configuration, VCO frequency is 6GHz, RFoutB output is 6GHz.

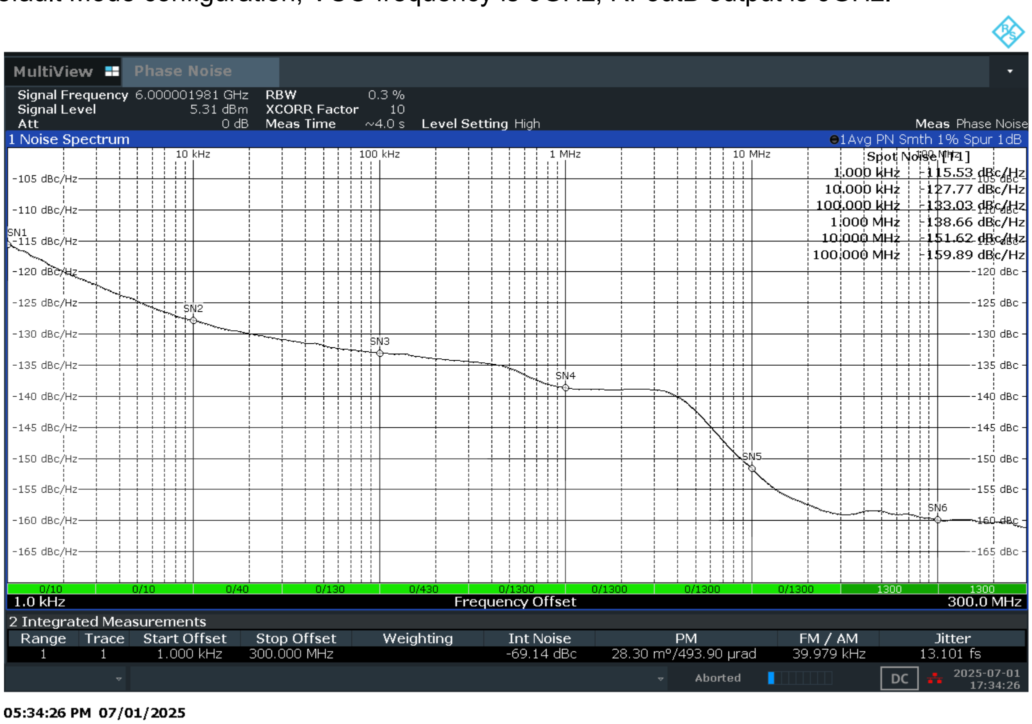


Figure 4-3. Direct VCO Output

The bump below 1MHz offset is due to the signal generator. The flat region between 1MHz and 3MHz offset represents the PLL noise of the synthesizer.

To get VCO doubler output, click on ***Output MUX*** and select *Doubler*. A VCO doubler calibration is required to configure the internal tracking filter so that the 2x signal passes through while the sub-harmonics are suppressed. To complete the doubler calibration, click the ***Calibrate VCO*** button once (this programs R0).

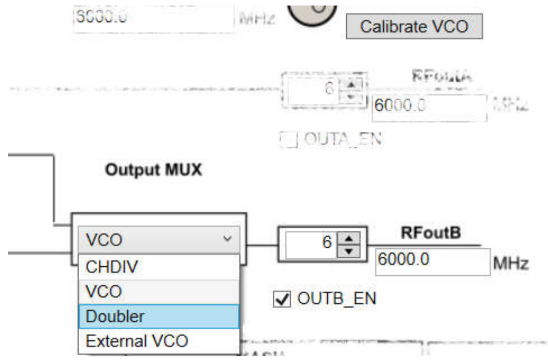


Figure 4-4. VCO Doubler Calibration

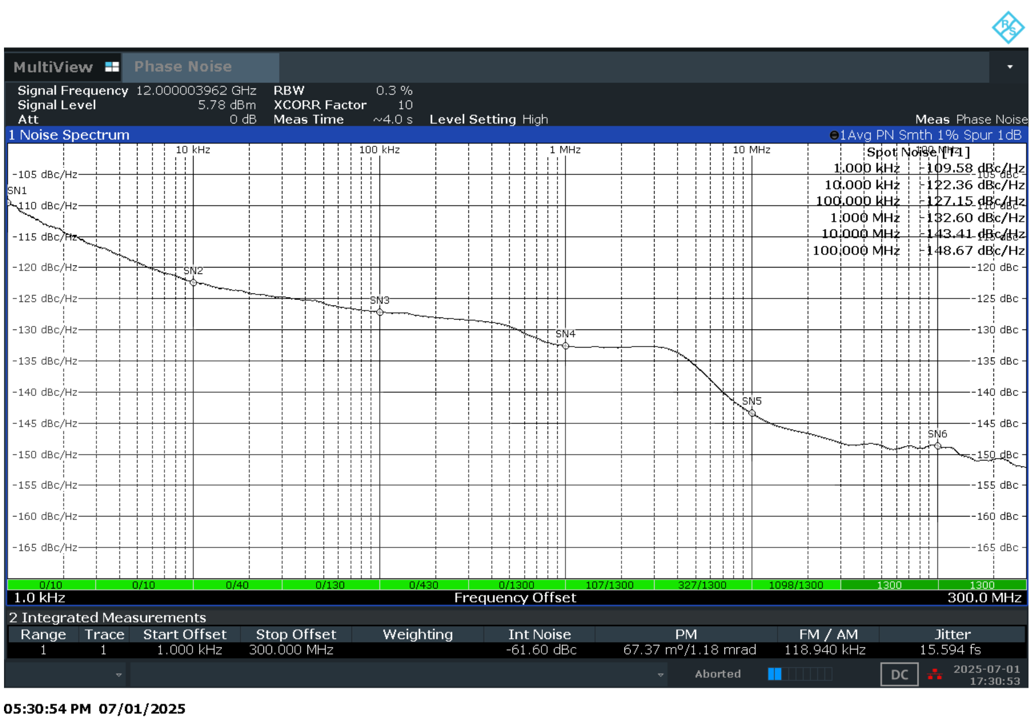


Figure 4-5. VCO Doubler Output

Sub-harmonic suppression is about −62dBc at 9GHz output and −56dBc at 18GHz output.

ADVANCE INFORMATION

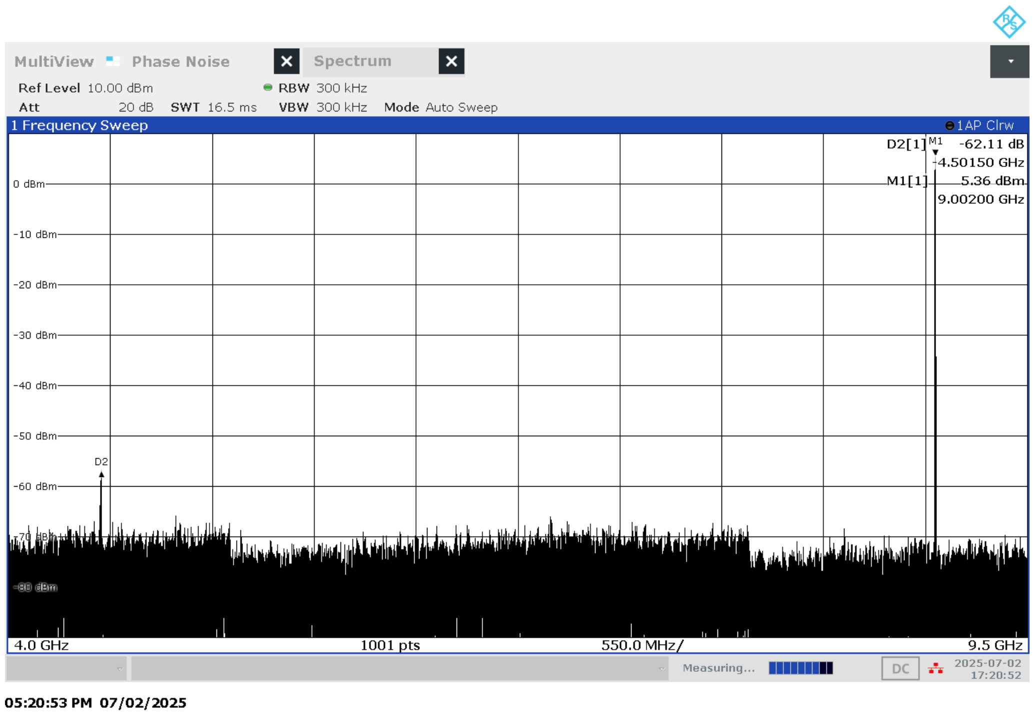


Figure 4-6. 9GHz Output

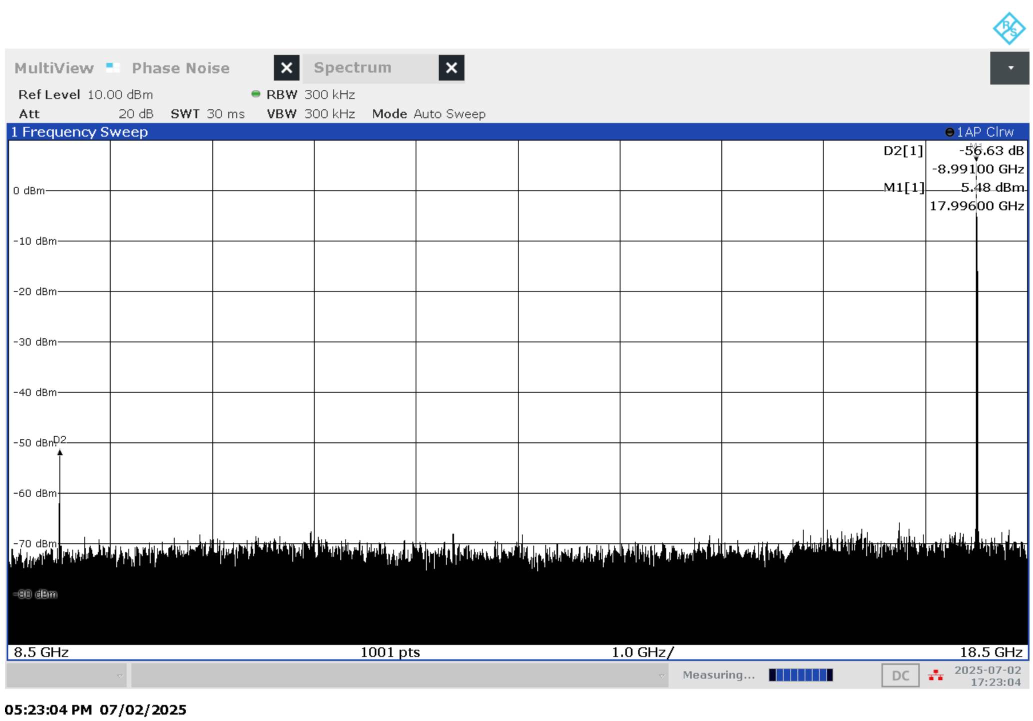


Figure 4-7. 18GHz Output

If RFOUTA or RFOUTB is not used, output driver can be shut down by setting OUTx_EN = 0. Unused output pins can be left floating or AC-shunt to ground.

5 Known Hardware or Software Issues

The LMX2831 device being used in this version of evaluation board is a test chip, it does not have the full feature as planned for the final silicon. There are also some restrictions in configuration.

Table 5-1. Do's and Don'ts

Parameters	Conditions
Reference clock frequency (f_{OSC})	1.1GHz max.
Reference clock level	4dBm max. single-ended
Phase detector frequency (f_{PD})	Integer channel: 1.1GHz max.
	1st order MASH: 300MHz max.
	2nd order MASH: 250MHz max.
	3rd order MASH: 160MHz max.
State machine clock frequency (f_{SM})	200MHz max. $f_{SM} = f_{OSC} / 2^{CAL\_CLK\_DIV}$.
N-divider value	6 min.
Output power setting	Do not use 7
Instant Calibration	Do not use
Good PLL noise configuration	Sets PFD_DLY_MANUAL = 1 and PFD_DLY = 3 for f_{PD} > 500MHz

ADVANCE INFORMATION

6 Hardware Design Files

6.1 Schematics

ADVANCE INFORMATION

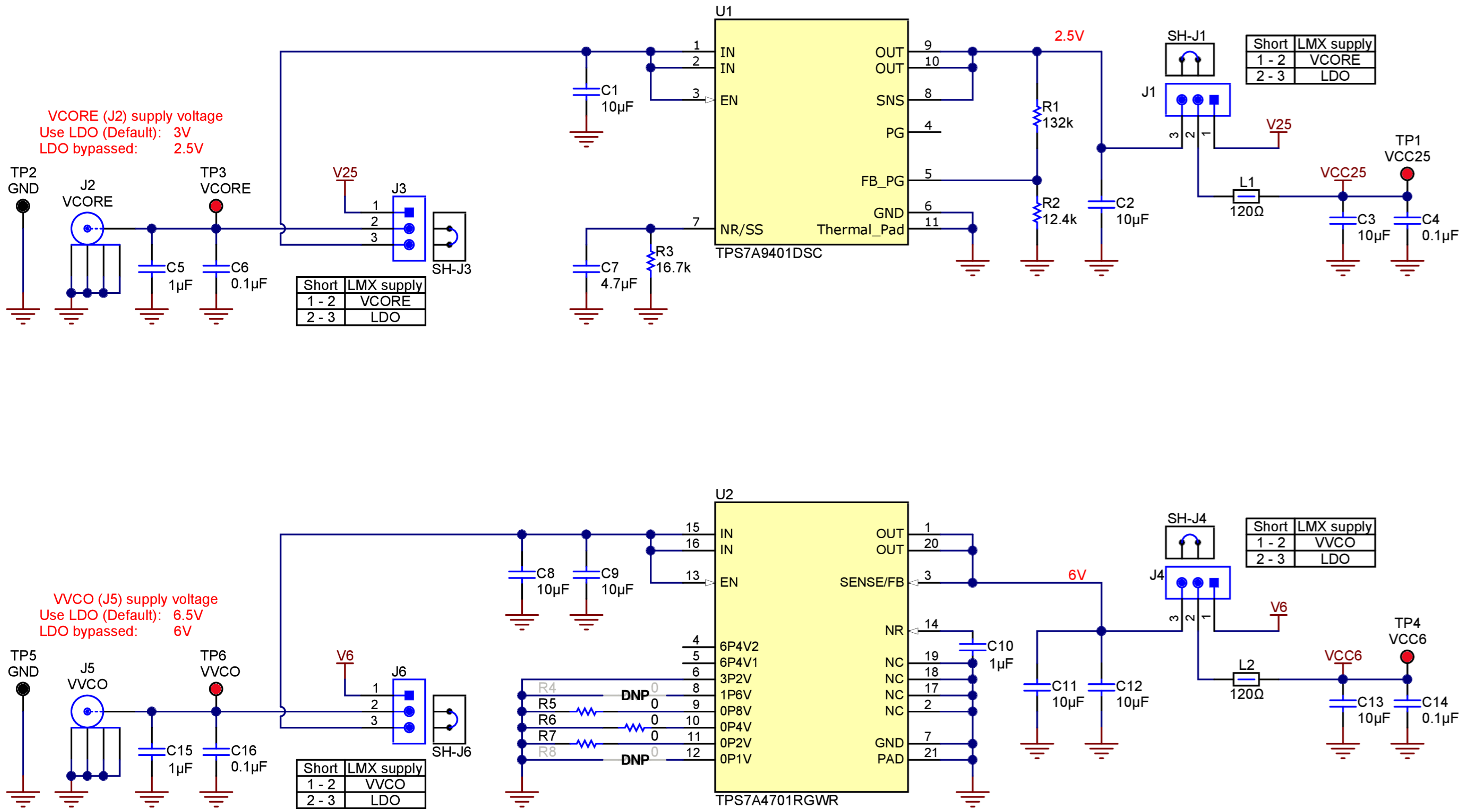


Figure 6-1. Power Supply

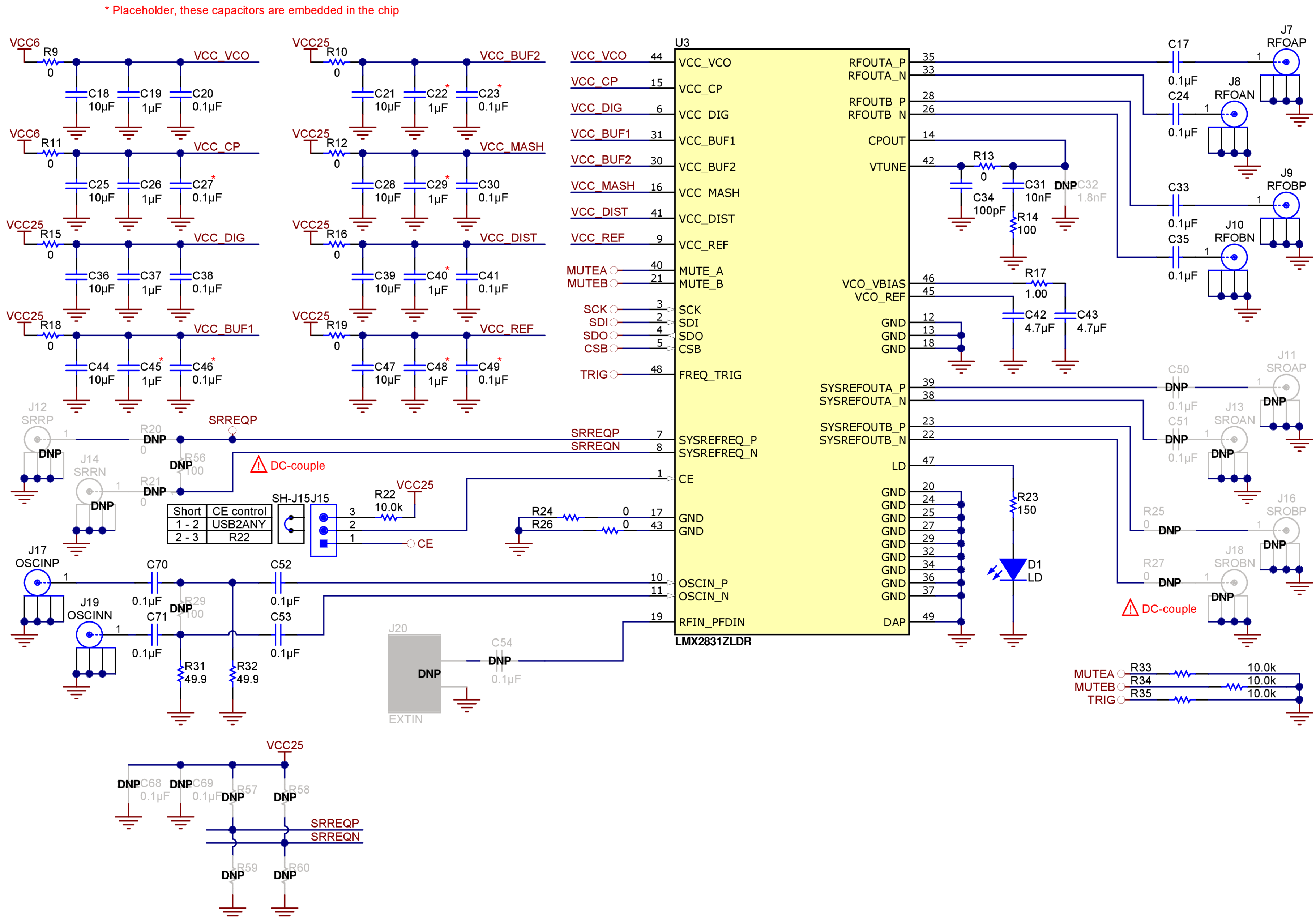


Figure 6-2. LMX2831 Synthesizer

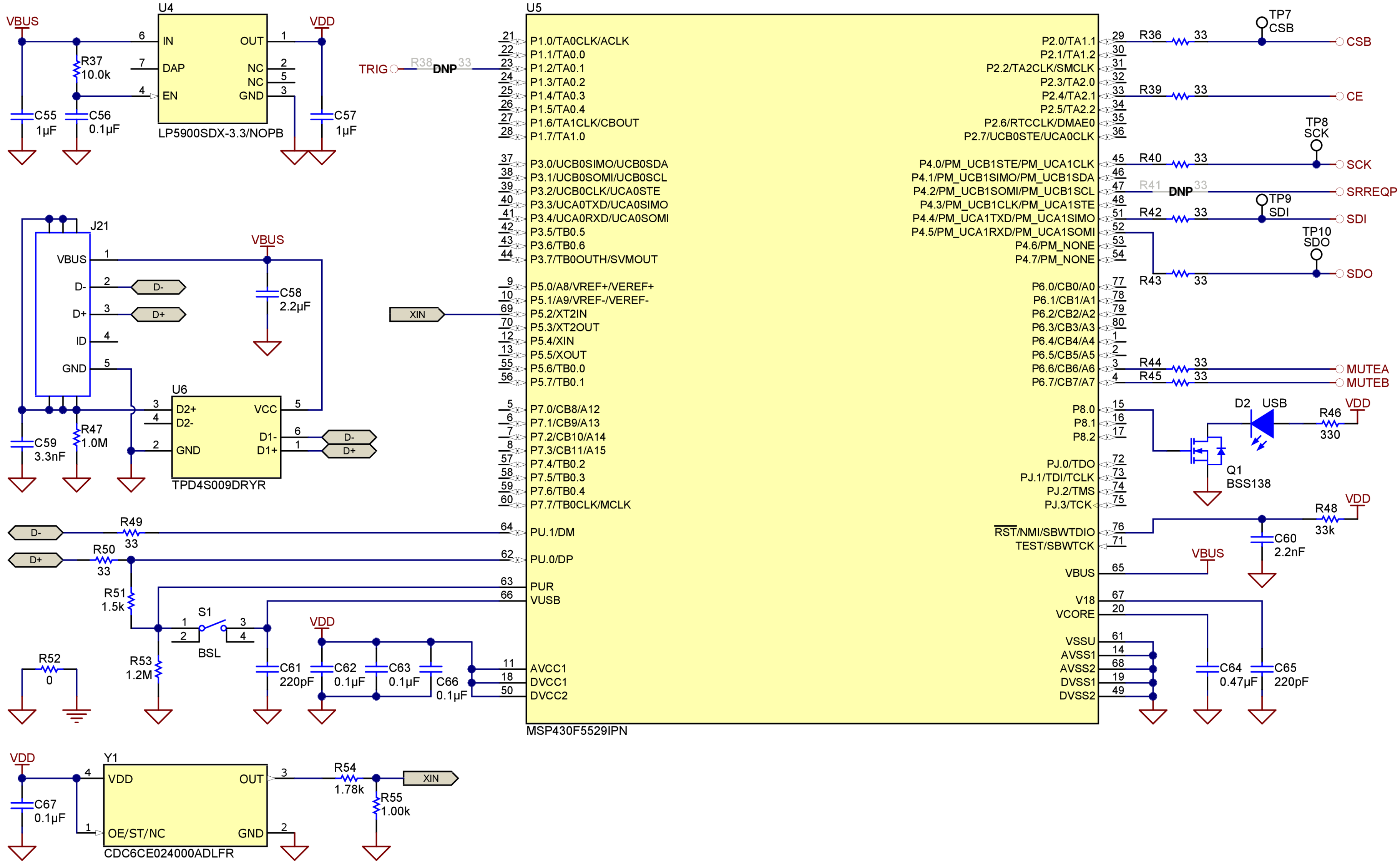


Figure 6-3. USB2ANY

6.2 PCB Layouts

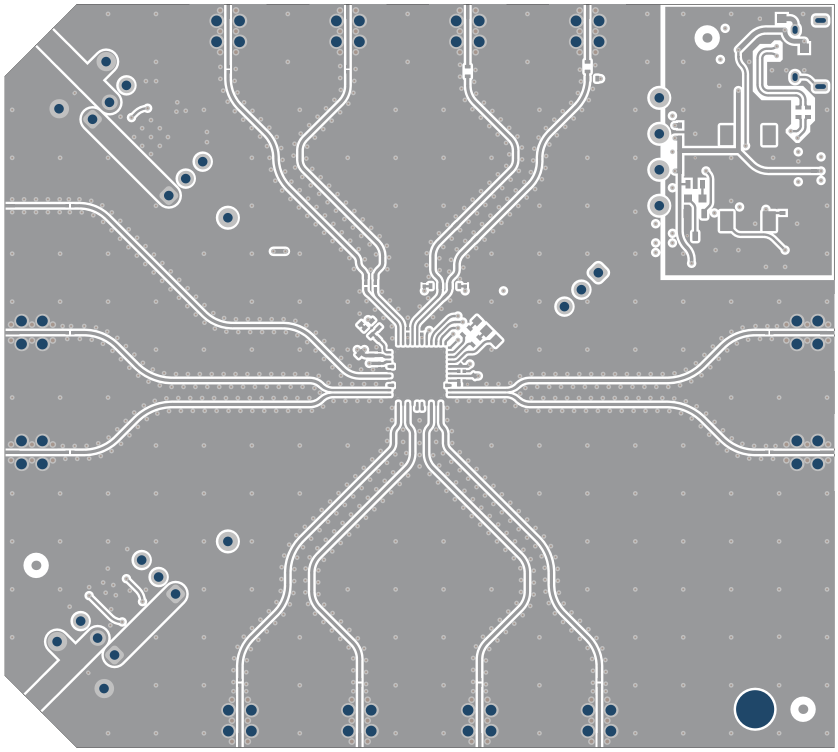


Figure 6-4. Top Layer

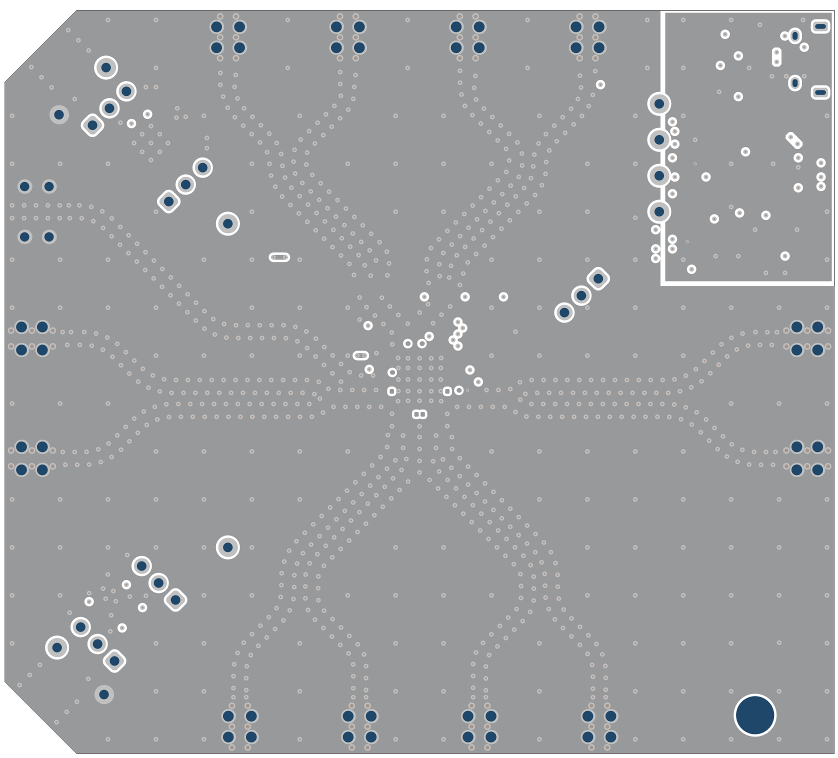


Figure 6-5. 2nd Layer

ADVANCE INFORMATION

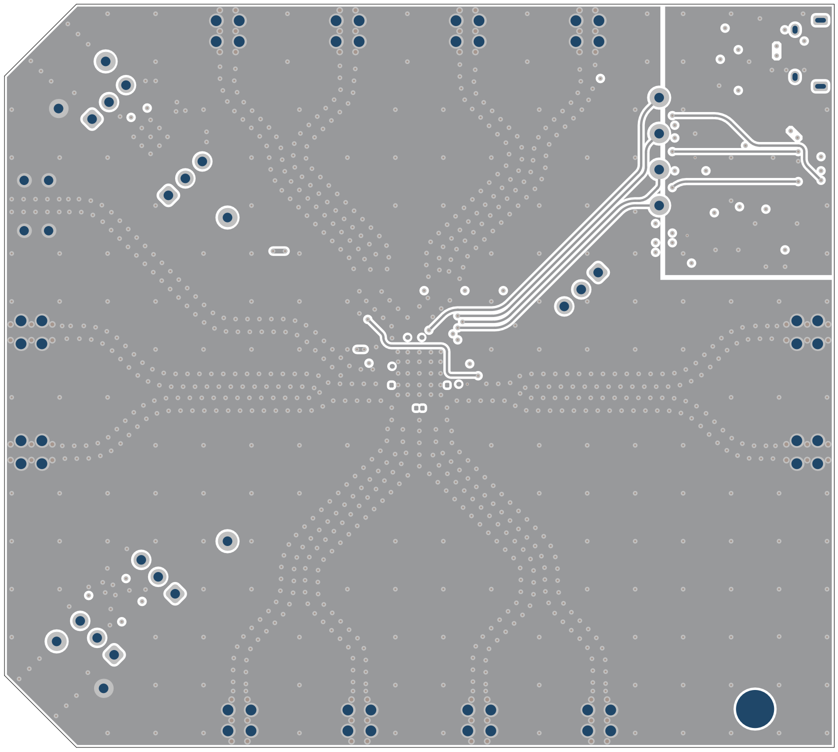


Figure 6-6. 3rd Layer

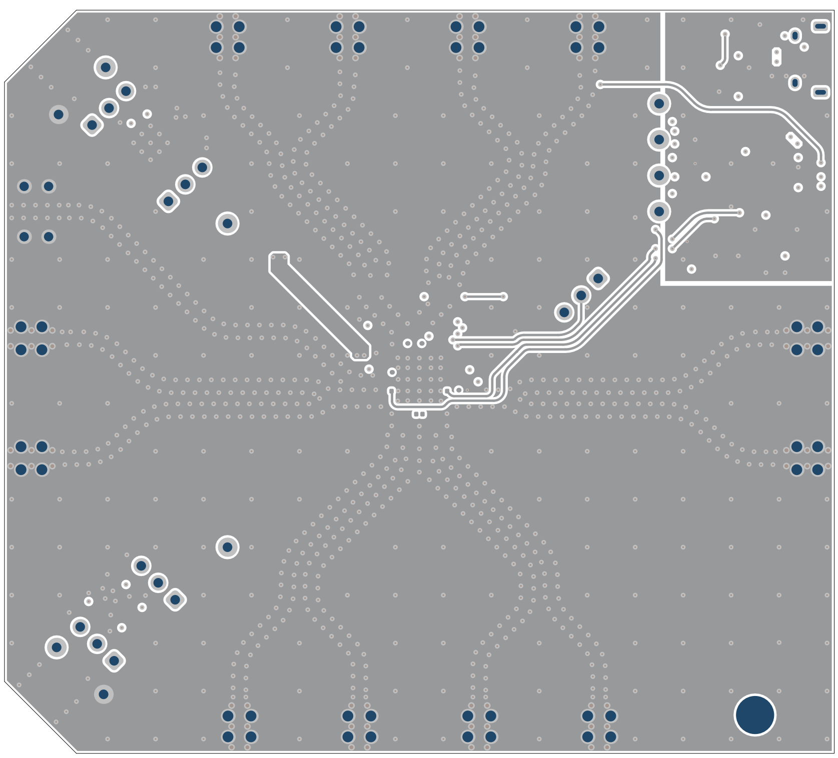


Figure 6-7. 4th Layer

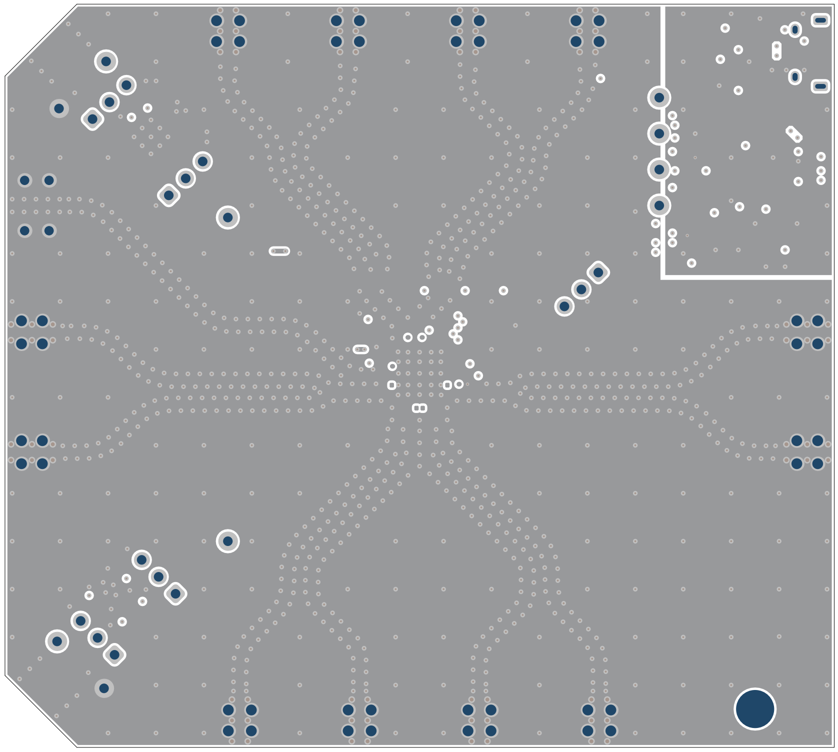


Figure 6-8. 5th Layer

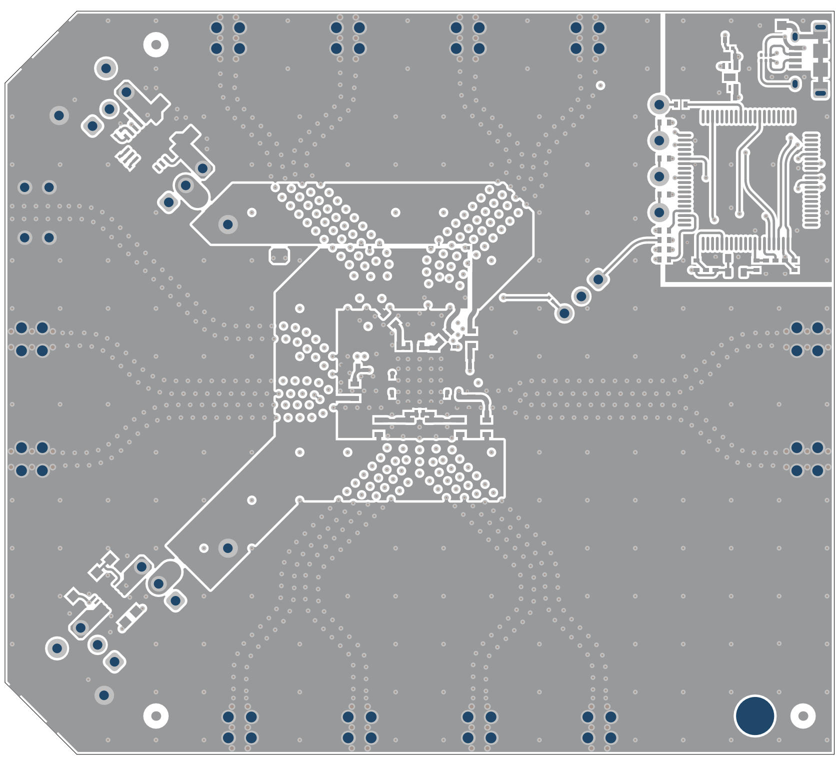


Figure 6-9. Bottom Layer

ADVANCE INFORMATION

ADVANCE INFORMATION

Table 6-1. PCB Stackup

Layer	Material	Thickness (mil)	Constant
Top	Copper	2.8	
Dielectric	RO4350B LoPro	7.3	3.55
2nd	Copper	1.4	
Dielectric	FR4	13	4.2
3rd	Copper	1.4	
Dielectric	FR4	9	4.2
4th	Copper	1.4	
Dielectric	FR4	13	4.2
5th	Copper	1.4	
Dielectric	FR4	9	4.2
Bottom	Copper	2.8	

6.3 Bill of Materials (BOM)

Designator	Description	PartNumber	Manufacturer
C1, C2, C3, C8, C9, C11, C12, C13, C18, C21, C25, C28, C36, C39, C44, C47	CAP, CERM, 10 µF, 10 V,+/- 10%, X5R, 0603	GRM188R61A106KAALD	MuRata
C4, C6, C14, C16, C56, C62, C63, C66, C67	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	885012205037	Wurth Elektronik
C5, C10, C15, C19, C22, C26, C29, C37, C40, C45, C48, C55, C57	CAP, CERM, 1 µF, 25 V, +/- 10%, X5R, 0402	GRM155R61E105KA12D	MuRata
C7, C42, C43	CAP, CERM, 4.7 uF, 16 V,+/- 10%, X7R, 0603	GRM188Z71C475KE21D	MuRata
C17, C20, C23, C24, C27, C30, C33, C35, C38, C41, C46, C49, C52, C53, C70, C71	CAP, CERM, 0.1 µF, 10 V,+/- 10%, X5R, 0201	530Z104KT10T	AT Ceramics
C31	CAP, CERM, 0.01 uF, 16 V, +/- 10%, X7R, 0402	885012205031	Wurth Elektronik
C34	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0402	885012005061	Wurth Elektronik
C58	CAP, CERM, 2.2 uF, 16 V, +/- 20%, X5R, 0603	885012106018	Wurth Elektronik
C59	CAP, CERM, 3300 pF, 50 V,+/- 10%, X7R, 0603	885012206086	Wurth Elektronik
C60	CAP, CERM, 2200 pF, 16 V, +/- 10%, X7R, 0402	885012205027	Wurth Elektronik
C61, C65	CAP, CERM, 220 pF, 50 V, +/- 5%, C0G/NP0, 0402	885012005063	Wurth Elektronik
C64	CAP, CERM, 0.47 uF, 10 V, +/- 10%, X5R, 0402	GRM155R61A474KE15D	MuRata
D1, D2	LED, Green, SMD, 0603	LTST-C190GKT	Lite-On
H1, H2, H3, H4	BUMPER CYLIN 0.312" DIA	SJ61A6	3M
J1, J3, J4, J6, J15	Header, 100mil, 3x1, Gold, TH	TSW-103-07-G-S	Samtec
J2, J5	CONN SMA JACK STR EDGE MNT	CON-SMA-EDGE-S	RF Solutions Ltd.
J7, J8, J9, J10, J17, J19	Connector, End launch SMA 50 ohm, TH	142-0761-881	Cinch Connectivity

Designator	Description	PartNumber	Manufacturer
J21	USB 2.0, Micro-USB Type B, R/A, SMT	10118194-0001LF	FCI
L1, L2	Ferrite Bead, 120 ohm @ 100 MHz, 3 A, 0603	BLM18SG121TN1D	MuRata
Q1	MOSFET, N-CH, 50 V, 0.22 A, SOT-23	BSS138	Fairchild
R1	RES, 132 k, 0.1%, 0.1 W, 0603	RT0603BRD07132KL	Yageo America
R2	RES, 12.4 k, 0.1%, 0.1 W, 0603	RT0603BRD0712K4L	Yageo America
R3	RES, 16.7 k, 0.1%, 0.1 W, 0603	RT0603BRD0716K7L	Yageo America
R5, R6, R7, R24, R26	RES, 0, 5%, 0.05 W, 0201	CRCW02010000Z0ED	Vishay-Dale
R9, R10, R11, R12, R15, R16, R18, R19, R52	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06030000Z0EA	Vishay-Dale
R13	RES, 0, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04020000Z0ED	Vishay-Dale
R14	RES, 100, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402100RFKED	Vishay-Dale
R17	RES, 1.00, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04021R00FKED	Vishay-Dale
R22, R33, R34, R35, R37	RES, 10.0 k, 1%, 0.05 W, 0201	CRCW020110K0FKED	Vishay-Dale
R23	RES, 150, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW0402150RJNED	Vishay-Dale
R31, R32	RES, 49.9, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040249R9FKED	Vishay-Dale
R36, R39, R40, R42, R43, R44, R45, R49, R50	RES, 33, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040233R0JNED	Vishay-Dale
R46	RES, 330, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW0603330RJNEA	Vishay-Dale
R47	RES, 1.0 M, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	CRCW06031M00JNEA	Vishay-Dale
R48	RES, 33 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW040233K0JNED	Vishay-Dale
R51	RES, 1.5 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04021K50JNED	Vishay-Dale
R53	RES, 1.2 M, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04021M20JNED	Vishay-Dale
R54	RES, 1.78 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04021K78FKED	Vishay-Dale
R55	RES, 1.00 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	CRCW04021K00FKED	Vishay-Dale
S1	Switch, Tactile, SPST, 0.05A, 12V, SMT	FSM4JSMA	TE Connectivity
SH-J1, SH-J3, SH-J4, SH-J6, SH-J15	Shunt, 100mil, Gold plated, Black	SNT-100-BK-G	Samtec
TP1, TP3, TP4, TP6	Test Point, Miniature, Red, TH	5000	Keystone Electronics
TP2, TP5	Test Point, Miniature, Black, TH	5001	Keystone Electronics
TP7, TP8, TP9, TP10	Test Point, Miniature, White, TH	5002	Keystone Electronics

Designator	Description	PartNumber	Manufacturer
U1	1A, Ultra-Low Noise, RF LDO	TPS7A9401DSC	Texas Instruments
U2	36V, 1A, Ultra-Low Noise, RF LDO	TPS7A4701RGWR	Texas Instruments
U3	Wideband RF Synthesizer	LMX2831ZLDR	Texas Instruments
U4	Ultra Low Noise, 150mA LDO	LP5900SDX-3.3/NOPB	Texas Instruments
U5	25MHz Microcontroller	MSP430F5529IPN	Texas Instruments
U6	4-Channel ESD Diode	TPD4S009DRYR	Texas Instruments
Y1	High-Performance BAW Oscillator	CDC6CE024000ADLFR	Texas Instruments

7 Additional Information

7.1 Debug Information

If the EVM does not work as expected, consider the following:

Verify hardware setup:

- Do not make modifications to the EVM or change the default settings until AFTER the EVM is verified to be working.
- Validate power supply is connected, is turned on, and current limit is appropriate for the device.
- Validate OSCIN signal is supplied, is turned on with appropriate output level.
- Verify that the spectrum analyzer center frequency matches target frequency. Choose wide span so that the carrier can be seen if the frequency is off from center.
- Verify that the device is not powered down by the CE pin.
- Using the onboard LDOs, power up currents of the EVM are:

Supply Source	POR Current	
	Without OSCIN Reference Clock	With OSCIN Reference Clock
VCORE (3.0V)	430mA	370mA
VVCO (6.5V)	11mA	60mA

- Quiescent current of the VCORE LDO and VVCO LDO are 13mA and 1mA respectively.

Verify software setup:

- If your configuration is not working, revert back to EVM Default Mode configuration, validate the device is locked and then modify the device again to your configuration.
- Validate that no red warning is prompted. If so, mouse over to the warning element, read the tool tips or check the message in the bottom left status window.
- With No Assist operation, after changing the VCO frequency or enabling VCO doubler output, a VCO calibration is required. Program R0 once to initiate VCO calibration.

Verify PC communications:

- In the menu bar, click USB Communications → Interface. Verify that the USB2ANY button is turned green. Click Identify to validate the USB LED on the EVM blinks.
- Program POWERDOWN = 1 to validate there is significant current change.

7.2 Trademarks

All trademarks are the property of their respective owners.

ADVANCE INFORMATION