EV-ADF4150HVEB2Z User Guide
UG-483

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Evaluating the ADF4150HV PLL Frequency Synthesizer

FEATURES

- General-purpose evaluation board for the ADF4150HV including octave range voltage controlled oscillator (VCO) loop filter, and a 25 MHz temperature controlled crystal oscillator (TCXO)
- Contains the ADF4150HV frequency synthesizer (500 MHz to 3 GHz)
- Contains the ADF5001 prescaler
- Accompanying software allows complete control of synthesizer functions from a PC

EVALUATION KIT CONTENTS

- EV-ADF4150HVEB2Z board
- CD with evaluation software
- USB cable

ADDITIONAL EQUIPMENT

- Windows-based PC with USB port for evaluation software
- Power supply (15 V)
- Spectrum analyzer
- 50 Ω terminators

ADDITIONAL DOCUMENTS NEEDED

- ADF4150HV data sheet
- PLL Software Installation Guide (UG-476)

REQUIRED SOFTWARE

- Analog Devices, Inc., ADF4150 family software Version 4.0.1 or higher (included on the CD in the evaluation board kit or available for download at www.analog.com)

GENERAL DESCRIPTION

This evaluation board allows you to evaluate the performance of the ADF4150HV frequency synthesizer for phase-locked loops (PLLs). Figure 1 shows the board, which contains the ADF4150HV synthesizer, a loop filter, a 1 GHz to 2 GHz octave range VCO, 28 V high tuning voltage, a 25 MHz TCXO for the reference input, power supply connectors, and an RF output. The ADF5001 prescaler allows optional direct connection of external microwave VCOs without the need for an active loop filter. A USB cable is included to connect the board to a PC USB port. In addition, the evaluation kit contains Windows®-based software to allow easy programming of the synthesizer.

EVALUATION BOARD PHOTOGRAPH

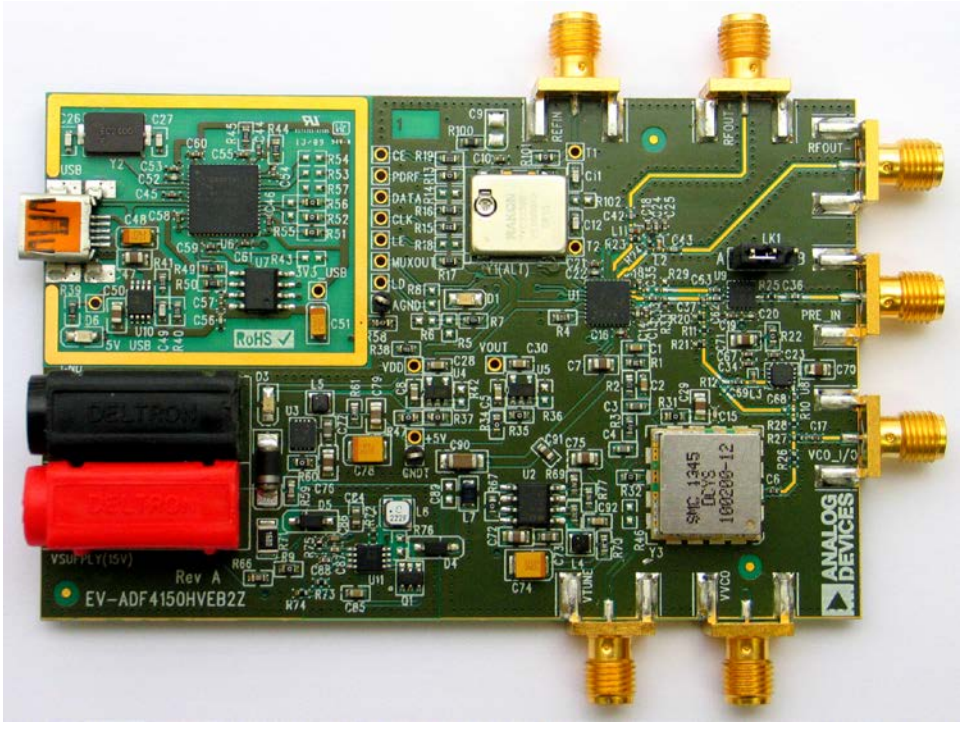

Figure 1. EV-ADF4150HVEB2Z

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REVISION HISTORY

6/14—Revision 0: Initial Version

QUICK START GUIDE

Follow these steps to evaluate the ADF4150HV device:

1. Install the ADF4150 family software (see UG-476).
2. Connect the evaluation board to the PC.
3. Connect the +15 V power supply to the banana connectors.
4. Run the ADF4150 software.
5. Select the **USB board** and the ADF4150HV device in the **Select Device and Connection** tab of the Software Front Panel Display window.
6. Click the **Main Controls** tab.
7. Update all registers.
8. Connect the spectrum analyzer to one of the RFOUT+ or RFOUT− SMA connectors.
9. Connect 50 Ω termination resistors to the unused RFOUT connector and VCO_I/O.
10. Measure the results.

EVALUATION BOARD HARDWARE

Refer to Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13 for the evaluation board schematics. Figure 2 shows the silkscreen of the evaluation board.

POWER SUPPLIES

The board is powered by a 15 V power supply connected to the red and black banana connectors. Connect the red connector to a 15 V power supply and connect the black connector to ground.

The ADP7104ACPZ-5.0 provides the 5 V supply; this voltage is used to power the ADL5541 buffer used to improve the PFD spur performance at the VCO output. The high precision, low noise ADP150AUJZ-3.3 linear regulator provides 3.3 V to V_{DD} (which supplies the ADF4150HV AV_{DD}, DV_{DD}, and SDV_{DD} pins). A separate ADP150AUJZ-3.3 linear regulator provides 3.3 V to V_{OUT} (supply for the ADF4150HV RF outputs pull-up). The ADP7104ARDZ regulator adjustable voltage output provides 12 V for the DCYS100200-12 VCO supply (V_{VCO}).

The ADP1613ARMZ step-up, dc-to-dc switching converter, in conjunction with the Transistor SI3458BDV, generates the 28 V supply for V_P (the charge pump supply of the ADF4150HV). Transistor SI3458BDV extends the output voltage of the step-up converter to the required 28 V.

The D3 LED indicates that the ADF4150HV has power supplied to it.

INPUT SIGNALS

The 25 MHz TXCO provides the on-chip reference frequency. The REFIN edge mount connector allows an optional external reference. 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 voltage. To assure 50 Ω input impedance, populate R102 with a 50 Ω resistor.

The Cypress microcontroller, U6, supplies the digital SPI signals for communication with the USB port of the PC.

OUTPUT SIGNALS

The evaluation board comes equipped with all components necessary for LO generation. The PLL components include the ADF4150HV synthesizer, a fourth-order passive loop filter, and the octave range VCO. Refer to Figure 13 for the loop filter located between the charge pump output and the VCO input. 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. RFOUT+ and RFOUT− edge mount SMA connectors provide the differential RF output from the ADF4150HV.

The ADL5541 buffer between the VCO output and the ADF4150HV RF_{IN}+ pin, significantly lowers the PFD spur levels seen at the VCO output to 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 ADF4150HV is sensitive to impedance mismatch at the RF_{OUT+}/RF_{OUT-} pins. When using only one port of the differential pair, connect a 50 Ω load to the other port. In addition, connect a 50 Ω load to the VCO output.

DEFAULT OPERATION SETTINGS

The board is populated with all components necessary for LO generation. This board is shipped with a 25 MHz reference TCXO, a fourth-order 20 kHz loop filter (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 different loop filter, change the relevant components on the board.

Note that the Synergy 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

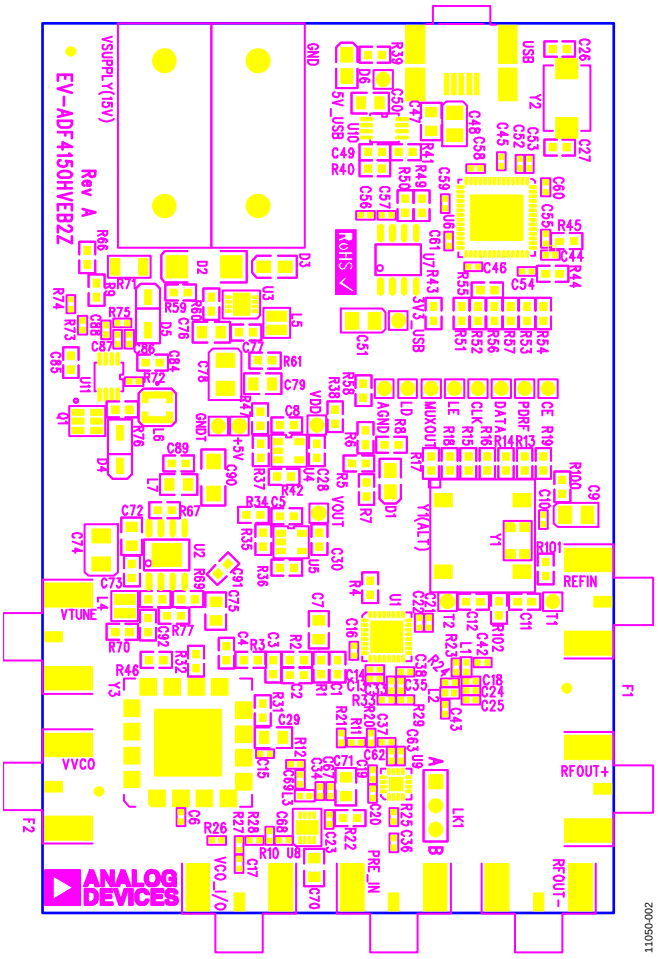

Figure 2. Evaluation Board Silkscreen

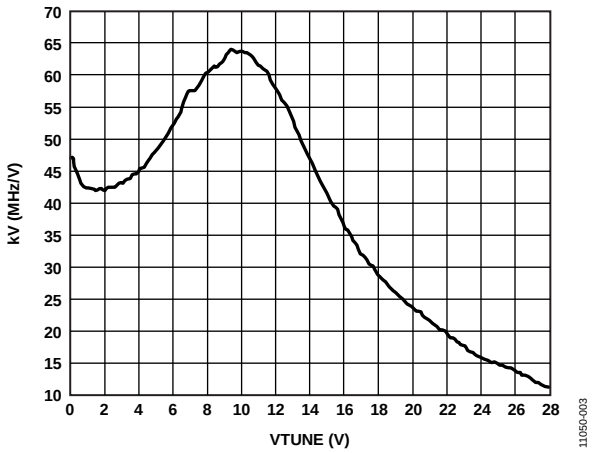

Figure 3. Frequency Gain vs. Tuning Voltage for DCYS100200-12 VCO

ADDITIONAL OPTIONS

In the default configuration, the VVCO connector is a test point to measure the supply voltage of the VCO. If required, the VVCO connector can provide an external supply for the on-board VCO.

Where an external supply for VCO is used, remove Resistor R31 to disconnect the VVCO connector from the output of the on-board voltage regulator.

External VCO Option

An external VCO is an option. In this case, it is necessary to

1. 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.
2. Remove R31 to disconnect the on-board VCO from the power supply.
3. Remove Resistor R26 to disconnect the output of the on-board VCO from the RF signal path.
4. 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 as an option 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. However, in this case, connect the VCO output to the PRE_IN SMA connector. Enable the prescaler by moving Jumper LK1 into Position B. Program the ADF4150HV to accept a 12 GHz ÷ 4 frequency, or 3 GHz. Isolate the VCO output from the prescaler output 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. Remove R33 as shown in Figure 4.

Design a new loop filter when changing the VCO and/or reference frequencies.

PHASE NOISE MEASUREMENT

With the default settings, the in-band phase noise is close to −101 dBc/Hz. 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 RSET 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, the phase noise is equal to approximately −103 dBc.

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

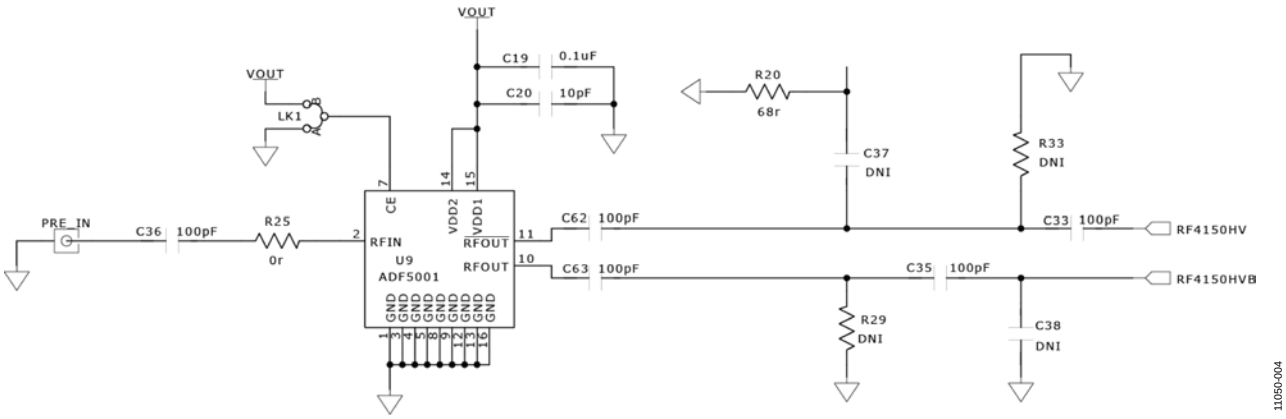

Figure 4. Configuration of the Board for External Microwave VCO Using the ADF5001 Prescaler

EVALUATION BOARD SOFTWARE

The control software for the EV-ADF4150HVEB2Z provided on the CD included in the evaluation kit. To install the software, see UG-476, the *PLL Software Installation Guide*.

To run the software, click the **ADF4150 Family** file on the desktop or in the **Start** menu.

On the **Select Device and Connection** tab, choose **ADF4150HV** and **USB board (green)**, and click **Connect** (see Figure 5).

Confirm that **ADF4xxx USB Adapter Board connected** is displayed at the bottom left of the window. Otherwise, the software has no connection to the evaluation board. Once the board is connected, it takes about 5 to 10 seconds for the status label to change.

Under the **File** menu, the current settings can be saved to, and loaded from, a text file.

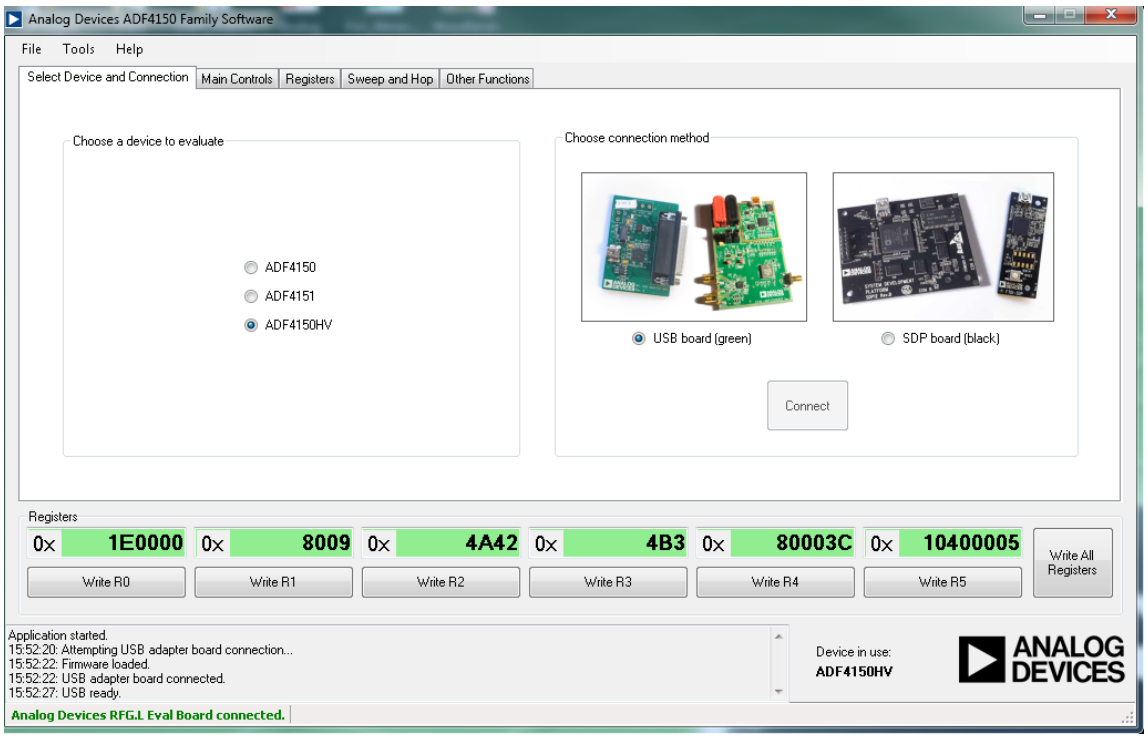

Figure 5. Software Front Panel Display—Select Device and Connection

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 of 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 at the bottom of the window displays the register values. If the background on the 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.

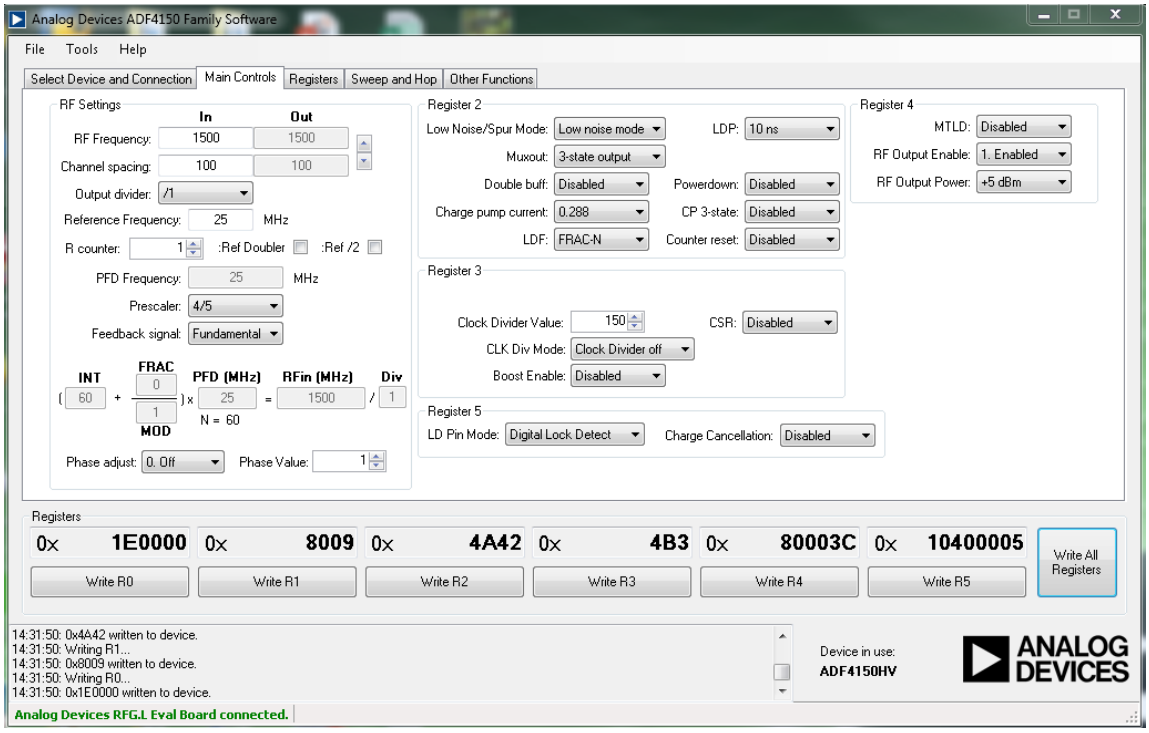

Figure 6. Software Front Panel Display—Main Controls

EVALUATION AND TEST

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

1. Check that LK1 is in Position A.
2. Install the ADF4150 family software.
3. Connect the evaluation board to a PC using the supplied USB cable.
4. 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.
5. Connect the power supply to the board.
6. Connect a spectrum analyzer to Connector VCO_I/O.
7. Connect 50 Ω termination resistors to unused RFOUT+ and RFOUT− connectors.
8. Run the ADF4150 family software.
9. Select **ADF4150HV** as the device to evaluate and **USB board** as the connection method.
10. In the **Main Controls** panel, set the RF frequency, PFD frequency and reference frequency. See Figure 8 for the suggested setup.
11. Measure the output spectrum. Figure 7 shows the signal source analyzer operating in phase noise mode, taken at a frequency of 1.5 GHz output.

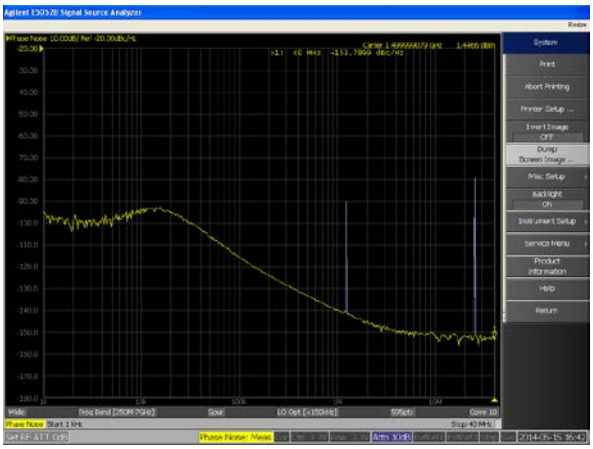

Figure 7. Signal Source Analyzer Display

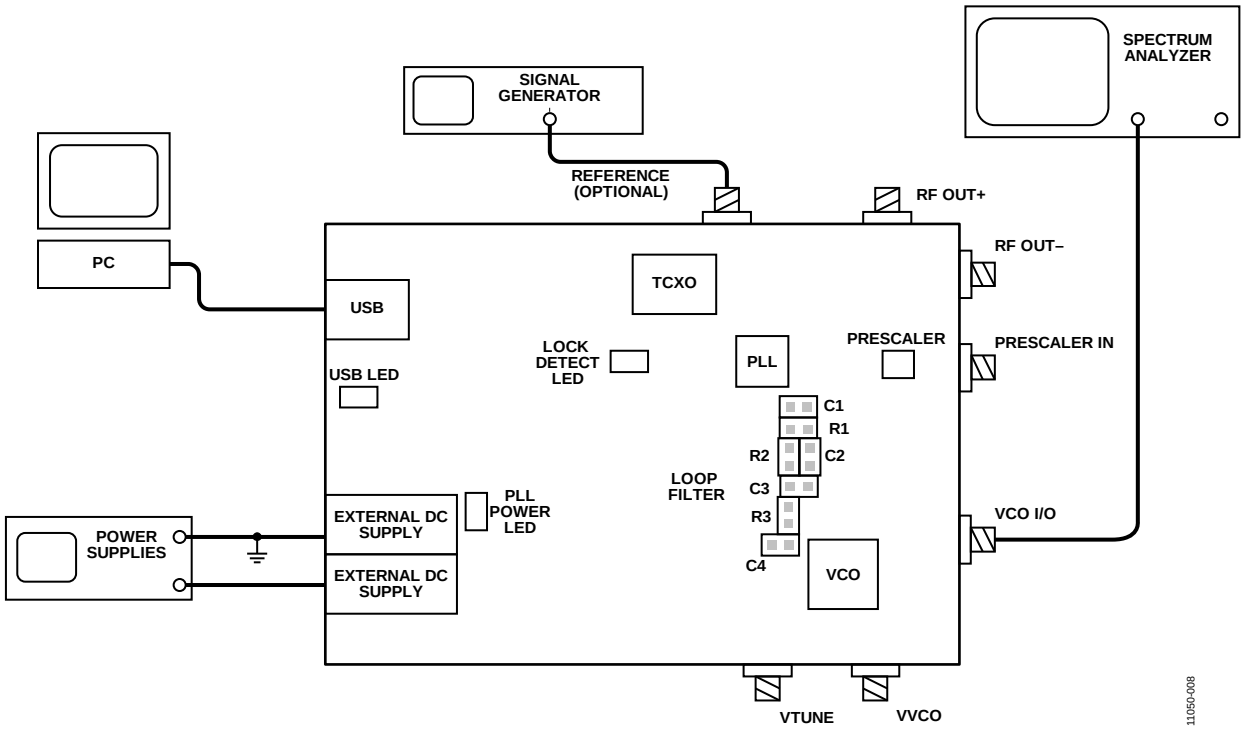

Figure 8. Typical Evaluation Setup

EVALUATION BOARD SCHEMATICS AND ARTWORK

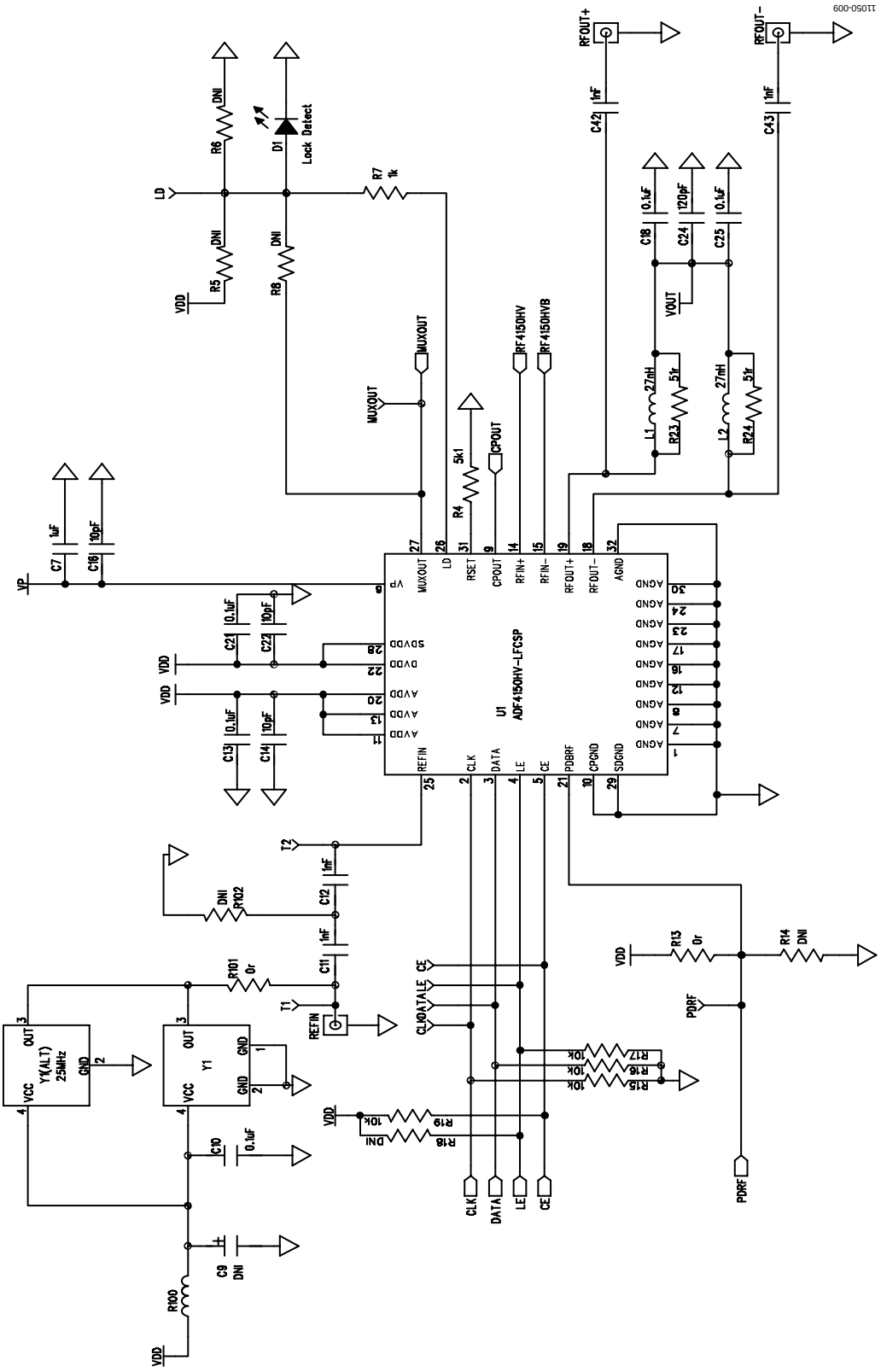

Figure 9. Evaluation Board Schematic (Page 1)

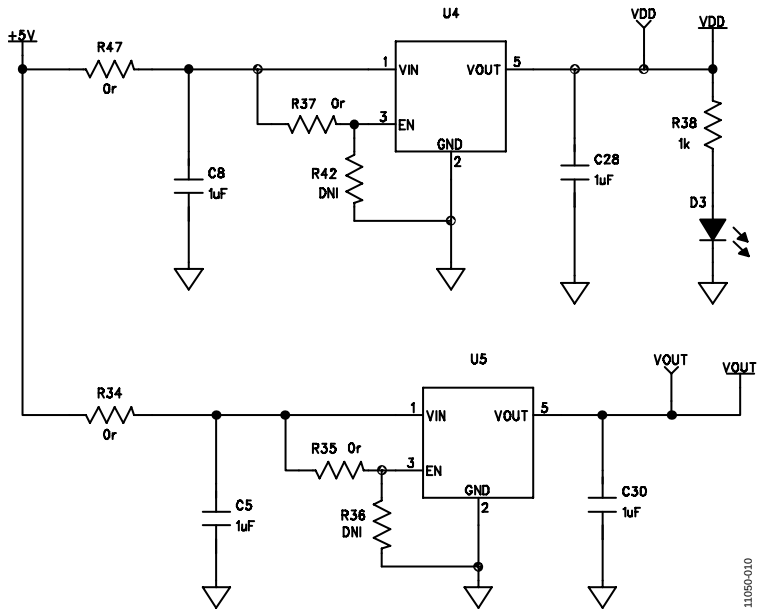

Figure 10. Evaluation Board Schematic (Page 2)

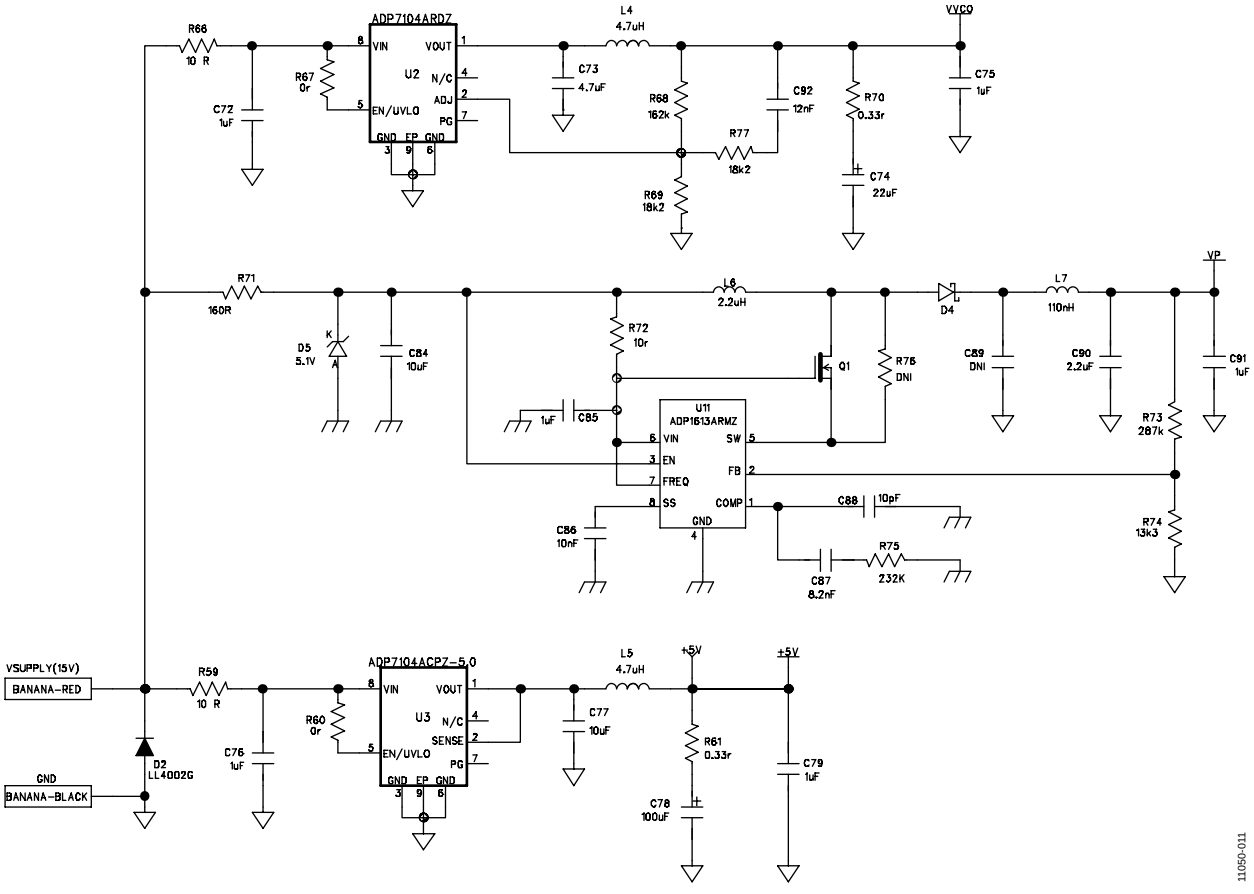

Figure 11. Evaluation Board Schematic (Page 3)

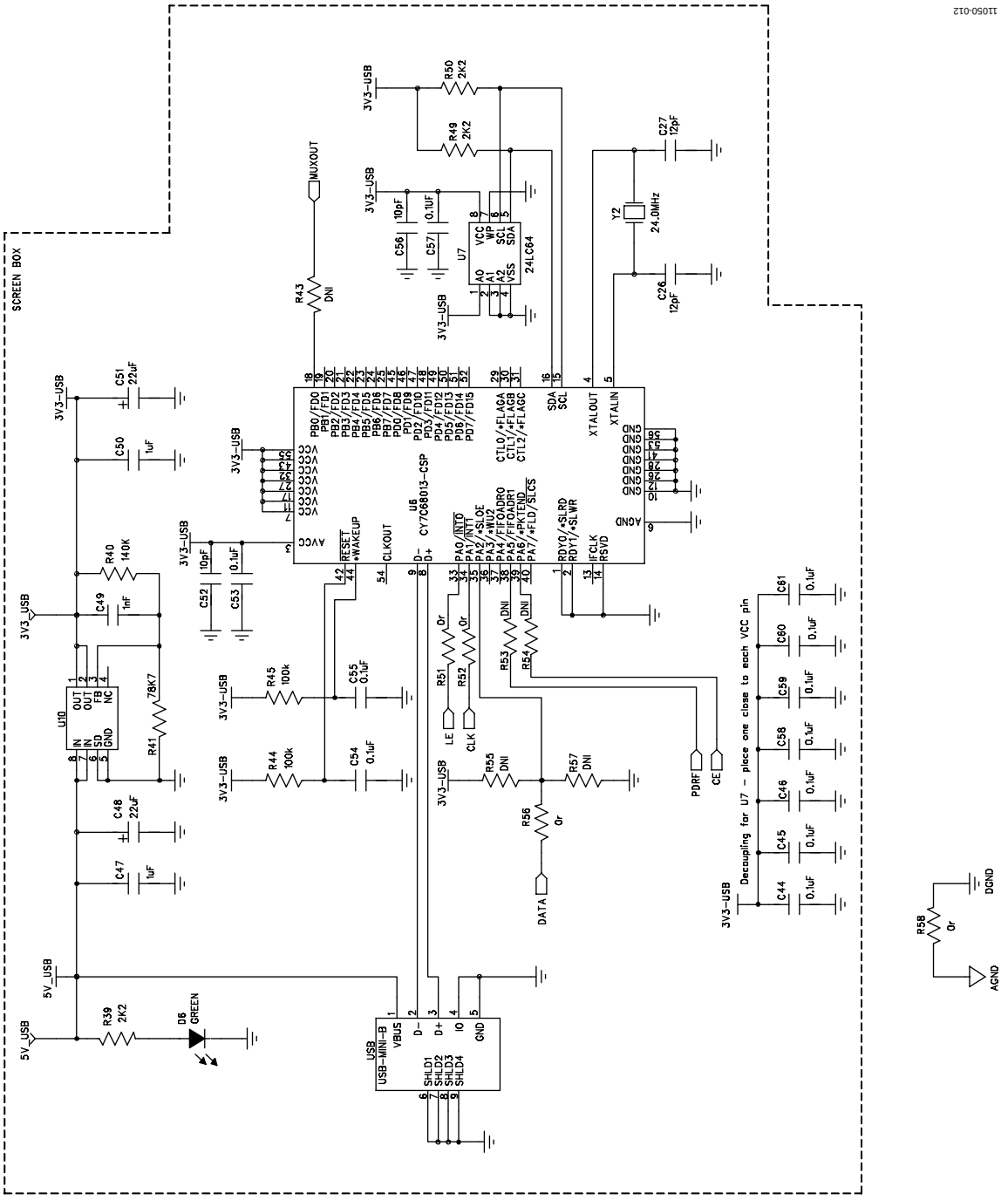

Figure 12. Evaluation Board Schematic (Page 4)

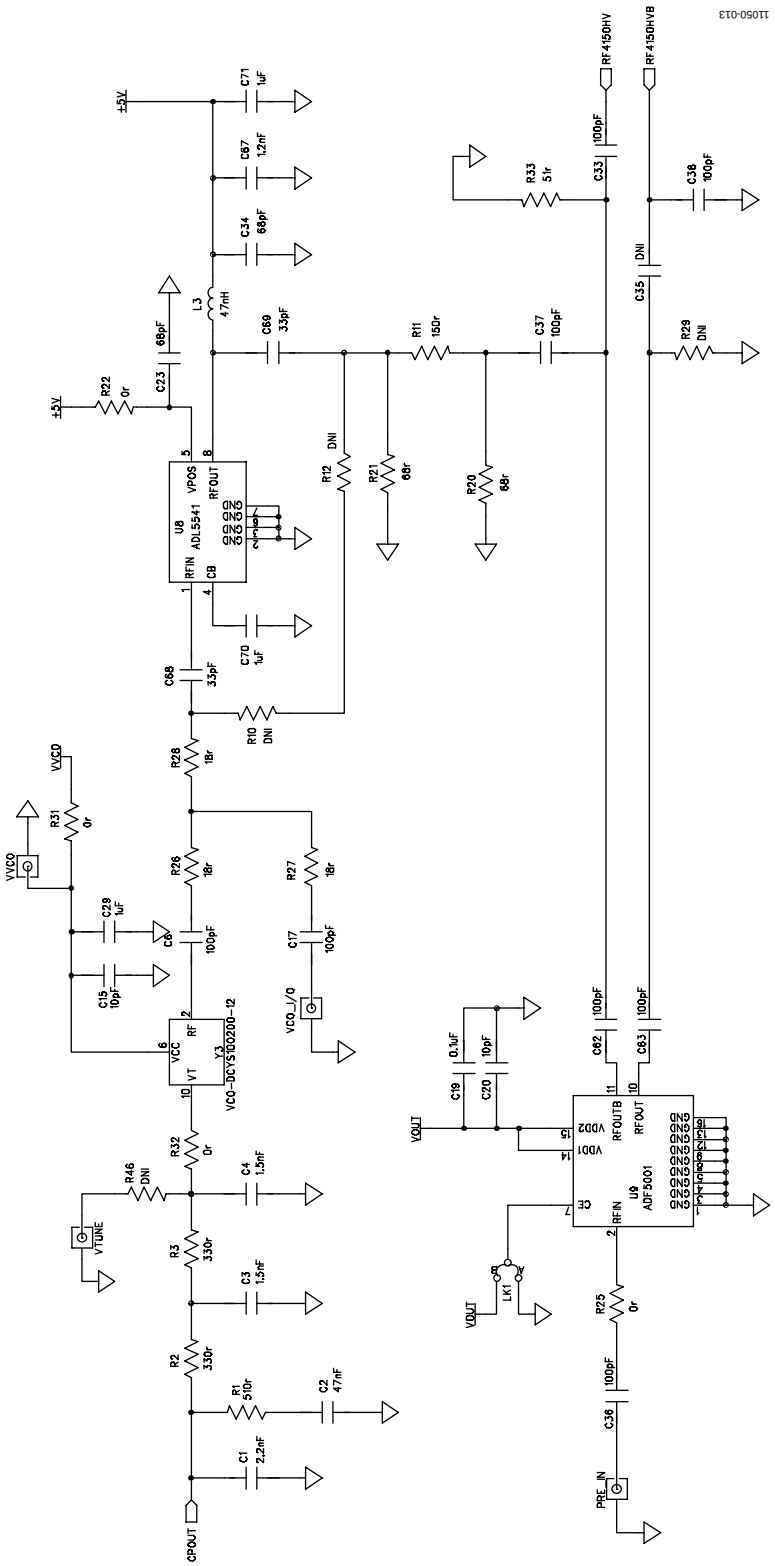

Figure 13. Evaluation Board Schematic (Page 5)

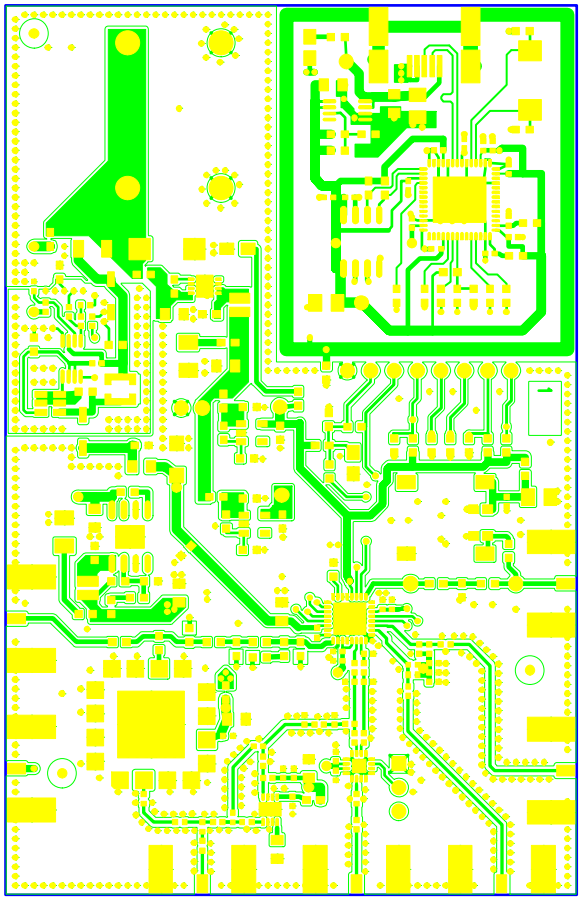

Figure 14. Layer 1 (Component Side)

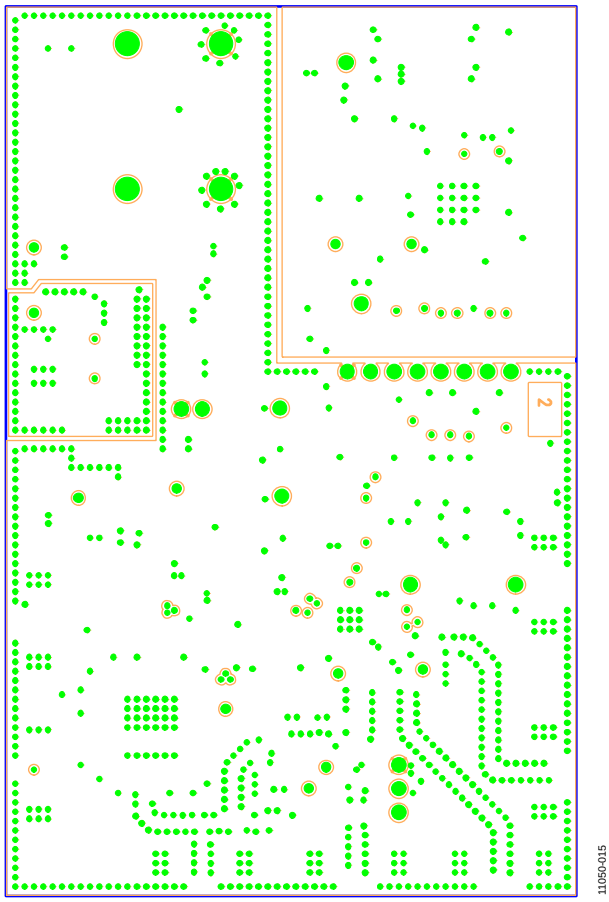

Figure 15. Layer 2 (Ground Plane)

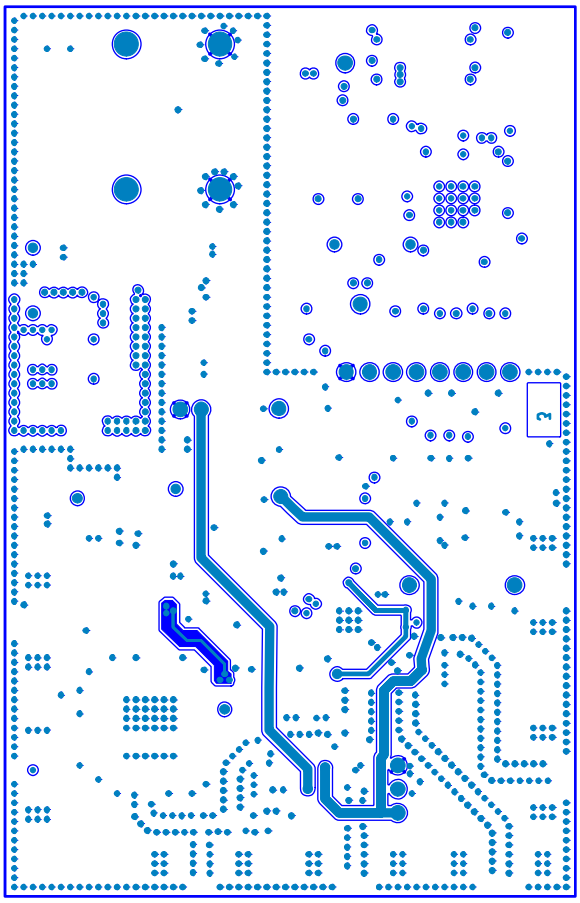

Figure 16. Layer 3 (Power Plane)

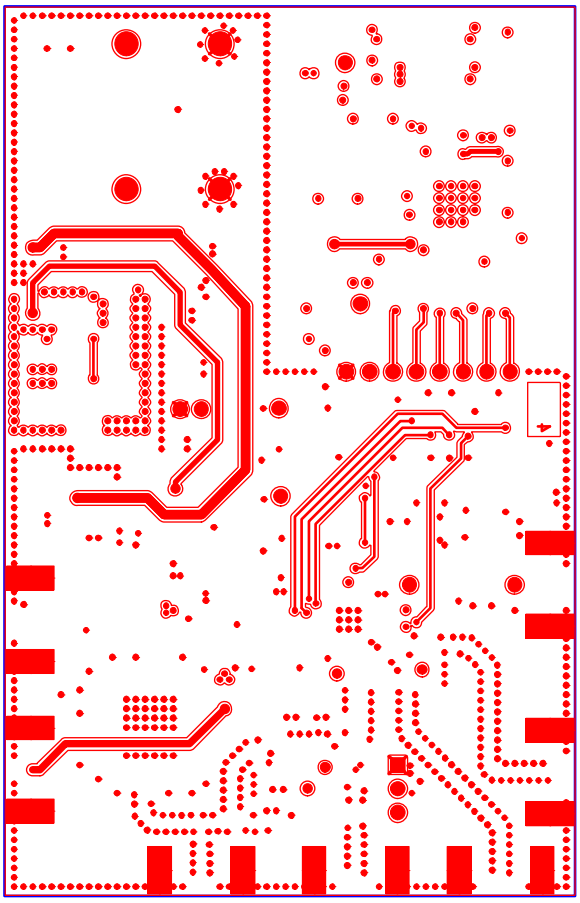

Figure 17. Layer 4 (Solder Side)

BILL OF MATERIALS

Table 1.

Reference Designator	Value	Description	Manufacturer/Part Number
+5 V		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, C85	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, C70, C71, C72, C75, C76, C79	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
C11, 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
C73	4.7 µF	Capacitor ceramic, 4.7 µF 16 V 10% X5R 0603	Tayo-Yuden EMK107ABJ475KA-T
C74	22 µF	Capacitor, Case B, 22 µF, 16 V	AVX TAJB226K016RNJ
C77, C84	10 µF	Capacitor, 0603, X5R, 10 V, 10 µF	Tayo-Yuden LMK107BJ106MALTD
C78	100 µF	Capacitor, Case B, 100 µF, 6.3 V	AVX TAJB107K006RNJ
C86	10 nF	Capacitor ceramic 10000 PF, 16 V, 10%, X7R, 0402	Murata GRM155R71C103KA01D
C87	8.2 nF	Capacitor, 0402, 8200 PF, 50 V, X7R	Kemet C0402C822K5RACTU
C88	10 pF	Capacitor ceramic, 50 V, 5%, COG, 0402	Murata GRM155R71C103KA01D
C89	Do not insert	0603 Capacitor location, not inserted	N/A
C90	2.2 µF	Capacitor, 1206, X7R, 50 V, 2.2 µF	Murata GRM31CR71H225KA88L
C91	1 µF	Capacitor ceramic, 1 µF, 50 V, X7R, 0603	Tayo-Yuden UMK107BJ105KA-T
C92	12 nF	Capacitor, MLCC, 0603, 50V, 12NF	AVX 06031C123JAT2A
CE, CLK	Do not insert	Red test point	N/A
D1, D6		Green LED	Avago Technologies, HSMG-C170
D2	LL4002G	Power rectifier diode	Multicomp LL4002G
D3		Red LED	Avago Technologies HSMS-C170
D4		Schottky diode, 30 V, 0.5 A, SOD123	Diodes Inc. B0530W-7-F

Reference Designator	Value	Description	Manufacturer/Part Number
D5		Zener Diode, 5.1 V, 500 mW, SOD123	Diodes, Inc. DDZ9689-7
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-27NXJLU
L3	47 nH	Coilcraft 0402CS SMD inductor	Coilcraft 0402CS-47NXJLU
L4, L5	4.7 µH	Coilcraft EPL2014 series shielded power inductor	Coilcraft EPL2014-472ML
L6	2.2 µH	Coilcraft EPL2014 series shielded power inductor	Coilcraft EPL2014-222ML
L7	110 nH	0805 inductor	Coilcraft 0805LS-111
LD, LE, MUXOUT, PDBRF	Do not insert	Red test point	N/A
LK1		3-pin SIL header and shorting link	Harwin M20-9990345 and M7567-05
PRE_IN		End-launch 50 Ω SMA jack	Emerson Network 142-0701-851
Q1		MOSFET,N CH,60 V,4.1 A,TSOP-6	Vishay SI3458BDV-T1-E3
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, R36, R42, R43 R46, R53, R54, R55, R57, R76, R102	Do not insert	0603 resistor location, not inserted	N/A
R7, R38	1 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1K
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
R9,R13, R22, R31, R32, R34, R35, R37,R47, R51, R52, R56, R58, R60, R67, 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, R33	51 Ω	0402 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
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
R61, R 70	0.33 Ω	SMD resistor	Panasonic, ERJ3BQFR33V
R68	162 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1% 162K
R69, R77	18.2 kΩ	SMD resistor	Multicomp MC 0.063W 0603 1% 18.2K
R71	160 Ω	1206 SMD resistor	Panasonic ERJP14F160OU
R59, R72, R66	10 Ω	0402 SMD resistor	Multicomp MC 0.0625W 0402 1% 10R
R73	287 kΩ	SMD resistor	Vishay Dale CRCW0402287KFKED
R74	13.3 kΩ	SMD resistor	Vishay Dale CRCW040213K3FKED
R75	232 kΩ	0402 SMD resistor	Vishay Dale CRCW0402232KFKED
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		Adjustable LDO regulator	Analog Devices ADP7104ARDZ
U3		LDO regulator	Analog Devices ADP7104ACPZ-5.0
U4, U5		3.3 V linear regulator	Analog Devices ADP150AUJZ-3.3
U6		USB microcontroller	Cypress Semiconductor CY7C68013A-56LFXC

Reference Designator	Value	Description	Manufacturer/Part Number
U7		64 k I^2C 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
U11		Step-up dc-to-dc switching converter	Analog Devices ADP1613ARMZ
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	Do not insert	TCXO	TX5080 IT3205CE 26MHZ
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	Description
ADF4150HV	Product Page, Fractional-N/Integer-N PLL Synthesizer
ADP150	Product Page, Ultralow Noise, 150 mA CMOS Linear Regulator
ADP7104	Product Page, Ultra Low Noise, 500 mA CMOS Linear Dropout Regulator
ADP3334	Product Page, High Accuracy Low I_Q, 500 mA anyCAP® Adjustable Low Dropout Regulator
ADP1613	Product Page, 1.3 MHz Step-Up PWM DC-to-DC Switching Converter with 2.0 A Current Limit
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

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.

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