![ANALOG DEVICES logo]

Evaluation Board User Guide
UG-406

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Evaluation Board for the ADF4150HV PLL Frequency Synthesizer

FEATURES

General-purpose evaluation board for ADF4150HV, including octave range VCO, loop filter, and TCXO

Contains the ADF4150HV frequency synthesizer (500 MHz to 3 GHz)

Contains the ADF5001 prescaler to allow optional connection of external microwave VCOs without the need for an active loop filter

Accompanying software allows complete control of synthesizer functions from a PC

EVALUATION KIT CONTENTS

EVAL-ADF4150HVEB1Z board

CD that includes

   Self-installing software that allows users to control the board and exercise all functions of the device

   Electronic version of the ADF4150HV data sheet

   Electronic version of the UG-406 user guide

   Electronic version of the UG-476 user guide

ADDITIONAL EQUIPMENT

PC running Windows XP or more recent version

Power supply

Spectrum analyzer

Oscilloscope (optional)

DOCUMENTS NEEDED

ADF4150HV data sheet

UG-406 user guide

UG-476 user guide

REQUIRED SOFTWARE

Analog Devices ADF4150 family software (Version 4.2.2 or higher)

GENERAL DESCRIPTION

This board is designed to allow the user to evaluate the performance of the ADF4150HV frequency synthesizer for phase-locked loops (PLLs). Figure 1 shows the board, which contains the ADF4150HV synthesizer, loop filter, voltage control oscillator (VCO) of 1 GHz to 2 GHz octave range and up to 28 V high tuning voltage, reference oscillator (TCXO) of 25 MHz frequency for the reference input, power supply connectors, and an RF output. The ADF5001 prescaler allows for optional direct connection of external microwave VCOs without the need for an active loop filter.

The evaluation kit also contains software that is compatible with Windows® XP and later versions to allow easy programming of the synthesizer.

The PC must have a USB port to program the part.
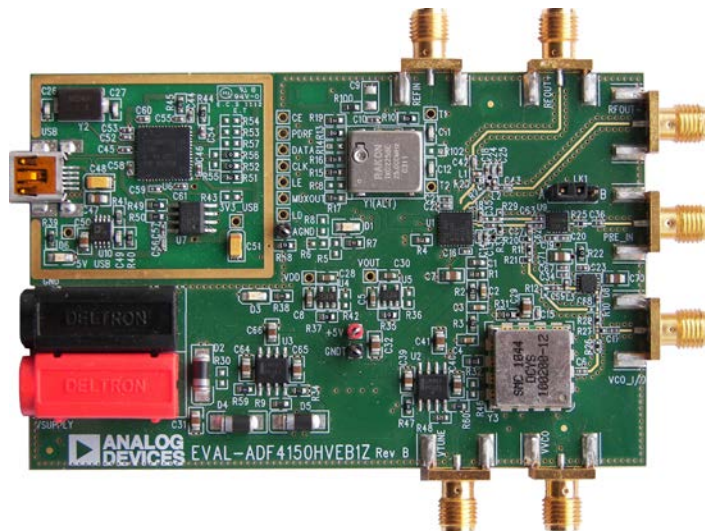
EVALUATION BOARD PHOTOGRAPH

Figure 1. EVAL-ADF4150HVEB1Z

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REVISION HISTORY

1/13—Rev. 0 to Rev. A

5/12—Revision 0: Initial Version

QUICK START GUIDE

Follow these steps to quickly evaluate the ADF4150HV device:

1. Install the Analog Devices ADF4150 family software (see UG-476, *PLL Software Installation Guide*).
2. Connect the EVAL-ADF4150HVEB1Z board to the PC.
3. Follow the hardware driver installation procedure when it appears (Windows XP only).
4. Connect the power supplies as follows:
   a. 30 V to banana connectors
   b. 5 V to the test point labeled +5V on the board

5. Run the Analog Devices ADF4150 family software.
6. Select **USB board (green)** and **ADF4150HV** in the **Select Device and Connection** tab of the software front panel display window.
7. Click the **Main Controls** tab.
8. Update all registers.
9. Connect the spectrum analyzer to one of the following SMA connectors: VCO_I/O, RFOUT+, or RFOUT−.
10. Connect a 50 Ω termination resistor to each unused VCO_I/O, RFOUT+, and RFOUT− connector.
11. Measure the results.

EVALUATION BOARD HARDWARE

The [EVAL-ADF4150HVEB1Z](#) schematics are shown in Figure 9, Figure 10, Figure 11, and Figure 12. The silkscreen of the evaluation board is shown in Figure 2.

POWER SUPPLIES

There are two separate supply voltages required for the evaluation board.

- Banana connectors should be supplied with 30 V. This powers the LM317LDG regulator, which provides a regulated 29 V to V_P (the charge pump supply of the [ADF4150HV](#)) and 12 V for the DCYS100200-12 VCO supply (V_{VCO}).
- The test point labeled +5V must be supplied with 5 V, as shown in Figure 8. This powers high precision, low noise [ADP150AUJZ-3.3](#) linear regulators to provide 3.3 V to V_{DD} on the board (which supplies the [ADF4150HV](#) AV_{DD}, DV_{DD}, and SDV_{DD} pins), to V_{OUT} (which supplies the [ADF4150HV](#) RF outputs pull-up), and to the [ADL5541](#) buffer, which improves phase frequency detector (PFD) spur levels at the VCO output.

The D3 LED indicates when the [ADF4150HV](#) is powered.

INPUT SIGNALS

The reference signal is necessary for proper operation of the synthesizer. It can be sourced from a provided TCXO or from an external generator, which can be connected to the REFIN edge mount connector. To use an external reference generator, it is necessary to remove R101 and R100 to disconnect the TCXO from the reference input and from the supply. R102 can be populated with a 50 Ω resistor to adjust the impedance matching of the evaluation board to the external reference source.

Digital SPI signals are supplied from the Cypress microcontroller, U6, which is used for communication with the USB port of the PC.

OUTPUT SIGNALS

All components necessary for local oscillator (LO) generation are inserted on the board. The PLL is made up of the [ADF4150HV](#) synthesizer, a fourth-order passive loop filter, and the octave range VCO. The loop filter is inserted between the charge pump output and the VCO input, as shown in Figure 12. If replacing the VCO, a VCO in a T-package (or similar) must be used. The VCO output is available at the edge mount SMA connector, VCO_I/O, and the differential RF output of the part is connected to the RFOUT+ and RFOUT− edge mount SMA connectors.

A buffer, the [ADL5541,](#) is placed between the VCO output and the [ADF4150HV](#) RF_{IN}+ pin, which significantly lowers the PFD spur levels seen at the VCO output below −110 dBc. If the PFD spur level measured on the VCO output without a buffer is sufficient (approximately −80 dBc) or if the output signal is taken only from the RF output pins of the ADF4150HV and not

from the VCO output, the [ADL5541](#) is not needed and can be bypassed.

The device is quite sensitive to impedance unbalance. If only one port of the differential pair is used, the other should be terminated with a 50 Ω load. The external VCO output should also be terminated in a 50 Ω load.

DEFAULT OPERATION SETTINGS

This board is shipped with a TCXO that provides a reference frequency of 25 MHz, a fourth-order low-pass filter with 20 kHz bandwidth at I_{CP} = 300 μA, and an octave range VCO with a 1 GHz to 2 GHz frequency range. To test the performance of the part for a different frequency range and a different loop filter, the relevant components on the board must be changed.

Note that the Synergy Microwave Corp. VCO tuning sensitivity decreases as the tuning voltage increases (see Figure 3). To maintain a constant loop filter bandwidth, increase the charge pump value to the maximum of 400 μA for frequencies greater than approximately 1.8 GHz.
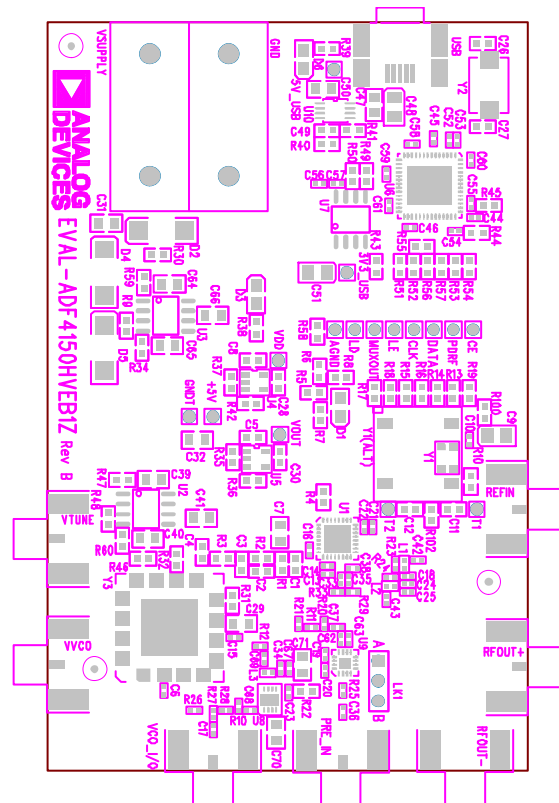

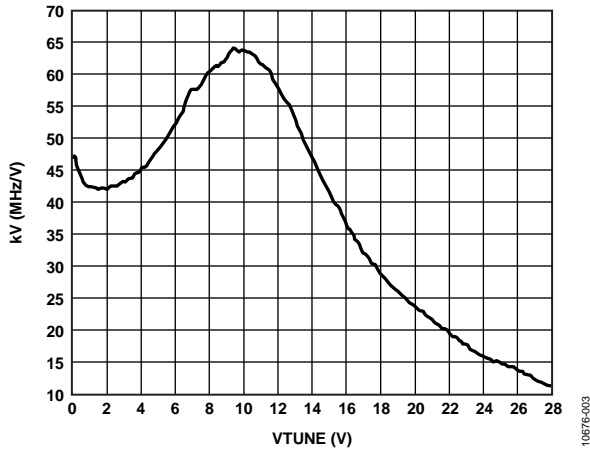Figure 2. Evaluation Board Silkscreen

Figure 3. Frequency Gain vs. Tuning Voltage for DCYS100200-12 VCO

ADDITIONAL OPTIONS

The VVCO connector can be used as a test point to measure the supply voltage of the VCO in its default configuration. It can also be used to provide an external supply for the on-board VCO; however, if an external supply for VCO is used, Resistor R31 must be removed to disconnect the connector from the output of the on-board voltage regulator.

External VCO Option

Optionally, an external VCO can be used. In this case, it is necessary to remove R32 and insert a 0 Ω link at R46 to form a connection between the loop filter output and the VTUNE SMA edge mount connector. Remove R31 to disconnect the on-board VCO from the power supply. Remove Resistor R26 to disconnect the output of the on-board VCO from the RF signal path, and replace Resistors R27 and R28 with 0 Ω links to ensure operation of the VCO_I/O connector as an input from an external VCO.

Prescaler for Microwave VCO

The board contains the ADF5001, an 18 GHz divide-by-4 prescaler for users who want to interface a high frequency microwave VCO to the ADF4150HV. For example, using a 12 GHz external VCO, use the VTUNE SMA as described in the External VCO Option section, but, in this case, connect the VCO output to the PRE_IN SMA connector. The prescaler must be enabled by moving Jumper LK1 into Position B. The ADF4150HV should be programmed to accept a 12 GHz ÷ 4 frequency, or 3 GHz. Isolate the VCO tracks from the output of the prescaler by removing C37. It is recommended to interface the prescaler differentially for best performance; therefore, swap C38 (100 pF) into the space provided for C35. R33 can be removed as shown in Figure 4. Note that the loop filter should be redesigned when changing the VCO and/or reference frequencies.

PHASE NOISE MEASUREMENT

With the default settings, in-band phase noise of close to −101 dBc/Hz can be measured. This translates to a normalized phase noise floor of −211 dBc/Hz. To measure the ADF4150HV normalized phase noise specification of −213 dBc/Hz, increase the loop bandwidth to 50 kHz or greater. The simplest way to do this is to change the R_{SET} resistor (R4) to 3.3 kΩ. This increases the charge pump current from 400 μA to 618 μA with a corresponding increase in loop bandwidth. With the wider loop bandwidth, a phase noise of −103 dBc/Hz can be measured:

$$PN = -213 + 10 \log(25\ \text{MHz}) + 20 \log(1500/25) = -103\ \text{dBc/Hz}$$

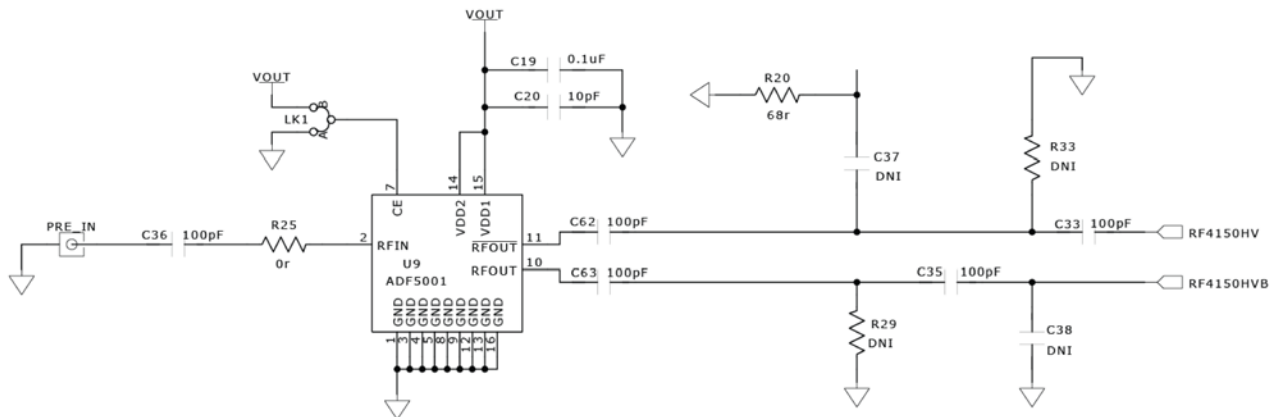The variation of phase noise vs. PLL loop bandwidth can be modeled in ADIsimPLL.

Figure 4. Configuration of the Board for External Microwave VCO Using the ADF5001 Prescaler

EVALUATION BOARD SOFTWARE

The control software for the EVAL-ADF4150HVEB1Z accompanies the board on the CD included in the evaluation kit. To install the software, see UG-476, *PLL Software Installation Guide*.

To run the software,

1. Click **ADF4150 Family** file on the desktop or from the **Start** menu.
2. On the **Select Device and Connection** tab, choose **ADF4150HV** and **USB board (green)**, and then click **Connect** (Figure 5).

3. Confirm that **ADF4xxx USB Adapter Board connected** is displayed at the bottom left of the window (see Figure 5). Otherwise, the software has no connection to the evaluation board. Note that when connecting the board, it takes about 5 sec to 10 sec for the status label to change.
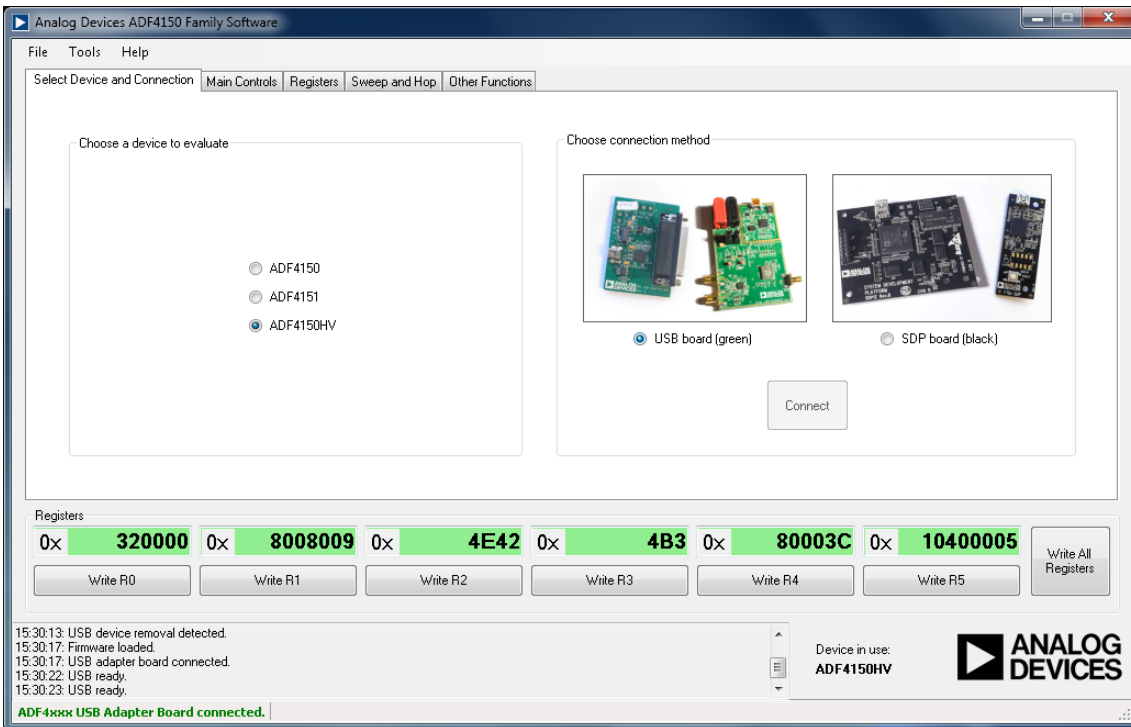4. Under the **File** menu, the current settings can be saved to and loaded from a text file.

Figure 5. Software Front Panel Display—Select Device and Connection

The **Main Controls** tab controls the PLL settings (see Figure 6).

Use the **Reference Frequency** text box to set the correct reference frequency and the reference frequency divider. If the on-board TCXO is used, the reference frequency should be set to 25 MHz.

Use the **RF Settings** section to control the output frequency. You can type the desired output frequency in the **RF Frequency** text box (in megahertz).

In the **Registers** tab, you can manually input the desired value to be written to the registers.

In the **Sweep and Hop** tab, you can make the device sweep a range of frequencies, or hop between two set frequencies.

The **Registers** section near the bottom of each window displays the value to be written to each register. If the background of a text box is green, the value displayed is different from the value actually on the device. Click **Write Rx** (where x = 0 to 5) to write that value to the device.
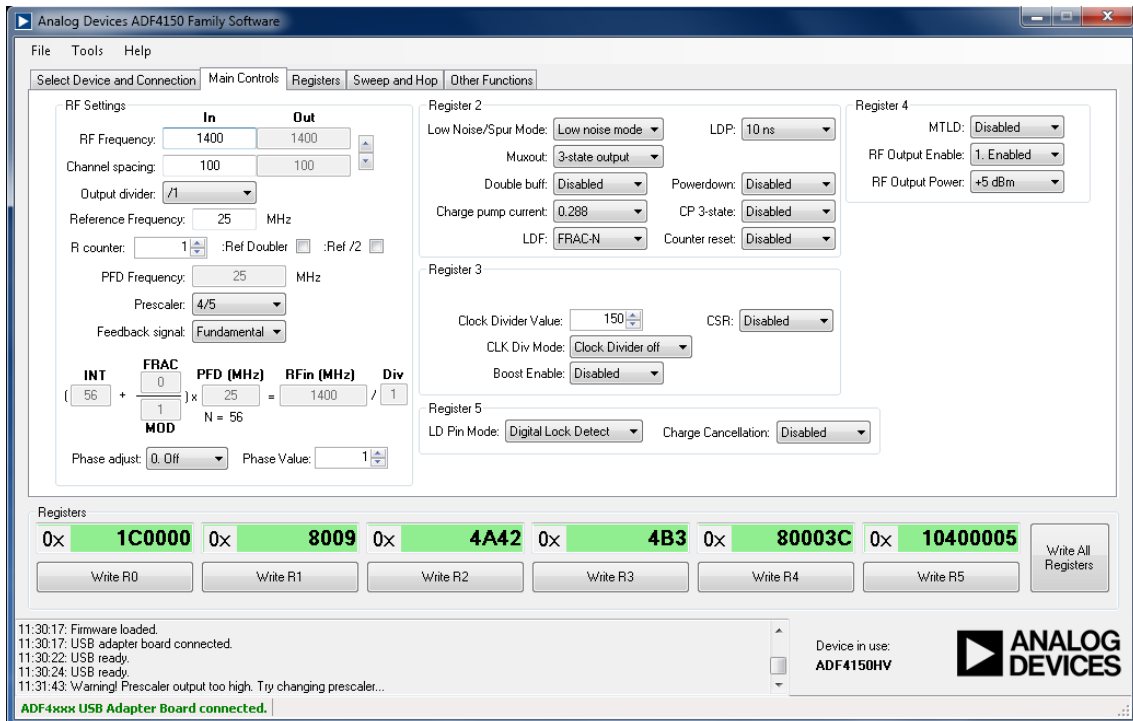

Figure 6. Software Front Panel Display—Main Controls

EVALUATION AND TEST

To evaluate and test the performance of the ADF4150HV, use the following procedure:

1. If using a different VCO and loop filter than provided on the board, ensure that a VCO and loop filter are properly inserted on the board. If a microwave VCO is going to be used together with the ADF5001 prescaler, move Jumper LK1 into Position B to power up the prescaler. Use ADIsimPLL to generate the loop filter component values.

2. Install the Analog Devices ADF4150 family software. Connect the evaluation board to a PC using the supplied USB cable. Follow the hardware driver installation procedure when it appears.

3. If the on-board crystal oscillator is used, skip this step. If an external reference is necessary, connect a reference signal to the REFIN edge mount connector.

4. Connect the power supply to the board.

5. Connect a spectrum analyzer to Connector VCO_I/O.

6. Run the ADF4150 family software.

7. In the software window, set the RF frequency (Figure 7 shows a screenshot of the signal source analyzer operating in phase noise mode, taken at a frequency of 1.4 GHz). Set the PFD frequency as defined in ADIsimPLL, and program the reference frequency to 25 MHz if the on-board TCXO is used or to the frequency that has been supplied to the REFIN connector. See Figure 8 for the suggested setup.

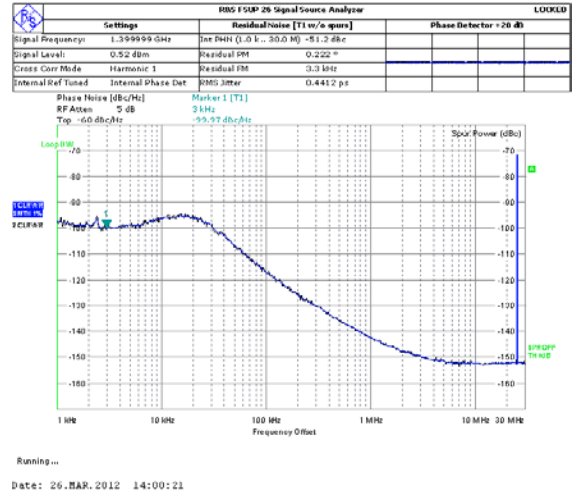8. Measure the output spectrum. Figure 7 shows a 1.4 GHz output.

Figure 7. Signal Source Analyzer Display

Figure 8. Typical Evaluation Setup
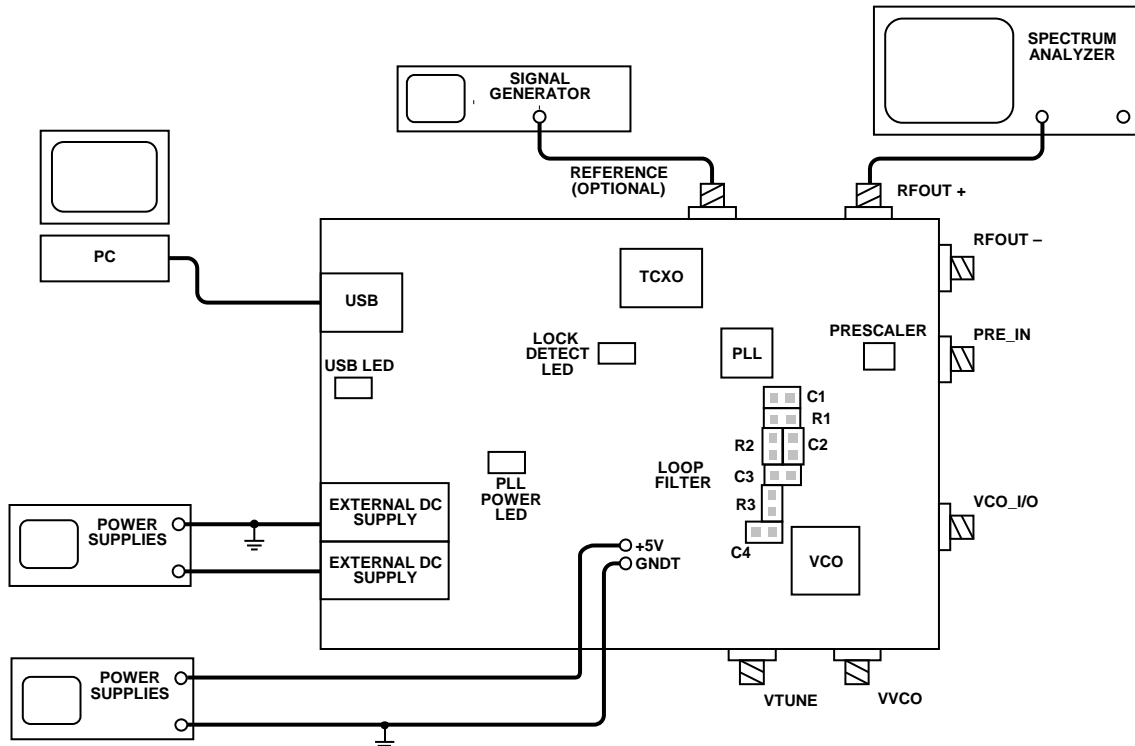
EVALUATION BOARD SCHEMATICS AND ARTWORK

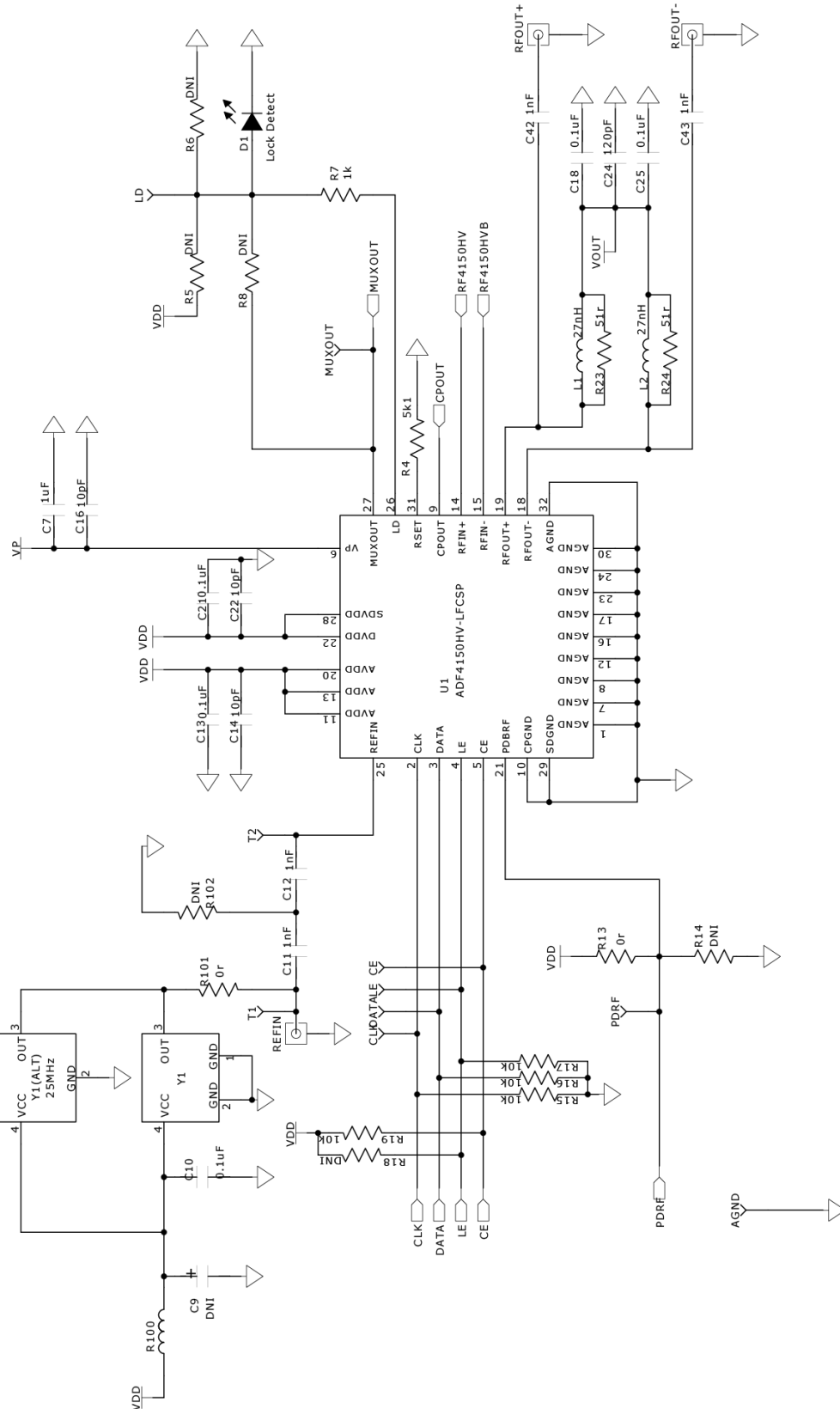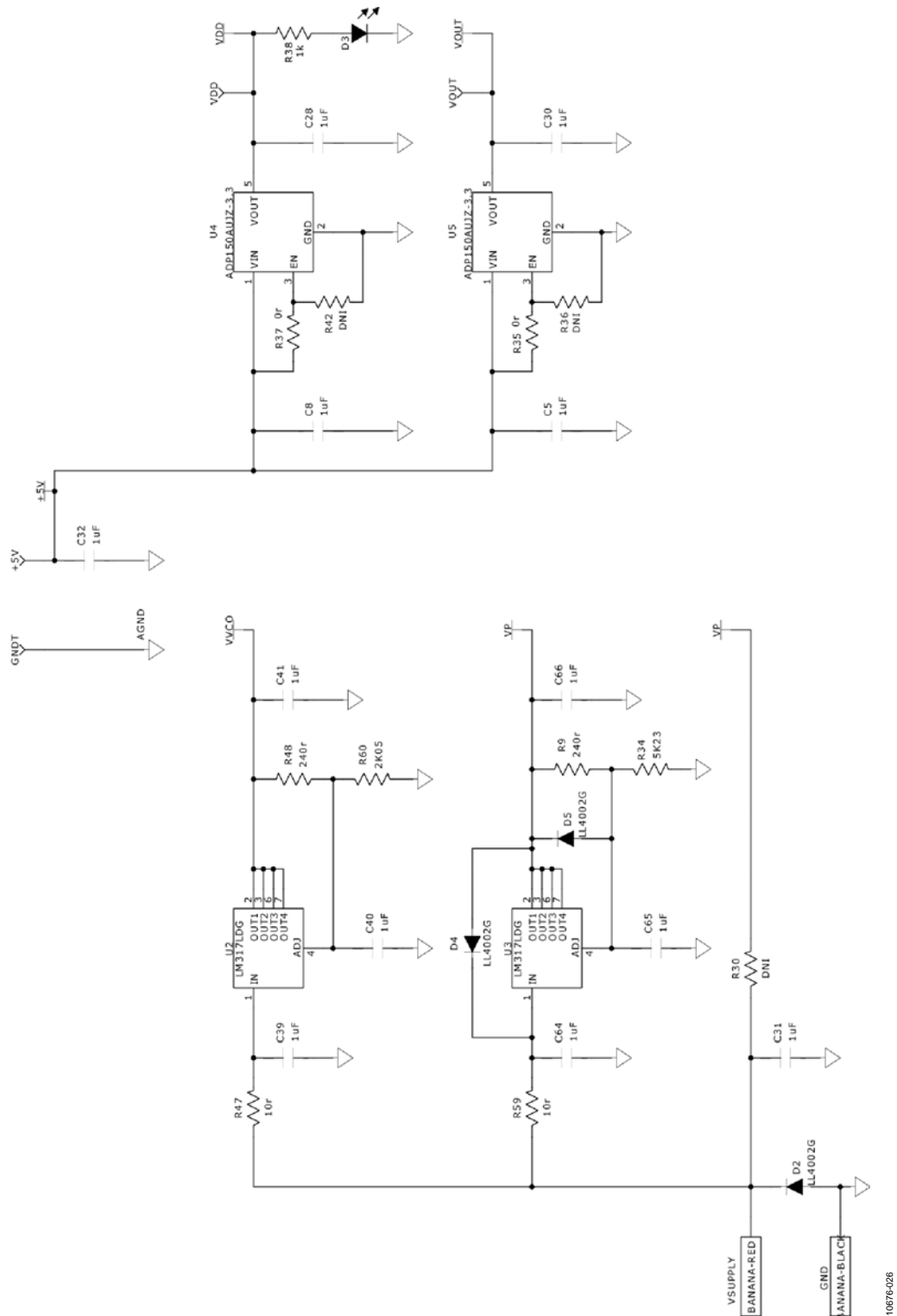Figure 9. Evaluation Board Schematic (Page 1)

Figure 10. Evaluation Board Schematic (Page 2)

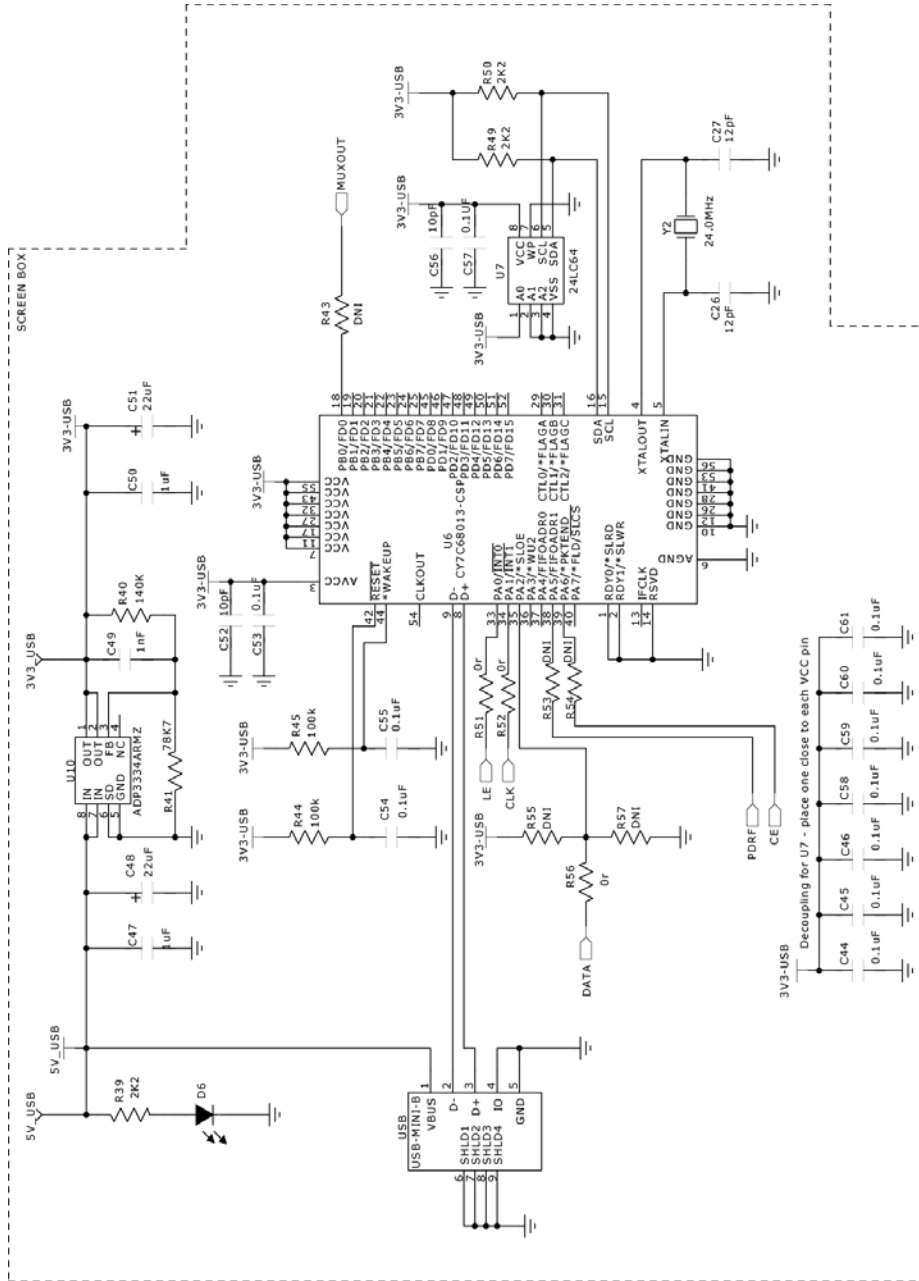Figure 11. Evaluation Board Schematic (Page 3)

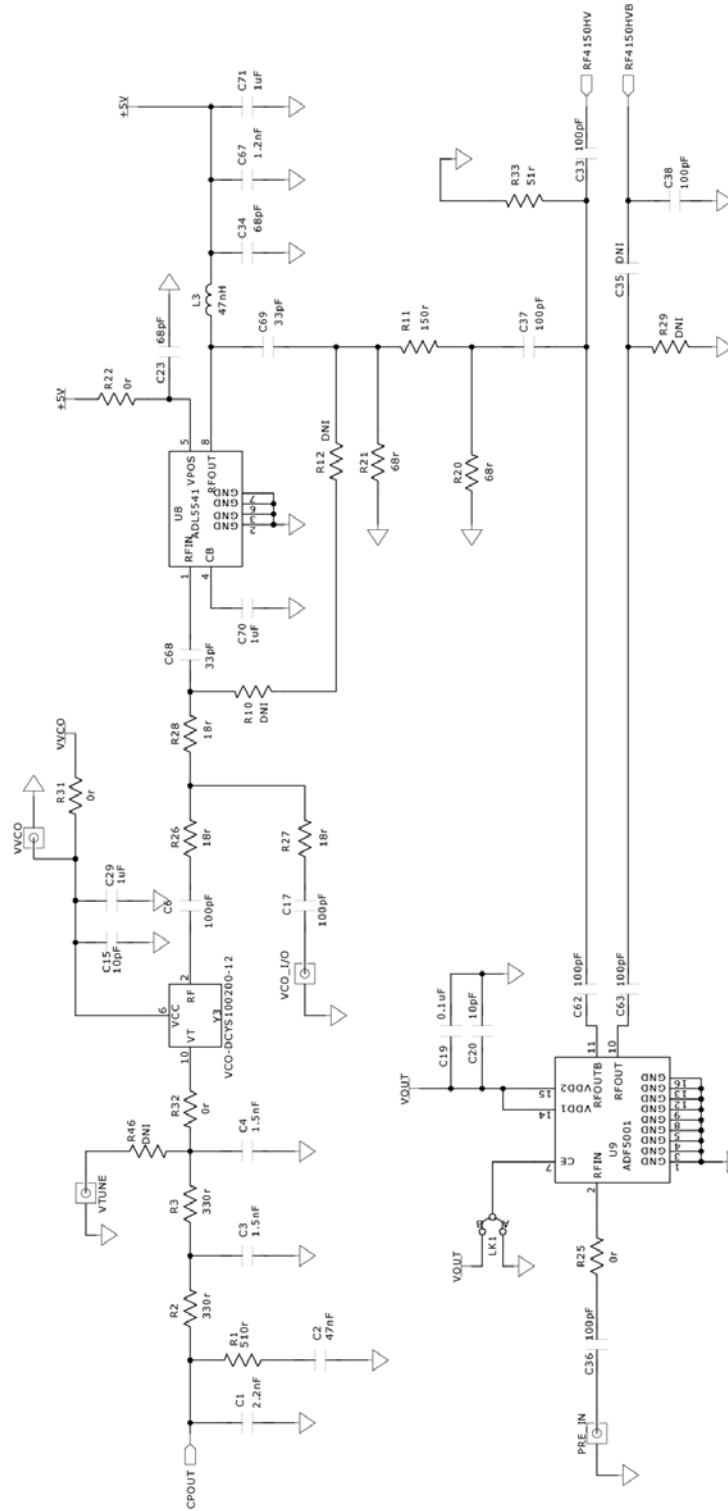*Figure 12. Evaluation Board Schematic (Page 4)*

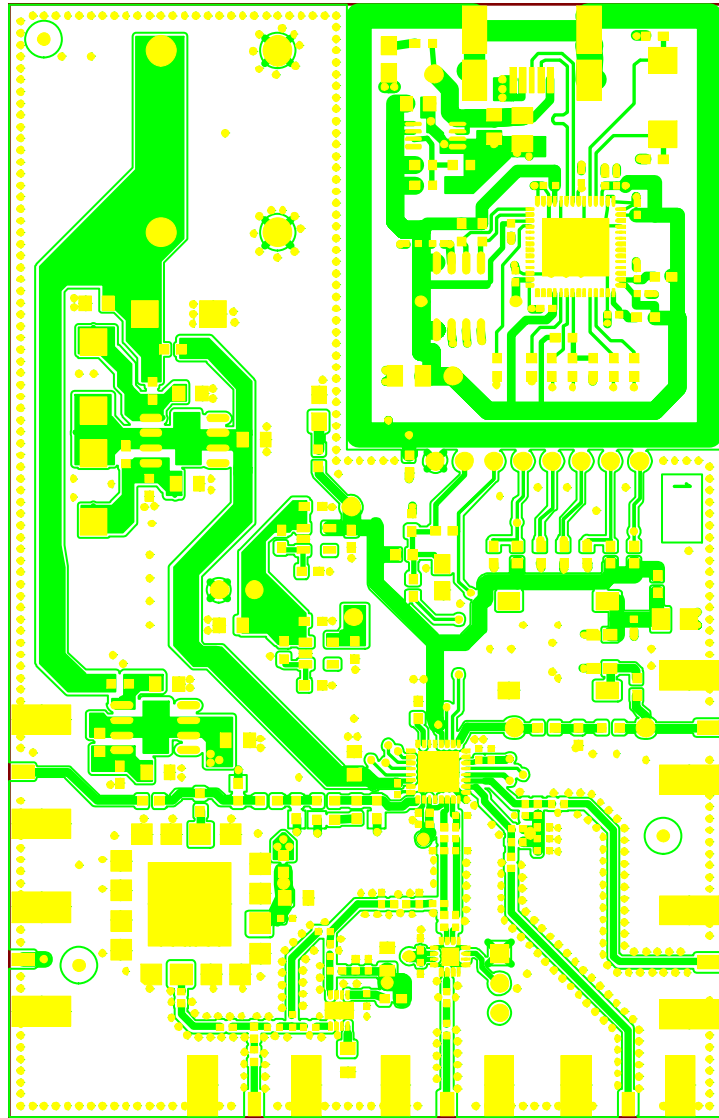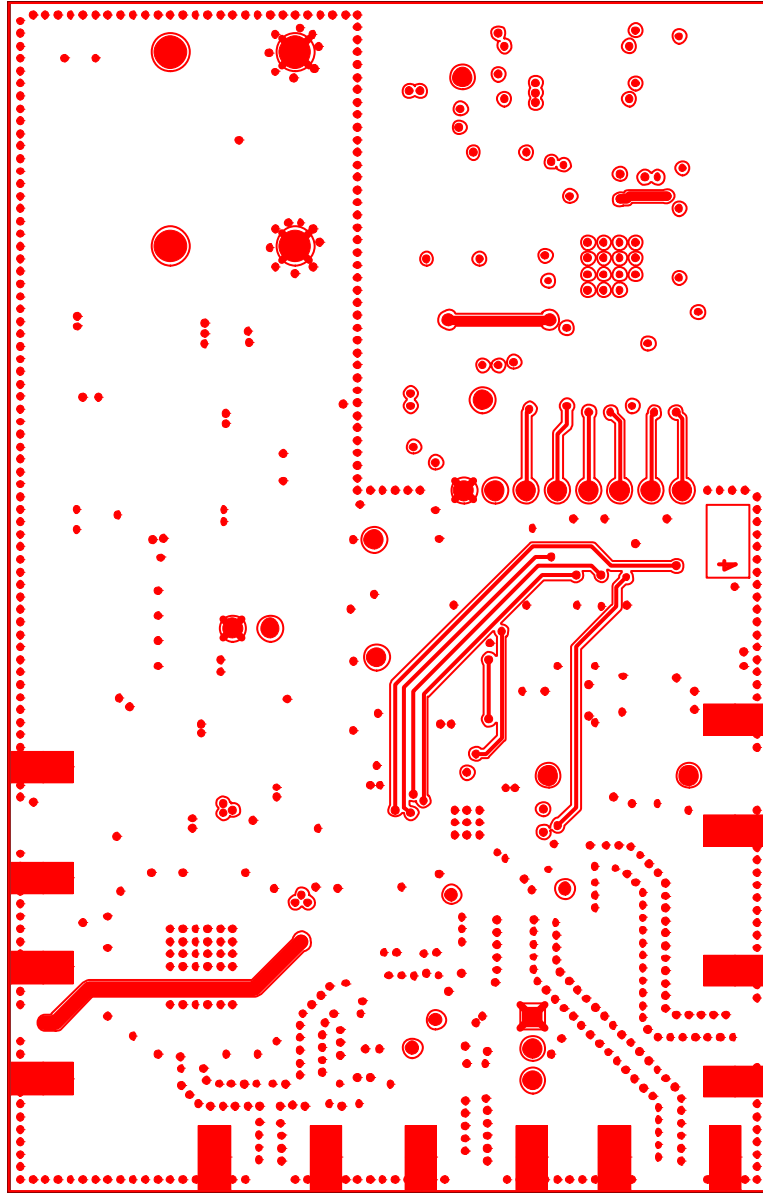Figure 13. Layer 1 (Component Side)
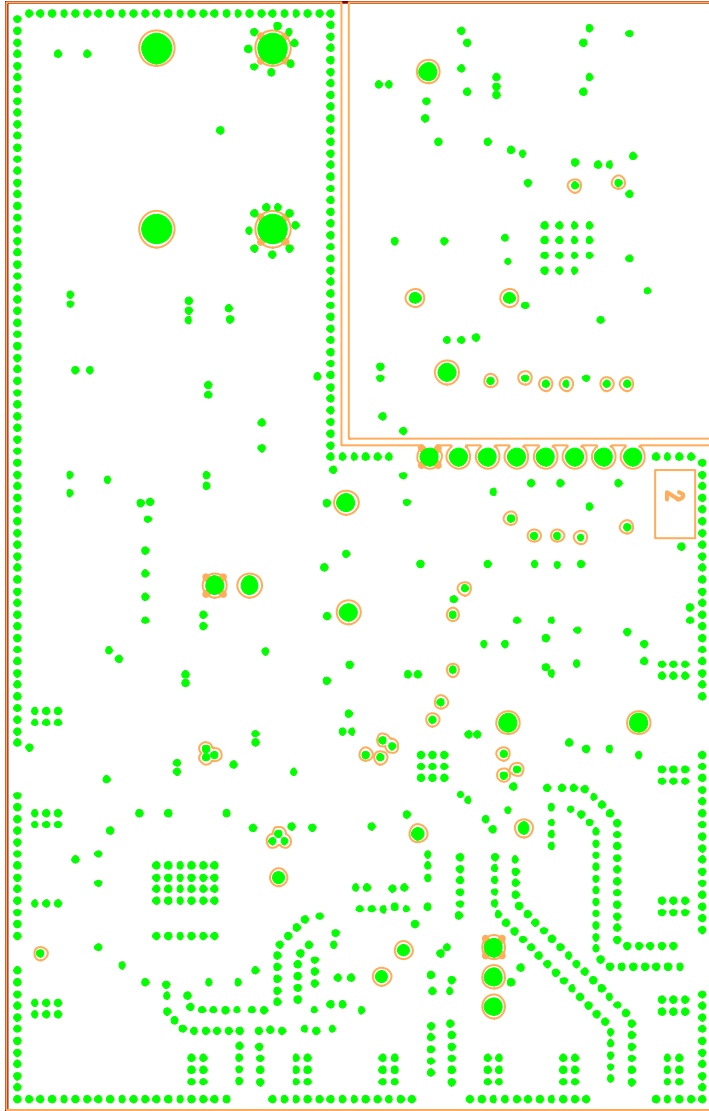
Figure 14. Layer 2 (Ground Plane)
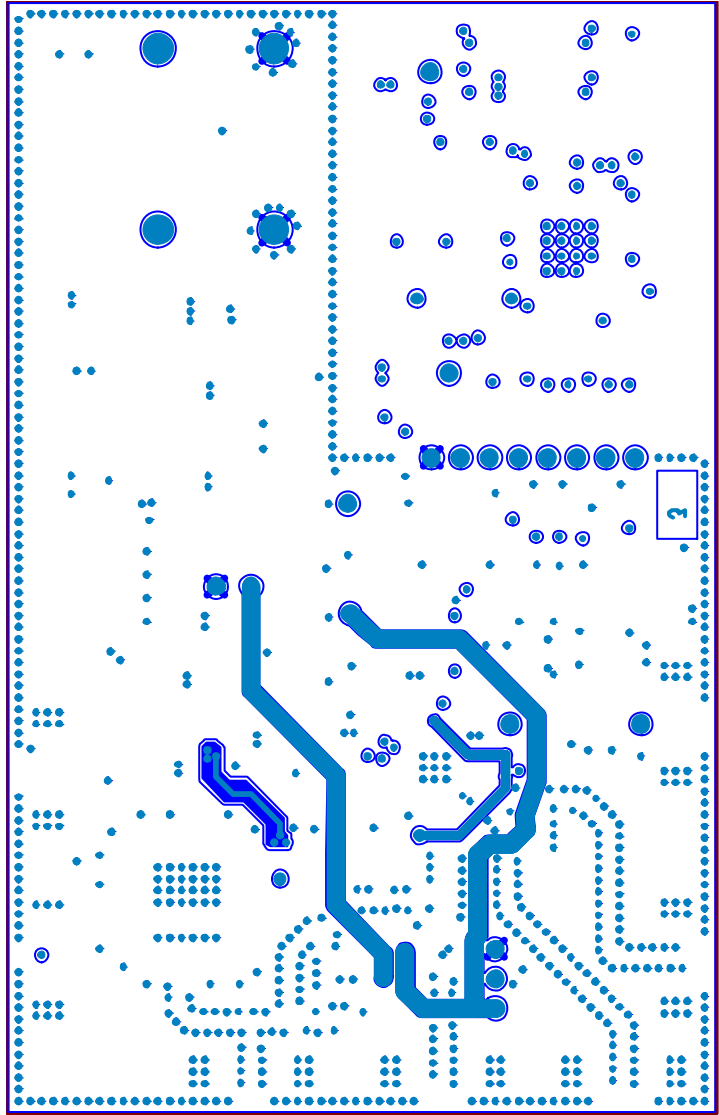
Figure 15. Layer 3 (Power Plane)

Figure 16. Layer 4 (Solder Side)

BILL OF MATERIALS

Table 1.

Reference Designator	Value	Description	Manufacturer/Part Number
+5V		Red test point	Vero 20-313137
3V3_USB, 5V_USB	Do not insert	Red test point	N/A
AGND		Black test point	Vero 20-2137
C1	2.2 nF	50 V X7R SMD ceramic capacitor	Multicomp MCCA000229
C2	47 nF	50 V X7R SMD ceramic capacitor	Multicomp MCCA000249
C3, C4	1.5 nF	50 V X7R SMD ceramic capacitor	Multicomp MCCA000227
C5, C8, C28, C30	1 µF	Capacitor, 0603 1 µF 10 V X5R	Murata GRM188R61A105KA61D
C6, C17, C33, C36, C37, C38, C62, C63	100 pF	50 V C0G ceramic capacitor	Murata GRM1555C1H101JD01D
C7, C29, C31, C32, C39, C40, C41, C64, C65, C66, C70, C71	1 µF	50 V X5R 0805 1.0 µF ceramic capacitor	Taiyo/Yuden GRM32RR71H105KA01L
C9	Do not insert	TAJ-A capacitor location, not inserted	N/A
C10, C13, C18, C19, C21, C25, C44, C45, C46, C53, C54, C55, C57, C58, C59, C60, C61	0.1 µF	16 V, X7R ceramic capacitor	Kemet C0402C104K4RAC
C1, C12, C49	1 nF	50 V NP0 ceramic capacitor	AVX 06035A102JAT2A
C14, C15, C16, C20, C22, C52, C56	10 pF	50 V NPO ceramic capacitor	AVX 04025U100GAT2A
C23, C34	68 pF	50 V C0G ceramic capacitor	Murata GRM1555C1H680JZ01D
C24	120 pF	50 V NP0 ceramic capacitor	AVX 04025A121JAT2A
C26, C27	12 pF	50 V NPO SMD ceramic capacitor	Phycomp 2238 867 15129
C35	Do not insert	0402 capacitor location , not inserted	N/A
C42, C43	1 nF	Capacitor ceramic 1000 pF 50 V C0G 0402	Murata GRM1555C1H102JA01D
C47, C50	1 µF	Capacitor ceramic 1.0 µF 50 V X5R 0805	Taiyo/Yuden TMK107BJ105KA-T
C48, C51	22 µF	6.3 V tantalum capacitor (TAJ-A case)	AVX TAJA226K006R
C67	1.2 nF	50 V X7R ceramic capacitor	Murata GRM155R71H122KA01D
C68, C69	33 pF	50 V C0G ceramic capacitor	Murata GRM1555C1H330JZ01D
CE, CLK	Do not insert	Red test point	N/A
D1, D6		Green LED	Avago Technologies, HSMG-C170
D2, D4, D5	LL4002G	Power rectifier diode	Multicomp LL4002G
D3		Red LED	Avago Technologies HSMS-C170
DATA	Do not insert	Red test point	N/A
GND		Black 4 mm banana socket	Deltron 571-0100-01
GNDT		Black test point	Vero 20-2137
L1, L2	27 nH	Coilcraft 0402CS SMD inductor	Coilcraft 0402CS-27NX-LU
L3	47 nH	Coilcraft 0402CS SMD inductor	Coilcraft 0402CS-47NX-LU
LD, LE, MUXOUT, PDBRF	Do not insert	Red test point	N/A
LK1		3-pin SIL header and shorting link	Harwin M20-9990345 & M7567-05
PRE_IN		End-launch 50 Ω SMA jack	Emerson Network 142-0701-851
R1	510 Ω	SMD resistor	Multicomp MC 0.063W 0603 510r
R2, R3	330 Ω	SMD resistor	Multicomp MC 0.063W 0603 330R
R4	5.1 kΩ	SMD resistor	Multicomp MC 0.063W 0603 5k1
R5, R6, R8, R14, R18, R30, R36, R42, R43, R46, R53, R54, R55, R57, R102	Do not insert	0603 resistor location, not inserted	N/A
R7, R38	1 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1K
R9, R48	240 Ω	SMD resistor	Multicomp MC 0.063W 0603 240R
R10, R12, R29	Do not insert	0402 resistor location, not inserted	N/A
R11	150 Ω	0402 SMD resistor	Multicomp MC 0.0625W 0402 1% 150R

Reference Designator	Value	Description	Manufacturer/Part Number
R13, R22, R31, R32, R35, R37, R51, R52, R56, R58, R101	0 Ω	SMD resistor	Multicomp MC 0.063W 0603 0R
R15, R16, R17, R19	10 kΩ	SMD resistor	Multicomp MC 0.063W 0603 10K
R20, R21	68 Ω	SMD resistor	Multicomp MC 0.0625W 0402 1% 68R
R23, R24	51 Ω	SMD resistor	Multicomp MC 0.063W 0402 51R
R25	0 Ω	0402 SMD resistor	Multicomp MC 0.0625W 0402 1% 0R
R26, R27, R28	18 Ω	0402 SMD resistor	Multicomp MC 0.0625W 0402 1% 18R
R33	51 Ω	0402 SMD resistor	Multicomp MC 0.063W 0402 51R
R34	5.23 kΩ	SMD resistor	Multicomp MC 0.063W 0603 5K23
R39, R49, R50	2.2 kΩ	SMD resistor	Multicomp MC 0.063W 0603 2k2
R40	140 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1% 140K
R41	78.7 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1% 78K7
R44, R45	100 kΩ	SMD resistor	Multicomp MC 0.063W 0603 100K
R47, R59	10 Ω	SMD resistor	Multicomp MC 0.063W 0603 10R
R60	2.05 kΩ	SMD resistor	Multicomp MC 0.063W 0603 2K05
R100	470 Ω at 100 MHz	Ferrite bead	Wuerth Elektronik 7427-92642
REFIN, RFOUT+, RFOUT−		End-launch 50 Ω SMA jack	Emerson Network 142-0701-851
T1, T2	Do not insert	Red test point	N/A
U1		PLL	Analog Devices ADF4150HVBCPZ
U2, U3		Positive voltage regulator; adjustable	On Semiconductor LM317LDG
U4, U5		3.3 V linear regulator	Analog Devices ADP150AUJZ-3.3
U6		USB microcontroller	Cypress Semiconductor CY7C68013A-56LFXC
U7		64 k I^{2}C serial EEPROM	Microchip Technology 24LC64-ISN
U8		50 MHz to 6 GHz RF/IF gain block	Analog Devices ADL5541ACPZ
U9		4 GHz to 18 GHz divide-by-4 prescaler	Analog Devices ADF5001BCPZ
U10		Adjustable LDO regulator	Analog Devices ADP3334ARMZ
USB		USB Mini-B connector (USB-OTG)	Molex 54819-0578
VCO_I/O, VTUNE, VVCO		End-launch 50 Ω SMA jack	Emerson Network 142-0701-851
VDD, VOUT	Do not insert	Red test point	N/A
VSUPPLY		Red 4 mm banana socket	Deltron 571-0500-01
Y1 (ALT)	25 MHz	SMD temperature compensated crystal oscillator	Rakon TXO225B
Y2	24 MHz	SMD crystal	ECS International ECS-240-12-20A-TR
Y3	1000 MHz to 2000 MHz	VCO	Synergy Microwave Corp. DCYS100200-12

RELATED LINKS

Resource[1]	Description
ADF4150HV	Product Page, Fractional-N/Integer-N PLL Synthesizer
ADP150	Product Page, Ultralow Noise, 150 mA CMOS Linear Regulator
ADP3334	Product Page, High Accuracy Low I$_Q$, 500 mA anyCAP® Adjustable Low Dropout Regulator
ADL5541	Product Page, 50 MHz to 6 GHz RF/IF Gain Block, Gain of 15 dB
ADF5001	Product Page, 4 GHz to 18 GHz Divide-by-4 Prescaler
UG-476	User Guide, PLL Software Installation Guide

[1] For additional related resources, see the Documentation section of the ADF4150HV product page.

NOTES

NOTES

I²C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

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.

Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS ($100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

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