

Evaluating the **ADF4371** Microwave Wideband Synthesizer with Integrated VCO

FEATURES

Self-contained board, including **ADF4371** frequency synthesizer with integrated VCO, loop filter (180 kHz), USB interface, and voltage regulators

Windows®-based software allows control of synthesizer functions from a PC

Externally powered by 6 V

EVALUATION KIT CONTENTS

EV-ADF4371SD2Z evaluation board

EQUIPMENT NEEDED

Windows-based PC with USB port for evaluation software

System demonstration platform, serial only (**SDP-S**)

EVAL-SDP-CS1Z controller board

Power supply (6 V)

Spectrum analyzer

50 Ω terminators

Low noise REF_{IN} source (optional)

DOCUMENTS NEEDED

ADF4371 data sheet

EV-ADF4371SD2Z user guide

REQUIRED SOFTWARE

ACE software, Version 1.10 or newer

ADF4371 plugin, Version 0.1.6 or newer

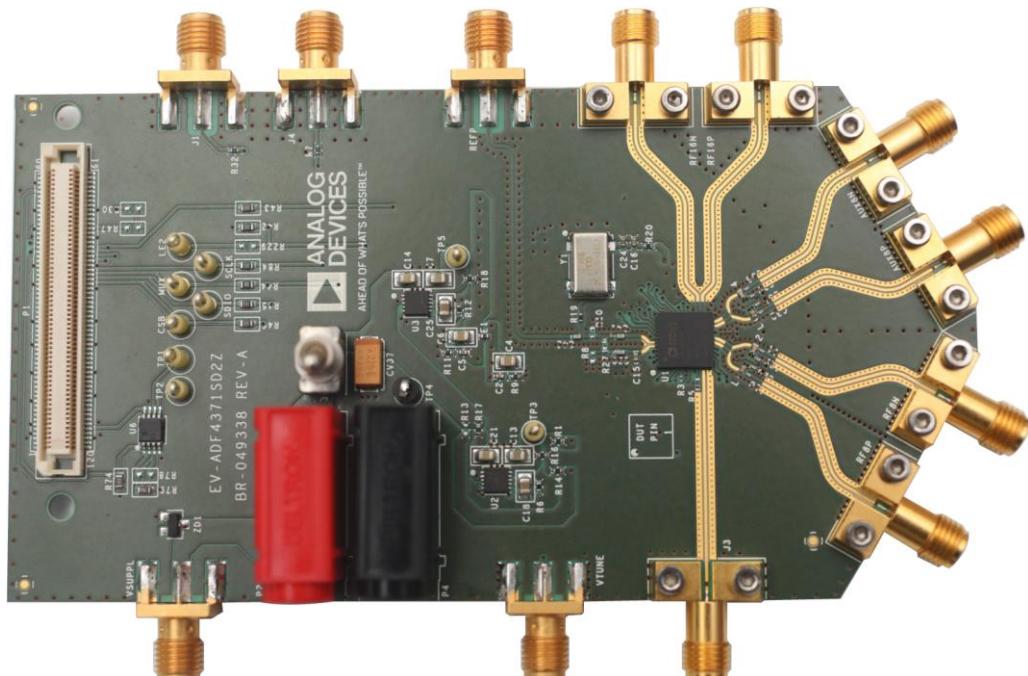
GENERAL DESCRIPTION

The EV-ADF4371SD2Z evaluates the performance of the **ADF4371** frequency synthesizer with an integrated voltage controlled oscillator (VCO) for phase-locked loops (PLLs). A photograph of the evaluation board is shown in Figure 1. The evaluation board contains the **ADF4371** frequency synthesizer with an integrated VCO, a USB interface, power supply connectors, and subminiature Version A (SMA) connectors.

This board requires an **SDP-S** board (not supplied with the kit). The **SDP-S** allows software programming of the EV-ADF4371SD2Z device.

Full specifications for the **ADF4371** frequency synthesizer are available in the product data sheet, which must be consulted in conjunction with this user guide when working with the evaluation board.

EV-AD4371SD2Z EVALUATION BOARD PHOTOGRAPH



17296-001

Figure 1.

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REVISION HISTORY

1/2019—Revision 0: Initial Version

GETTING STARTED

SOFTWARE INSTALLATION PROCEDURES

To install the [ACE](#) software and [ADF4371](#) plugin, perform the following steps:

1. Install the latest version of the [ACE](#) software platform.
2. If the [ADF4371](#) plugin appears automatically, proceed to Step 4.
3. Double click the [ADF4371](#) plugin file, **Board.ADF371.0.1.6.acezip**.
4. Check that the [ADF4371](#) plugin appears when the EV-ADF4371SD2Z board is attached through the system demonstration platform (SDP) connector to the PC.

EVALUATION BOARD SETUP PROCEDURES

To run the software, perform the following steps:

1. Select **Start > All Programs > Analog Devices > ACE**.
2. On the **Select Device and Connection** tab, choose **ADF4371** and the **ADF4371 board** appears under attached hardware.
3. When connecting the EV-ADF4371SD2Z board, allow 5 sec to 10 sec for the label on the status bar to change.

EVALUATION BOARD HARDWARE

The EV-ADF4371SD2Z requires the [SDP-S](#) platform that uses the [EVAL-SDP-CS1Z](#). The [SDP-B](#) is not recommended.

The EV-ADF4371SD2Z schematics are shown in Figure 10, Figure 11, Figure 12, and Figure 13. The silkscreens for the evaluation board are shown in Figure 14 and Figure 15.

POWER SUPPLIES

The EV-ADF4371SD2Z board is powered by a 6 V power supply connected to the VSUPPL SMA, or the red banana plug, P2. Connect GND to the black banana plug, P4.

The power supply circuitry has two [LT3045](#), high performance, low noise, and low dropout (LDO) regulators.

One [LT3045](#) is used to generate 5 V to drive the VCO supply pins. The remaining supplies are powered from the other [LT3045](#), which is set to 3.3 V voltage.

Use Switch S1 to switch the 6 V to the board on and off.

RF OUTPUT

The EV-ADF4371SD2Z has three pairs of SMA, 3.5 mm output connectors: RF8P/RF8N, AUX8P/AUX8N, and RF16P/RF16N (differential outputs). The EV-ADF4371SD2Z board has one single 2.92 mm connector, J3, for the RF32P pin. RF32 is also differential, but the RF32N pin is terminated by a 50 Ω on-board resistor. Because they are sensitive to impedance mismatch, connect the radio frequency (RF) outputs to equal load impedances.

If only one port of a differential pair is used, terminate the complementary port with an equal load terminator (in general, a 50 Ω terminator).

LOOP FILTER

The loop filter schematic is included in the board schematic in Figure 10. Figure 2 shows the loop filter component placement. The loop filter on the evaluation board is optimized for fractional mode performance with a phase frequency detector (PFD) frequency of 100 MHz and 1.8 mA charge pump current. The values of the loop filter components are as follows:

- Resistors: RCPOUT = 91 Ω , R2 = 400 Ω , R4 = 200 Ω , R15 = 0 Ω
- Capacitors: C20 = 220 pF, C19 = 0.018 μ F, C23 = 330 pF

The lowest rms jitter is achieved in integer mode by using a high PFD frequency. This jitter can be tested by using the same filter with a PFD frequency of 200 MHz (enabling the doubler) and 2.4 mA charge pump current. Additional optimization is still possible depending on target frequency and integration limits.

In general, narrower loop filter bandwidths have lower spurious signals. Wide loop filters in integer N mode can achieve <50 fs jitter with very clean reference frequency input (REF_{IN}) signals.

ADDITIONAL OPTIMIZATION ON LOOP FILTER

The PLL loop bandwidth can be optimized for different parameters like reference spurs or VCO noise, depending on the system requirements.

Reducing $\Sigma\Delta$ Modulator (SDM) Noise

In fractional mode, SDM noise becomes apparent and starts to contribute to overall phase noise. This noise can be reduced to insignificant levels by using a series resistor between the CPOUT pin and the loop filter. Place this resistor close to the CPOUT pin. Select a reasonable resistor value that does not affect the loop bandwidth and phase margin of the designed loop filter. In most cases, a 91 Ω resistor value produces the best results. This resistor is not required in integer mode (SDM not enabled) or when a narrow-band loop filter (SDM noise attenuated) is used. This resistor is labeled as RCPOUT in schematics.

Optimizing Spurious Signals

On the evaluation board, the loop filter is placed at the secondary side of the board to create a more compact layout and so that the board is more tolerant to external signals. Using a capacitor on the same side with the [ADF4371](#) (the primary side) results in higher isolation on internally generated spurious signals. For this purpose, a small valued capacitor (10 pF) can be placed close to the VTUNE pin to achieve lower spurious signal levels.

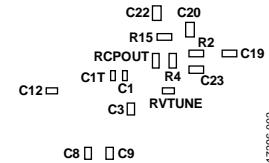


Figure 2. Loop Filter Component Placement

REFERENCE SOURCE

The EV-ADF4371SD2Z board is supplied with a low noise 100 MHz crystal oscillator (XO) from Crystek (CCHD-575-50-100.000).

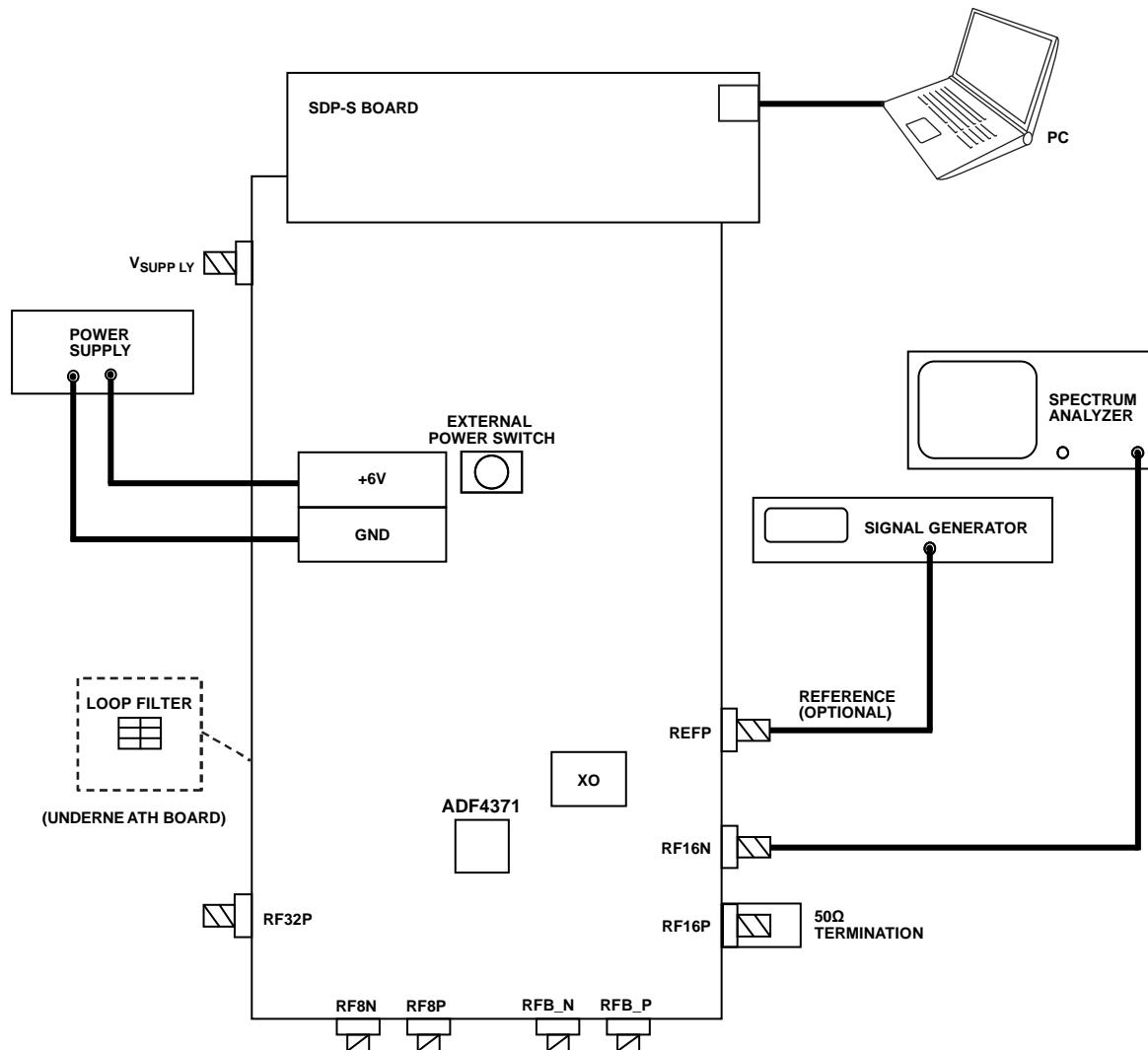
To use an external single-ended REF_{IN}, connect a low noise reference source to the REFP SMA connector. Remove Resistor R19 (0 Ω) and Resistor R20 (0 Ω) to remove power from the crystal and break the connection to the REFP input.

DEFAULT CONFIGURATION

All components necessary for local oscillator (LO) generation are inserted on the EV-ADF4371SD2Z board. The EV-ADF4371SD2Z board is shipped with 100 MHz XO, the [ADF4371](#) synthesizer with an integrated VCO, and a 180 kHz loop filter (charge pump current (I_{CP}) = 1.8 mA).

DOUBLER AND QUADRUPLER OUTPUT

The [ADF4371](#) contains a frequency doubler and quadrupler to double the 4 GHz to 8 GHz VCO signal on RF16P and RF16N and quadruple the VCO signal on RF32P and RF32N. It is advised to not enable the doubler and quadrupler at the same time.



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Figure 3. Evaluation Board Setup Diagram

EVALUATION BOARD SOFTWARE

The **ACE** software is the main platform that is used to control the EV-ADF4371SD2Z. The **ADF4371** plugin includes user interfaces that relate to the **ADF4371** and allow evaluation of the device. Use the following steps to open the main control window for **ADF4371**.

1. Launch the **ACE** application. With the **SDP-S** board connected to the EV-ADF4371SD2Z, the attached hardware

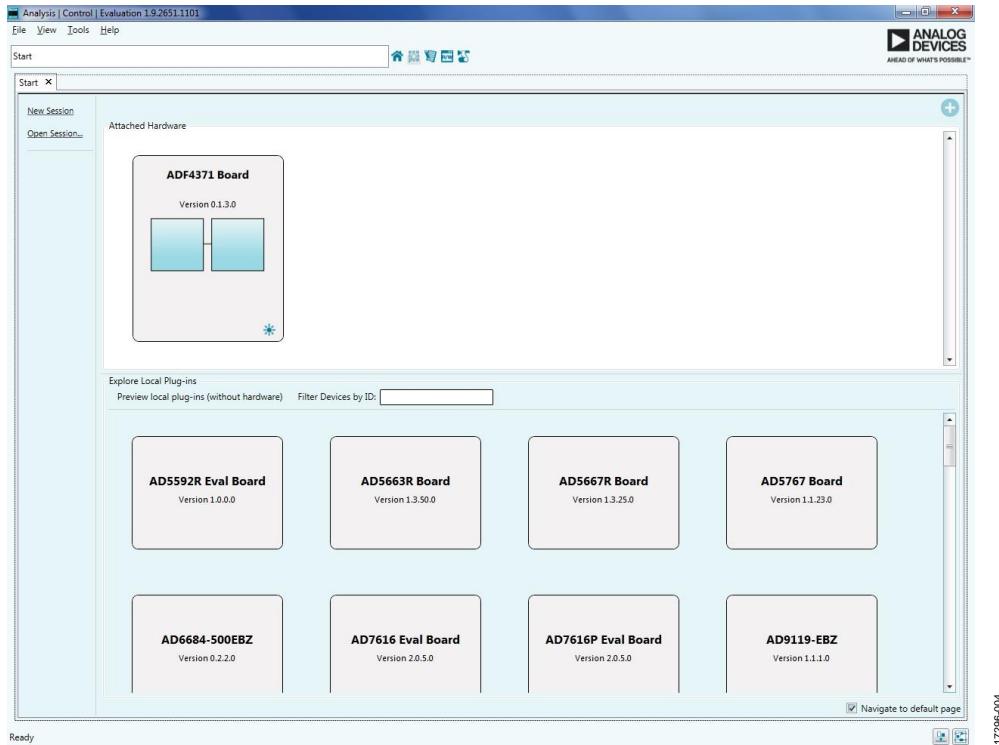


Figure 4. **ACE Start Page, Attached Hardware (ADF4371 Evaluation Board)**

appears in the graphical user interface (GUI) as shown in Figure 4.

2. Double click the **ADF4371 Board** icon, and the tab shown in Figure 5 appears.
3. Double click the **ADF4371** icon that appears on the board GUI to open the main control window shown in Figure 8.

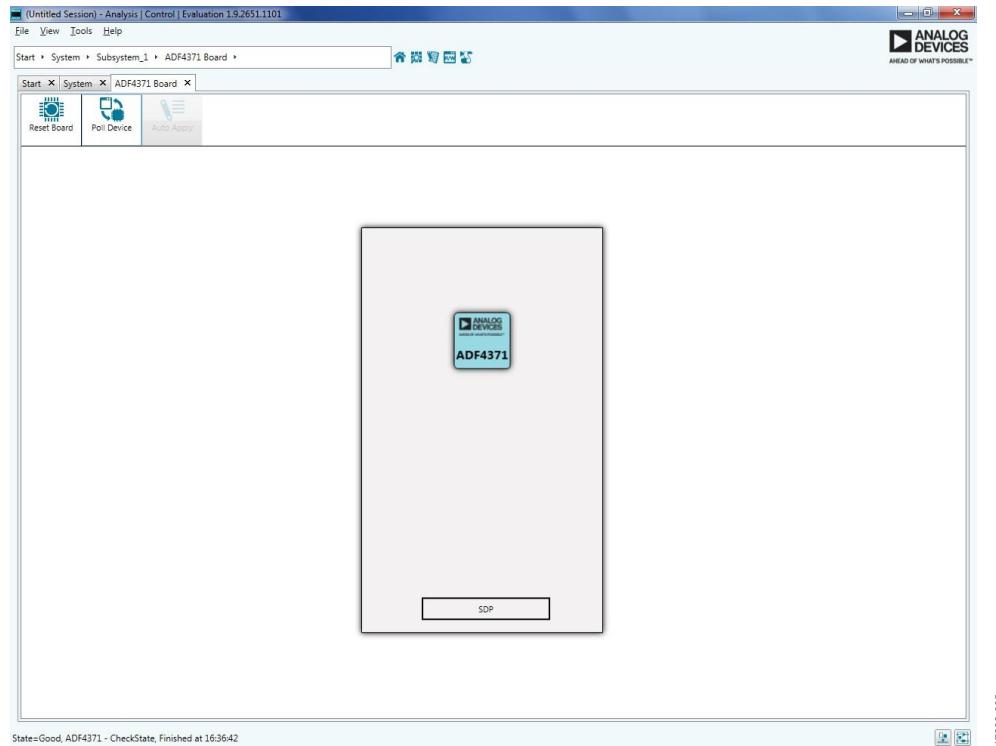


Figure 5. ACE Board Page, Device Selection

MAIN CONTROLS

The main controls are available in the high level register map shown in Figure 8. To modify registers, perform the following steps:

1. Click **Write All Registers/ Initialize** to load all registers and initialize the device.
2. Modify the registers as desired.
3. Click **Apply Changes** to load modified settings to the device. This action loads the updated registers only. All registers can be reloaded using the **Write All Registers/ Initialize** button.

QUADRUPLER OUTPUT CONTROLS

For the main, auxiliary, and doubler outputs, the optimal harmonic performance is achieved by using the automatic filter outputs. However, for the quadrupler output, some additional software settings may need to be adjusted to achieve optimal performance.

The settings are available in the **Outputs** section (shown in Figure 6). The output settings include the **Tracking Filter Mux** box that can be set to automatic or manual, the **Quad Bias** box that varies from the lowest setting 0 to the highest of 3, and the **Quad Band Filter** box that varies from 0 to 7.

The bias and filter settings in Table 1 are recommended for quadrupler output.

Table 1. Filter and Bias Setting for Quadrupled Output

| Frequency (GHz) | Filter | Bias |
|-----------------|--------|------|
| <18 | 7 | 3 |
| 18 to 19 | 3 | 3 |
| 19 to 20.5 | 1 | 0 |
| 20.5 to 26 | 0 | 0 |
| >26 | 0 | 1 |

The recommended settings for quadrupler frequencies from 16 GHz to 18 GHz are shown in Figure 6. The summarized filter performance is shown in Figure 7.

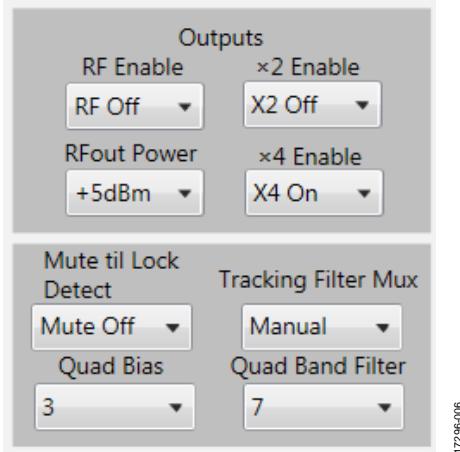


Figure 6. Recommended Quadrupler Filter Settings, 16 GHz to 18 GHz

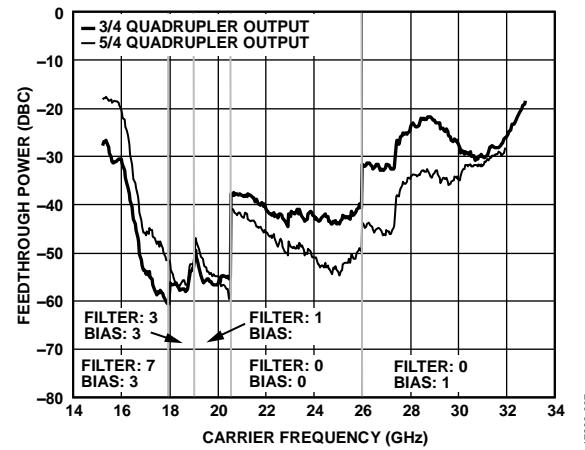


Figure 7. Aggregated Quadrupler Filter Performance, 3/4 Quadrupler Output and 5/4 Quadrupler Output

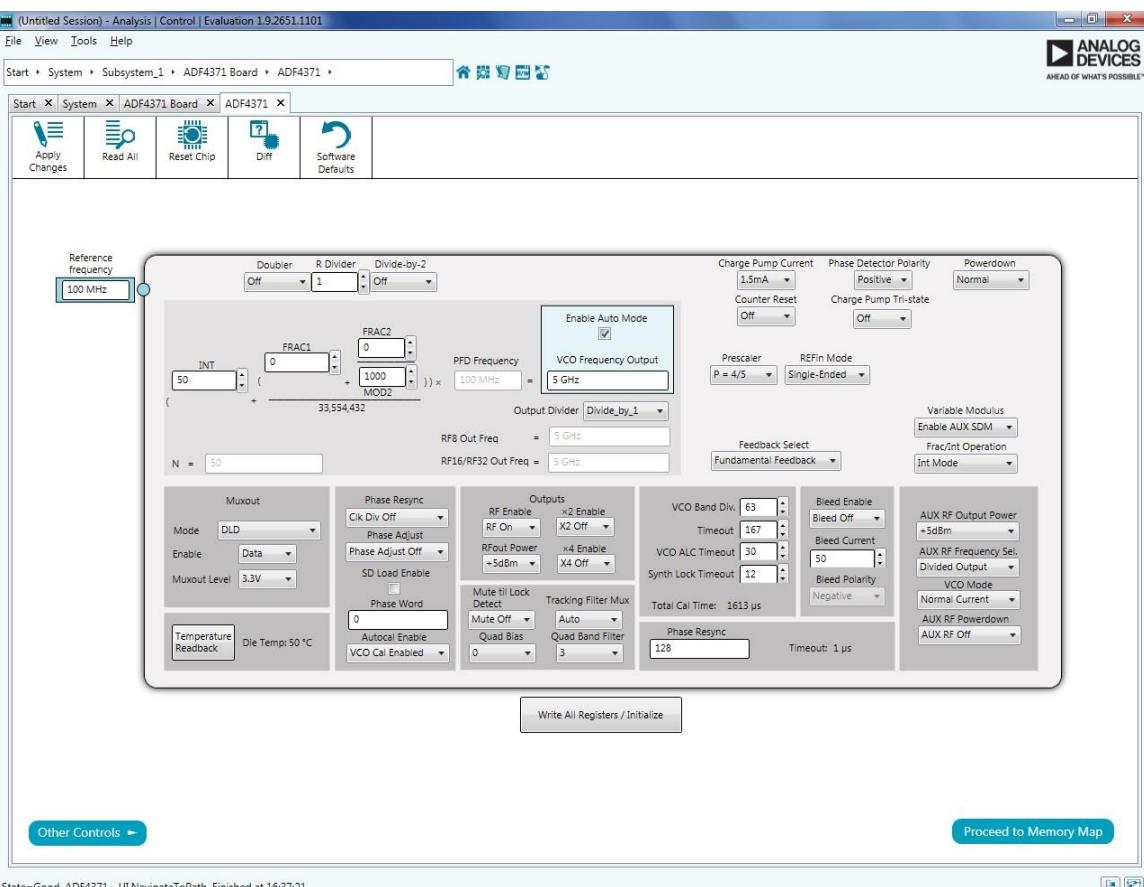


Figure 8. Software Front Panel Display, Main Controls

EVALUATION AND TEST

To evaluate and test the performance of the [ADF4371](#), prepare the hardware and software setup as explained in the Evaluation Board Hardware section and the Evaluation Board Software section.

Run the software and set the **VCO Frequency Output** to 5 GHz. Measure the output spectrum and single sideband phase noise on a spectrum analyzer. Figure 9 shows a phase noise plot of the SMA RF8P pin equal to 5 GHz.

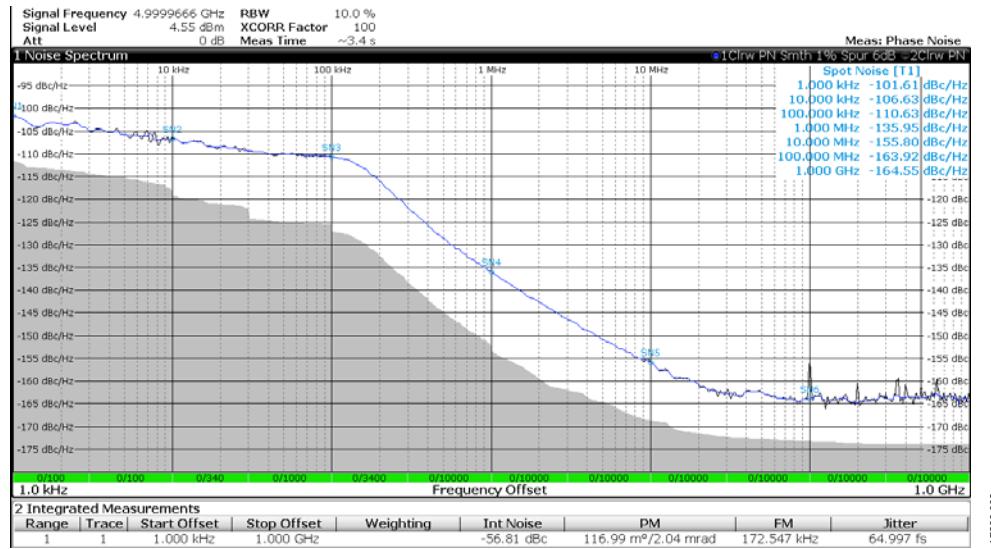


Figure 9. Single Sideband Phase Noise

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EVALUATION BOARD SCHEMATICS AND ARTWORK

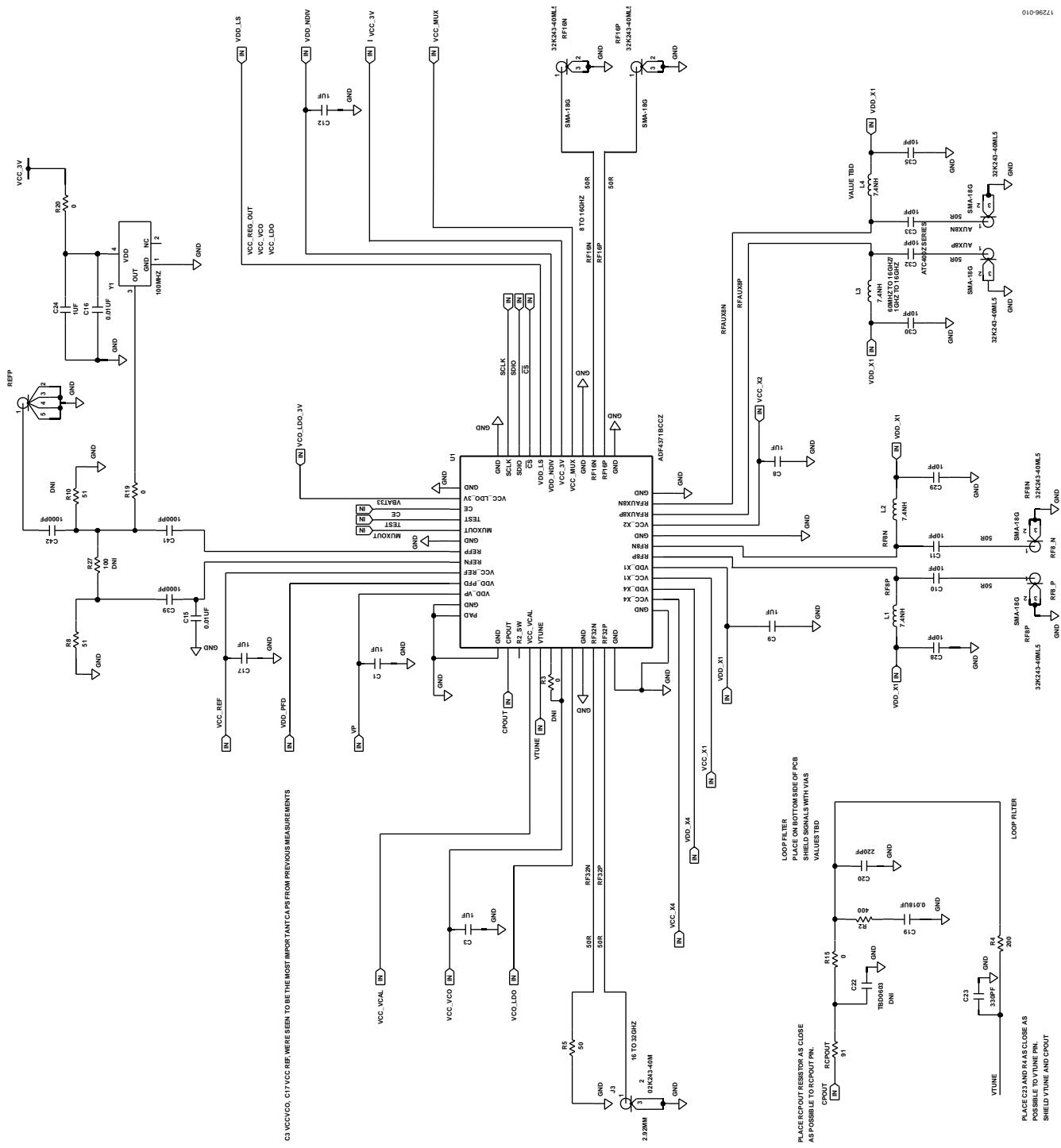


Figure 10. Evaluation Board Schematic, ADF4371 Connections and Loop Filter

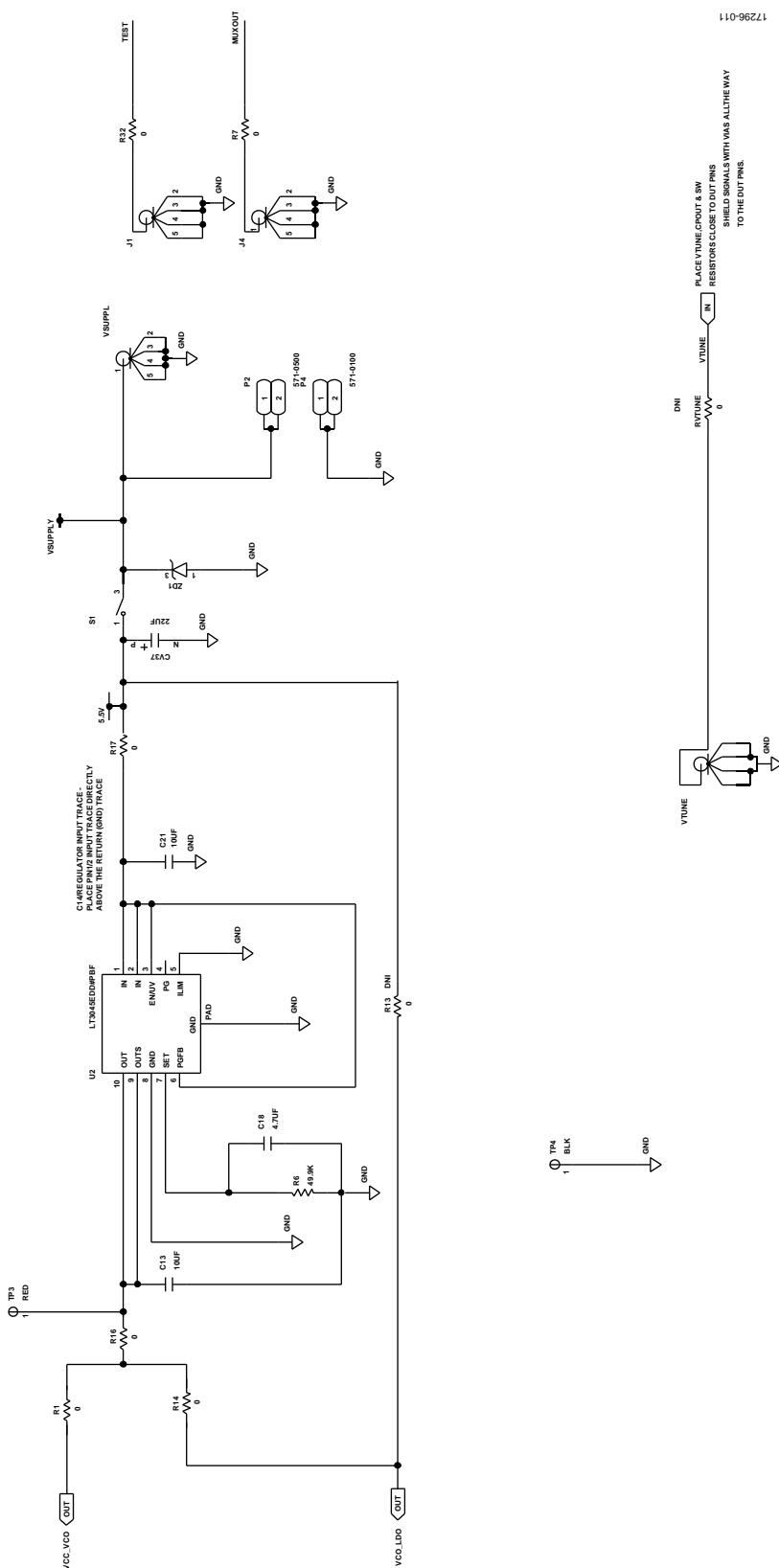


Figure 11. Evaluation Board Schematic, 5 V LDO Regulator

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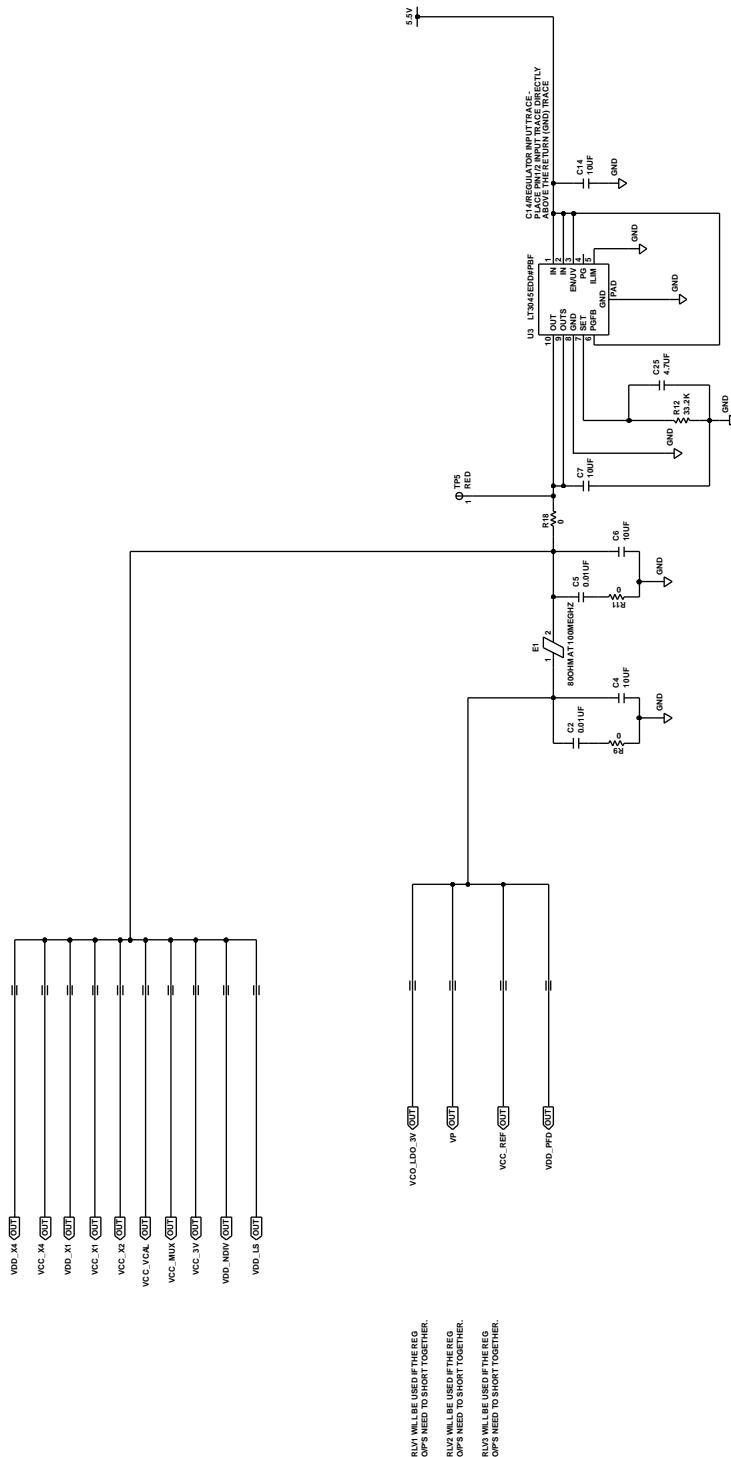


Figure 12. Evaluation Board Schematic, 3.3 V LDO Regulator

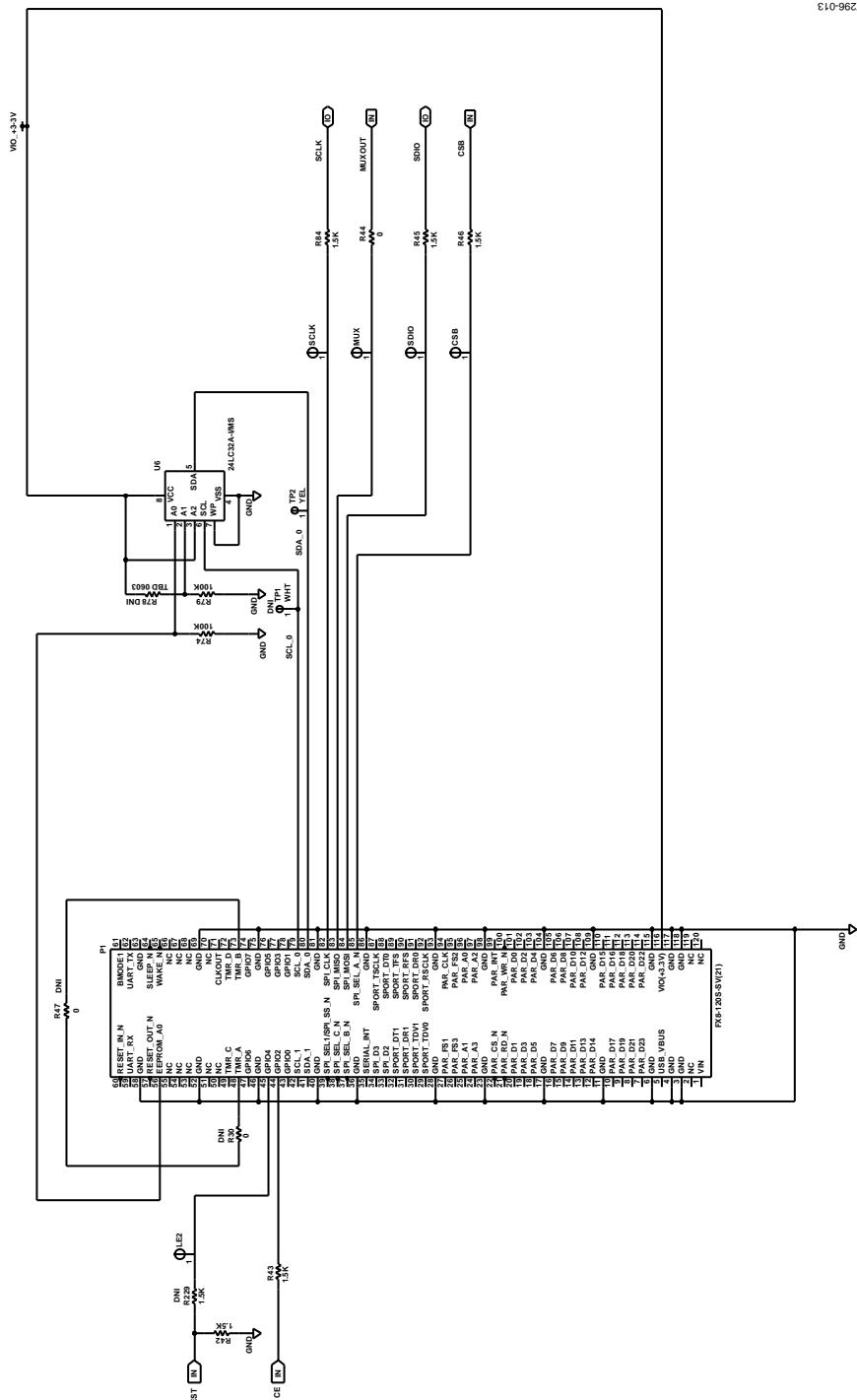


Figure 13. Evaluation Board Schematic, Board Connector

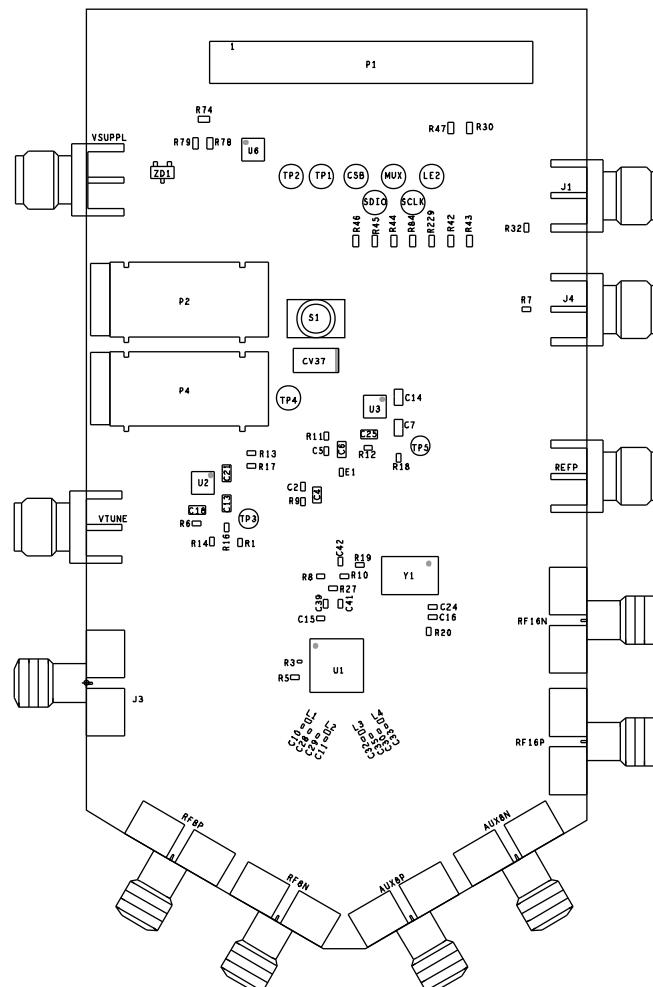


Figure 14. Evaluation Board Silk Screen, Top Side

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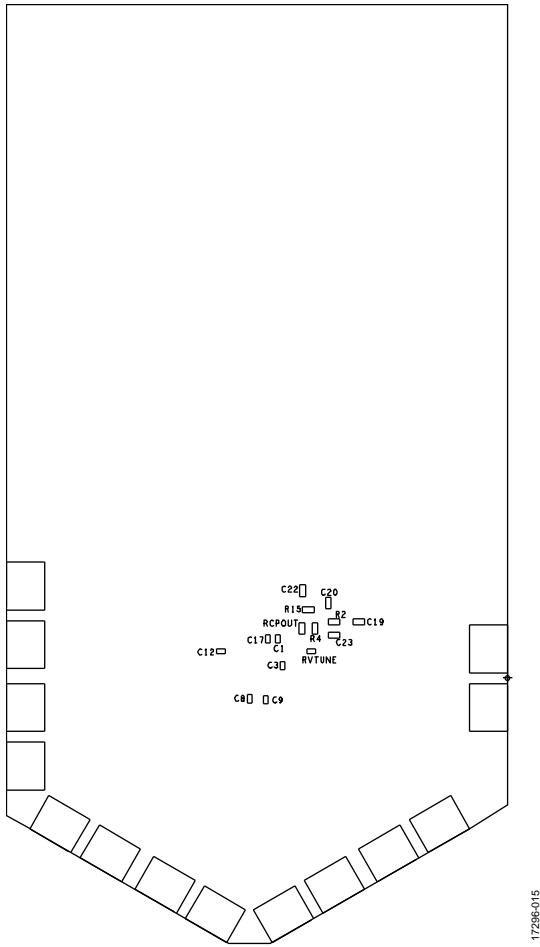


Figure 15. Evaluation Board Silk Screen, Bottom Side

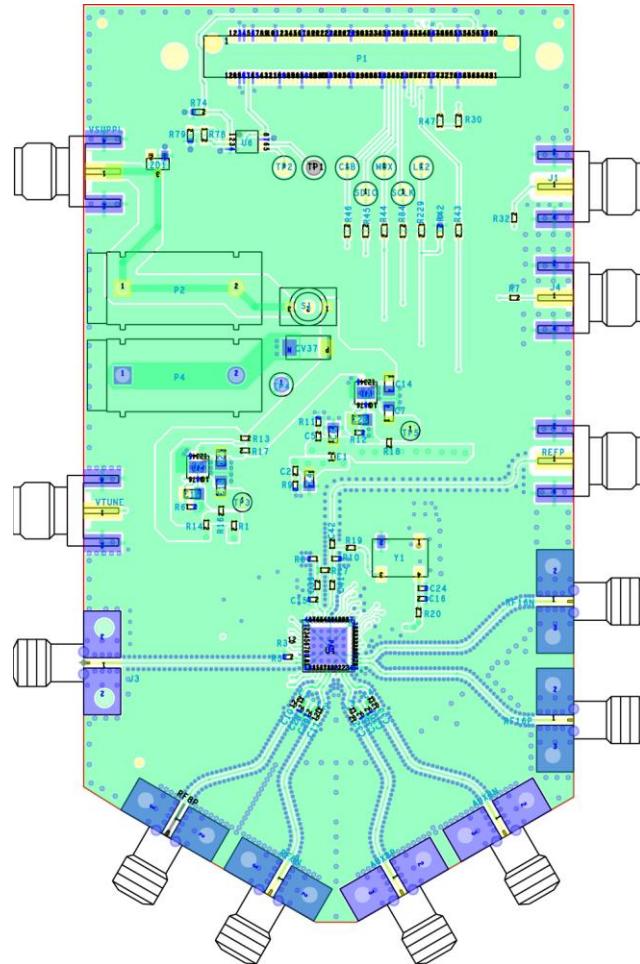


Figure 16. Evaluation Board Layer 1, Primary

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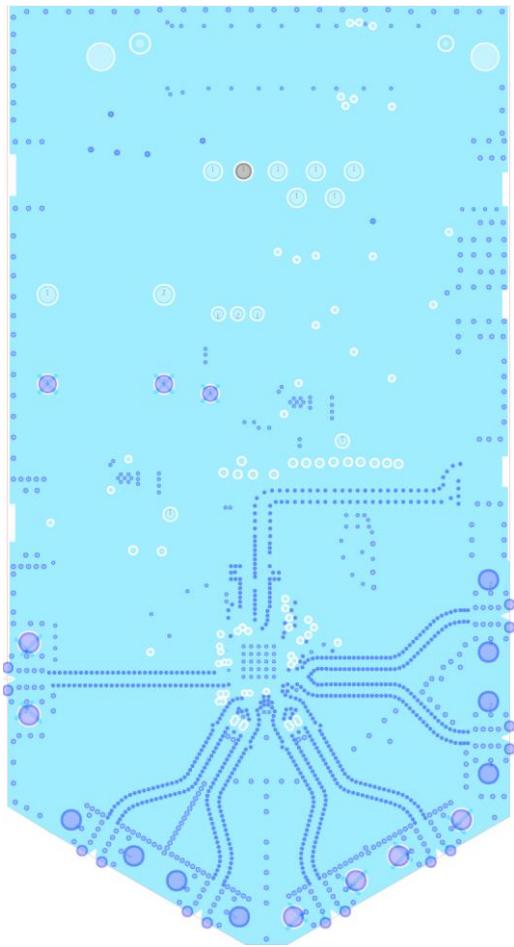


Figure 17. Evaluation Board Layer 2, Ground

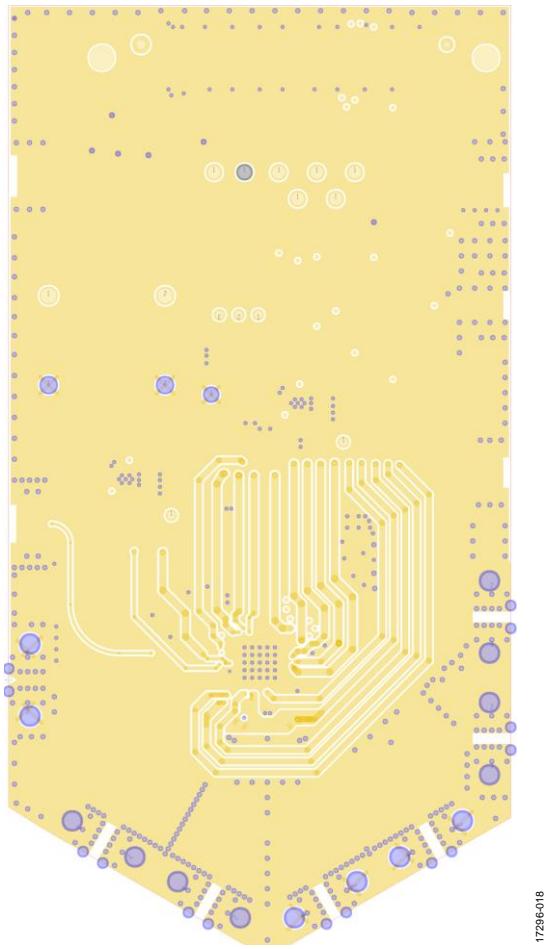


Figure 18. Evaluation Board Layer3, Power

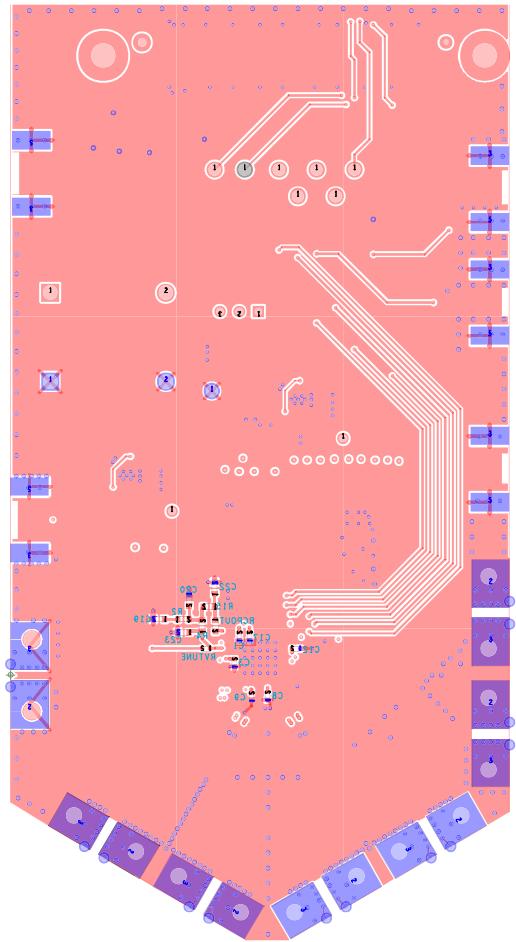


Figure 19. Evaluation Board Layer 4, Secondary

ORDERING INFORMATION

BILL OF MATERIALS

Table 2.

| Reference Designator | Description | Value | Manufacturer | Part Number |
|--|---|------------------------|------------------------------|------------------------|
| AUX8N, AUX8P, RF8N, RF8P, RF16N, RF16P | Printed circuit boards (PCBs), SMA, right angle jack connectors | 32K243-40ML5 | Rosenberger | 32K243-40ML5 |
| C1, C3, C8, C9, C12, C17, C24 | Capacitors, ceramic, X6S | 1 μ F | TDK | C1005X6S1C105K050BC |
| C10, C11, C28, C29, C30, C35 | Ceramic capacitors, C0G (NP0), general-purpose | 10 pF | Murata | GRM0335C1E100JA01D |
| C4, C6, C7, C13, C14, C21 | Ceramic capacitors, X5R, general-purpose | 10 μ F | Murata | GRM21BR61C106KE15L |
| C2, C5, C15, C16 | Ceramic capacitors, X7R, general-purpose | 0.01 μ F | Murata | GRM155R71E103KA01D |
| C18, C25 | Ceramic capacitors, X5R, general-purpose | 4.7 μ F | Murata | GRM21BR61E475KA12L |
| C19 | Ceramic capacitor, X7R 0603 | 0.018 μ F | AVX | 06033C183JAT2A |
| C20 | Chip capacitor, C0G, 0603 | 220 pF | TDK | C1608C0G1H221J |
| C23 | Capacitor, ceramic, NP0 | 330 pF | TDK | CGJ3E3C0G2D331J080AA |
| C32, C33 | Multilayer ceramic capacitors (MLCCs), NP0, RF and microwave | 10 pF | American Technical Ceramics | 400Z100FT16T |
| C39, C41, C42 | Ceramic capacitors, C0G (NP0), general-purpose | 1000 pF | Murata | GRM1555C1H102JA01 |
| CSB, LE2, MUX, SCLK, SDIO, TP2 | PCB test point connectors | Yellow | Components Corporation | TP-104-01-04 |
| CV37 | Tantalum solid electrolytic ceramic | 22 μ F | AVX | TCJC226M025R0100 |
| E1 | Chip ferrite bead | 80 Ω at 100 MHz | Murata | BLM15PX800SN1D |
| J1, J4, REFP, VSUPPL, VTUNE | PCBs, coaxial, SMA, end launch connectors | 142-0701-801 | Cinch Connectivity Solutions | 142-0701-801 |
| J3 | PCB, SMA, right angle jack connector | 02K243-40M | Rosenberger | 02K243-40M |
| L1, L2, L3, L4 | Chip inductors | 7.4 nH | Coilcraft | 0302CS-7N4XJLU |
| P1 | PCB, vertical type receptacle, surface-mount device (SMD) connector | FX8-120S-SV(21) | Hirose | FX8-120S-SV(21) |
| P2 | PCB, single socket connector | Red | Deltron | 571-0500 |
| P4 | PCB, single socket connector | Black | Deltron | 571-0100 |
| R1, R7, R9, R11, R14, R16, R17, R18, R19, R20, R32 | Thick film, chip resistors | 0 Ω | Multicomp | MC00625W040210R |
| R12 | Thick film, chip resistor | 33.2 k Ω | Vishay | CRCW040233K2FKED |
| R15, R44 | Film, SMD resistors, 0603 | 0 Ω | Multicomp | MC0603WG00000T5E-TC |
| R2 | Precision, thin film, chip resistor | 400 Ω | Vishay | PAT0603E4000BST1 |
| R27 | High frequency, thin film, chip resistor | 100 Ω | Vishay | FC0402E1000BST1 |
| R4 | Thick film, chip resistor | 200 Ω | Multicomp | MC 0.063W 0603 1% 200R |
| R42, R43, R45, R46, R84 | Thick film, chip resistors | 1.5 k Ω | Multicomp | MC 0.063W 0603 1% 1K5 |
| R5 | High frequency, chip resistor | 50 Ω | Vishay | FC0402E50R0BST1 |
| R6 | Antisurge, high power, thick film, chip resistor | 49.9 k Ω | Vishay | RCS040249K9FKED |
| R74, R79 | Thick film, chip resistors | 100 k Ω | Multicomp | MC 0.063W 0603 1% 100K |
| RCPOUT | Thick film, chip resistor | 91 Ω | Yageo | RC0603FR-0791RL |
| S1 | Single-pole single-throw, momentary switch | TT11AGPC104 | TE Connectivity | TT11AGPC104 |
| TP3, TP5 | PCB test point connectors | Red | Keystone Electronics | 5000 |
| TP4 | PCB test point connector | Black | Keystone Electronics | 5006 |

| Reference Designator | Description | Value | Manufacturer | Part Number |
|----------------------|--|---------------|----------------------|---------------------|
| U1 | Microwave, wideband synthesizer with integrated VCO | ADF4371BCCZ | Analog Devices, Inc. | ADF4371BCCZ |
| U2, U3 | 20 V, 500 mA, ultralow noise, ultrahigh power supply rejection ratio (PSRR), linear regulators | LT3045EDD#PBF | Analog Devices, Inc. | LT3045EDD#PBF |
| U6 | 32 kB, serial electronically erasable programmable read-only memory (EEPROM) | 24LC32A-I/MS | Microchip Technology | 24LC32A-I/MS |
| Y1 | Ultralow, phase noise XO, high density, complementary metal-oxide semiconductor (HCMOS) | 100 MHz | Crystek | CCHD-575-50-100.000 |
| ZD1 | BZX84C 6.8 V, Zener, SOT-23 diode | BZX84-C6V8 | Philips | BZX84-C6V8 |

**ESD Caution**

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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