

## Evaluation Board for the ADF4156 Fractional-N PLL Frequency Synthesizer

### FEATURES

Self-contained board including synthesizer, VCO, TCXO for reference frequency, and loop filter  
Designed for 10 MHz PFD frequency, minimum charge pump current, and a 20 kHz loop bandwidth  
Accompanying software allows complete control of synthesizer functions from PC

### EVALUATION KIT CONTENTS

**EV-ADF4156SD1Z** 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 **ADF4156** data sheet
- Electronic version of the UG-171 user guide

### ADDITIONAL EQUIPMENT

PC running Windows XP or more recent version  
SDP-S board (system demonstration platform, serial only)  
Spectrum analyzer  
Oscilloscope (optional)

### DOCUMENTS NEEDED

**ADF4156** data sheet

### REQUIRED SOFTWARE

Analog Devices ADF4153-4-6-7 PLL software (Version 4 or higher)  
**ADIsimPLL**

### GENERAL DESCRIPTION

This board is designed to allow the user to evaluate the performance of the **ADF4156** frequency synthesizer for phase-locked loops (PLLs). Figure 1 shows the board, which contains the **ADF4156** synthesizer, an SMA connector for the output signal, power supplies, a reference oscillator, and an SDP connector. There is also a loop filter (20 kHz) and a VCO (Z-Comm VCO940ME03 5.8GHz) on board. The evaluation board is set up for a 10 MHz PFD comparison frequency. An on-board TCXO provides the 10 MHz reference frequency.

The package also contains Windows® software (XP or later) to allow easy programming of the synthesizer.

### EVALUATION BOARD

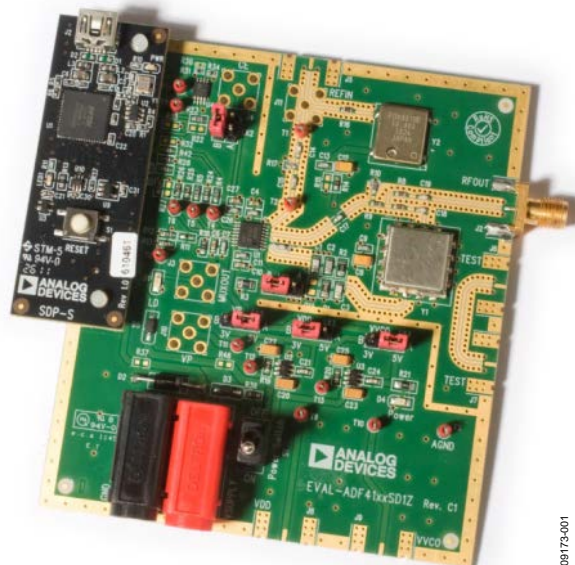


Figure 1. EV-ADF4156SD1Z with SDP-S

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## REVISION HISTORY

### 2/12—Rev. A to Rev. B

Changes to Title, Features Section, and General Description Section.....	1
Replaced Figure 1 .....	1
Added Evaluation Kit Contents, Additional Equipment, Documents Needed, and Required Software Sections .....	1
Added Quick Start Guide Section .....	3
Deleted Figure 2; Renumbered Sequentially.....	3
Deleted Local Oscillator Components Section.....	3
Deleted Test Setup Section and Figure 4 .....	4
Changes to Evaluation Board Hardware Section .....	4
Changes to Power Supplies Section and Figure 2.....	4
Added Input Signals Section and Output Signals Section .....	4
Deleted Software Installation and Setup Section and Software Operation Section.....	5
Added Default Operation and Jumper Selection Settings Section and System Demonstration Platform (SDP) Section.....	5
Added Table 1; Renumbered Sequentially .....	5
Added Evaluation Board Setup Procedure Section.....	6
Added Figure 3 and Figure 4; Renumbered Sequentially .....	6
Added Figure 5 to Figure 8.....	7

Added Figure 9 to Figure 12 .....	8
Added Figure 13 to Figure 16 .....	9
Changes to Evaluation Board Software Section .....	10
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Added Evaluation and Test Section, Figure 19, and Figure 20 .....	12
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Added Figure 25 .....	17
Added Figure 26 .....	18
Added Figure 27 .....	19
Changes to Table 2.....	20

### 6/11—Rev. 0 to Rev. A

Document Title, Format, and Content Changed from EVAL-ADF4156, Revision 0, to UG-171, Rev. A .....	Universal
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### 5/07—Revision 0: Initial Version

## QUICK START GUIDE

Follow these steps to quickly evaluate the [ADF4156](#) device:

1. Install the system development platform (SDP) drivers.
2. Install the Analog Devices ADF4153-4-6-7 software.
3. Connect the SDP-S motherboard to the PC and to the [EV-ADF4156SD1Z](#).
4. Follow the hardware driver installation procedure.
5. Connect the power supplies to banana connectors (6 V to 12 V).
6. Run the ADF4153-4-6-7 software.
7. Select the SDP board and the [ADF4156](#) device in the **Select Device and Connection** tab of the software front panel window.
8. Click the **Main Controls** tab. Update all registers.
9. Connect the spectrum analyzer to J2.
10. Measure the results.

## EVALUATION BOARD HARDWARE

The evaluation board requires the use of an SDP-S motherboard to program the device. This is not included and must be purchased separately. The [EV-ADF4156SD1Z](#) schematics are shown in Figure 21 to Figure 23.

### POWER SUPPLIES

The board is powered from external banana connectors. The voltage can vary between 6 V and 12 V. The power supply circuit provides 3.0 V to  $V_{DD}$  on the board (which supplies the [ADF4156](#)  $AV_{DD}$  and  $DV_{DD}$  pins) and allows the user to choose either 3.0 V or 5 V for the [ADF4156](#)  $V_P$ . The default settings are 3.0 V for the [ADF4156](#)  $V_{DD}$  and 5 V for the [ADF4156](#)  $V_P$ . Note that  $V_{DD}$  should never exceed 3.3 V. This can damage the device.

External power supplies can be used to directly drive the device. In this case, the user must insert SMA connectors as shown in Figure 2.

### INPUT SIGNALS

The necessary reference input comes from the on-board TCXO.

Alternatively, this can be sourced from an external generator. A low noise, high slew rate reference source is best for achieving the stated performance of the [ADF4156](#). This can be connected to Connector J11. If preferred, the edge mount connector, J5, can be inserted and used instead. To use this option, it is necessary to remove R16 and insert a 51  $\Omega$  resistor in R17.

Digital SPI signals are supplied through the SDP connector, J1. SDP-S is the preferred platform to be used. The SDP-B can also be used but Resistor R57 must be removed on the SDP-B board. Some additional low frequency spurious may appear if the SDP-B connector is used.

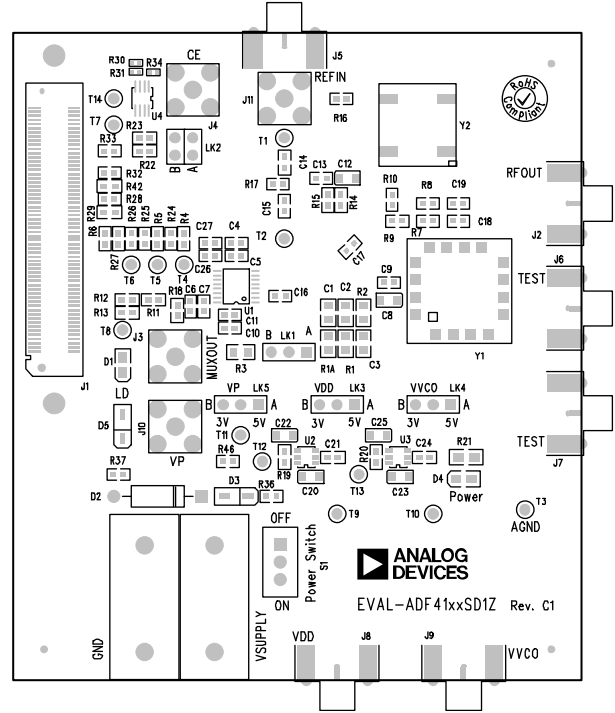


Figure 2. Evaluation Board Silkscreen

### OUTPUT SIGNALS

All components necessary for LO generation are on board. The PLL is made up of the [ADF4156](#) synthesizer, a passive loop filter, and the VCO. A 5.8 GHz VCO from Z-Comm is supplied with the evaluation board. A 20 kHz low-pass filter is inserted between the charge pump output and the VCO input. The 0.31 mA charge pump current setting is used. The VCO output is available at RFOUT through a standard SMA connector, J2. The MUXOUT signal can be monitored at Test Point T8 or at SMA Connector J3.

## DEFAULT OPERATION AND JUMPER SELECTION SETTINGS

Links positions are outlined in Table 1.

**Table 1. Link Positions and Functions**

Link	Position	Options	Description
LK1	A	R1A	Not used
	B	RSET	Normal operation
LK2	A	GND	Hardware power-down
	B	VDD	Normal operation
LK3 (V <sub>DD</sub> )	A	5 V	Not used
	B	3 V	Normal operation
LK4 (V <sub>VCO</sub> )	A	5 V	VCO supply (5 V)
	B	3 V	VCO supply (3 V)
LK5 (V <sub>P</sub> )	A	5 V	V <sub>P</sub> supply (5 V)
	B	3 V	V <sub>P</sub> supply (3 V)

## SOFTWARE DEVELOPMENT PLATFORM (SDP)

The system demonstration platform (SDP) is a series of controller boards, interposer boards, and daughter boards that can be used for easy low cost evaluation of Analog Devices, Inc., components and reference circuits. It is a reusable platform whereby a single controller board can be reused in various daughter board evaluation systems.

Controller boards connect to the PC via USB 2.0 and provide a range of communication interfaces on a 120-pin connector. The pinout for this connector is strictly defined. This 120-pin connector's receptacle is on all SDP daughter boards, component evaluation boards, and Circuits from the Lab™ reference circuit boards. There are two controller boards in the platform: the SDP-B, which is based on the Blackfin® [ADSP-BF527](#), and the SDP-S, which is a serial interface only controller board. The SDP-S has a subset of the SDP-B functionality.

Interposer boards route signals between the SDP 120-pin connector and a second connector. When the second connector is also a 120-pin connector, the interposer can be used for signal monitoring of the 120-pin connector signals. Alternatively, the second connector allows SDP platform elements to be integrated into a second platform, for example, the BeMicro SDK. More information on the SDP can be found at [www.analog.com/sdp](http://www.analog.com/sdp).

## EVALUATION BOARD SETUP PROCEDURE

### SOFTWARE INSTALLATION

Use the following steps to install the SDP drivers and ADF4153-4-6-7 software.

1. Install the SDP drivers by double-clicking **SDPDrivers.exe** and following the relevant installation instructions. See the [UG-291](#) for further instructions on installation of the SDP-S platform or the [UG-277](#) if the SDP-B platform is used.
2. Install the Analog Devices ADF4153-4-6-7 PLL software by double-clicking **ADF4153-4-6-7\_Setup.msi**.

If you are using Windows XP, follow the instructions in the Windows XP Software Installation Guide section (see Figure 3 to Figure 7).

If you are using Windows Vista or Windows 7, follow the instructions in the Windows Vista/7 Software Installation Guide section (see Figure 8 to Figure 12).

Note that the software requires Microsoft Windows Installer and Microsoft .NET Framework 3.5 (or higher). The installer connects to the Internet and downloads Microsoft .NET Framework automatically. Alternatively, before running **ADF4153-4-6-7\_Setup.msi**, both the installer and .NET Framework can be installed from the CD provided.

3. Connect your SDP board (black) or USB adapter board (green) by USB. If you are using an SDP board, the drivers install automatically, and you are ready to run the software. If you are using a USB adapter board on Windows XP, follow the steps in the Windows XP Driver Installation Guide section (see Figure 13 to Figure 16). On Windows Vista or Windows 7, the drivers install automatically.

#### Windows XP Software Installation Guide

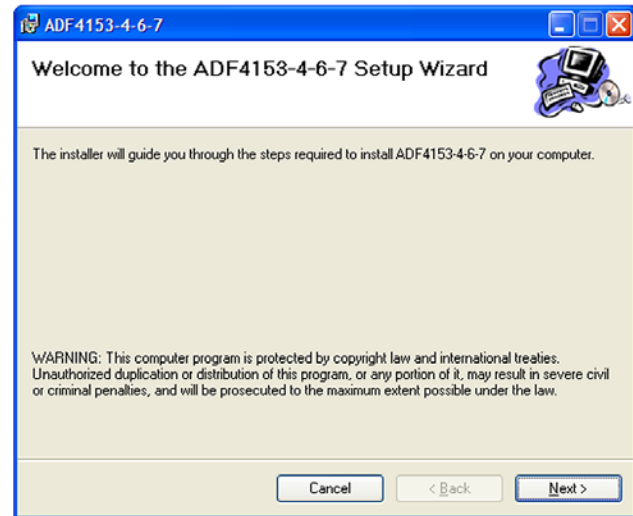


Figure 3. Windows XP ADF4153-4-6-7 Software Installation, Setup Wizard

1. Click **Next**.

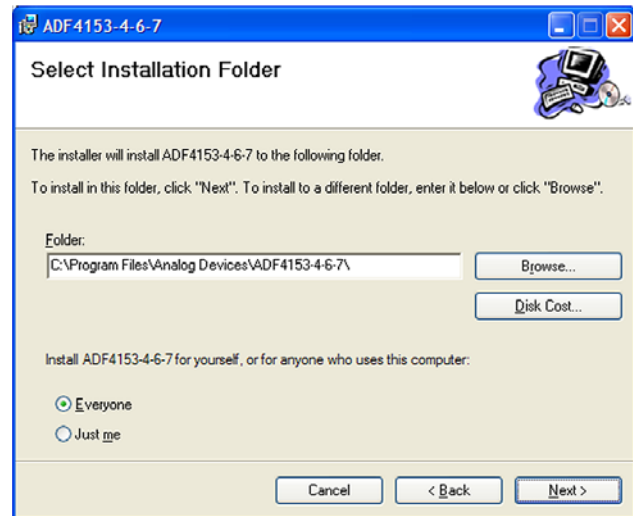


Figure 4. Windows XP ADF4153-4-6-7 Software Installation, Select Installation Folder

2. Choose an installation directory and click **Next**.

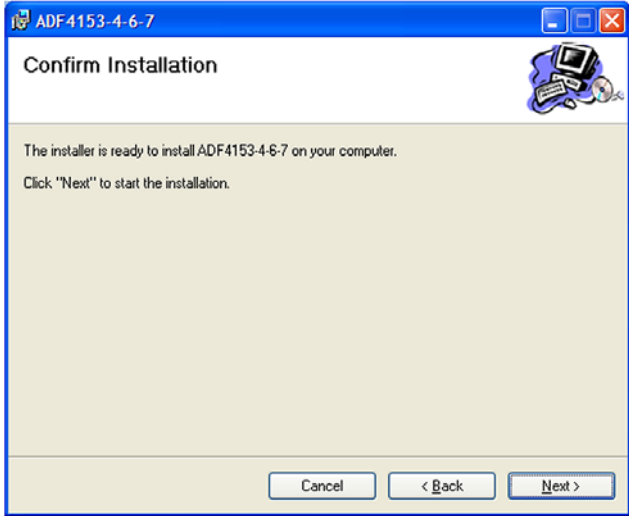


Figure 5. Windows XP ADF4153-4-6-7 Software Installation, Confirm Installation

3. Click **Next**.

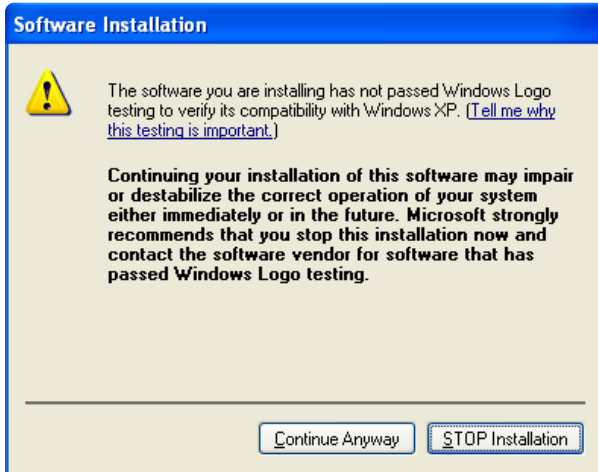


Figure 6. Windows XP ADF4153-4-6-7 Software Installation, Logo Testing

4. Click **Continue Anyway**.

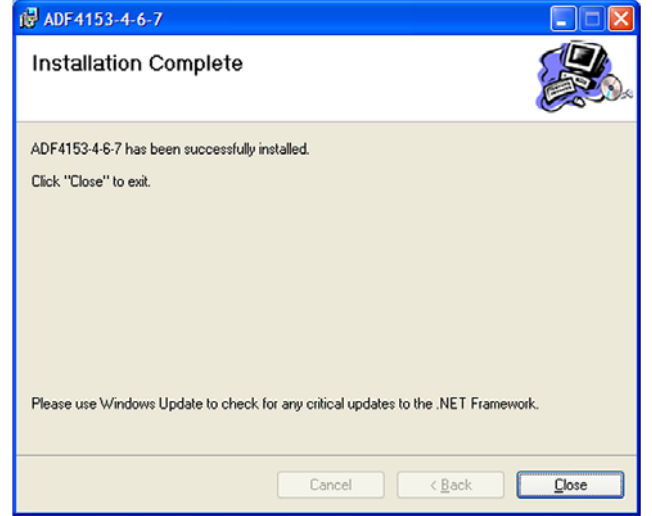


Figure 7. Windows XP ADF4153-4-6-7 Software Installation, Installation Complete

5. Click **Close**.

### Windows Vista/7 Software Installation Guide

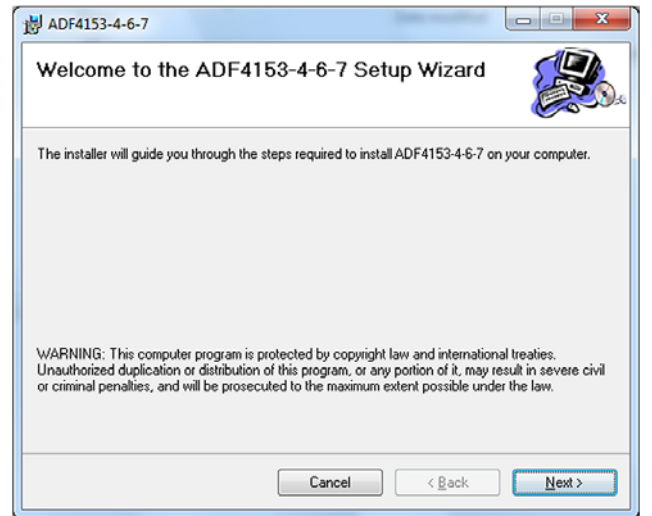


Figure 8. Windows Vista/7 ADF4153-4-6-7 Software Installation, Setup Wizard

1. Click **Next**.

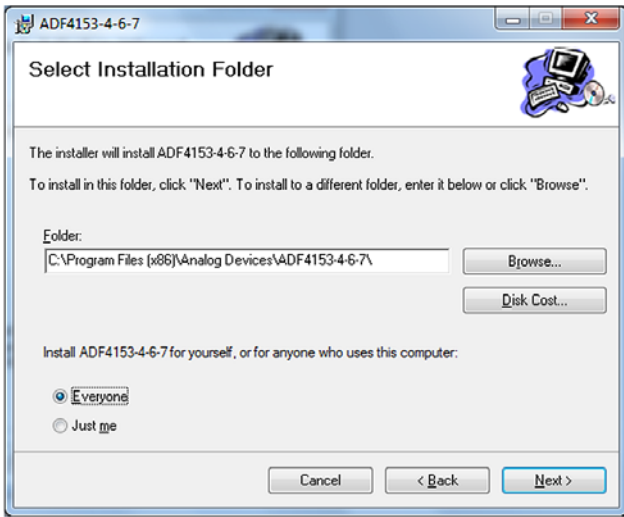


Figure 9. Windows Vista/7 ADF4153-4-6-7 Software Installation, Select Installation Folder

2. Choose an installation directory and click **Next**.

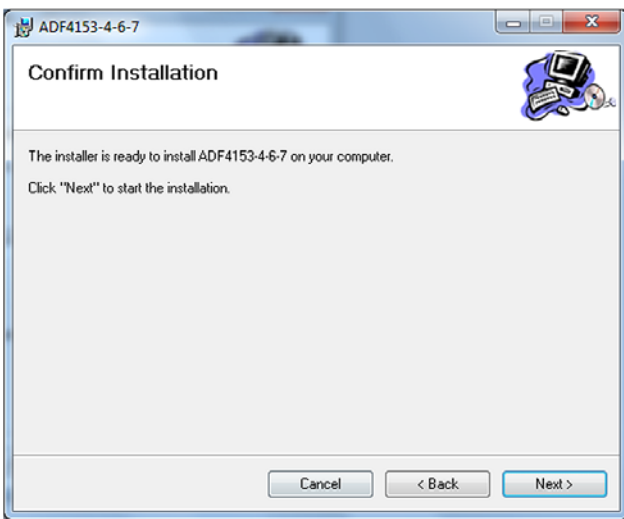


Figure 10. Windows Vista/7 ADF4153-4-6-7 Software Installation, Confirm Installation

3. Click **Next**.



Figure 11. Windows Vista/7 ADF4153-4-6-7 Software Installation, Start Installation

4. Click **Install**.

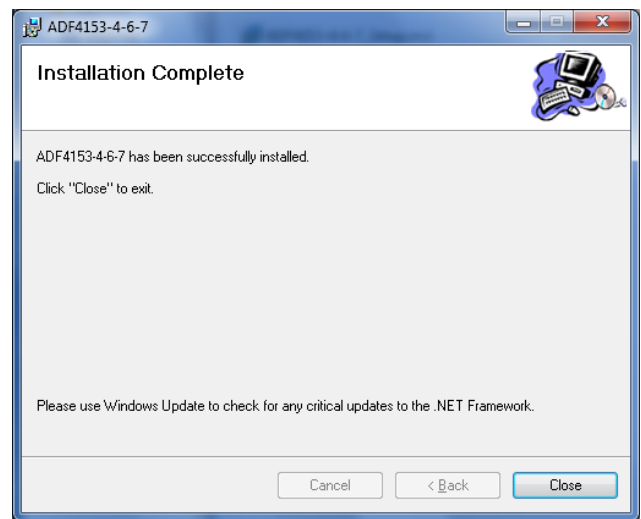


Figure 12. Windows Vista/7 ADF4153-4-6-7 Software Installation, Installation Complete

5. Click **Close**.



**Windows XP Driver Installation Guide**

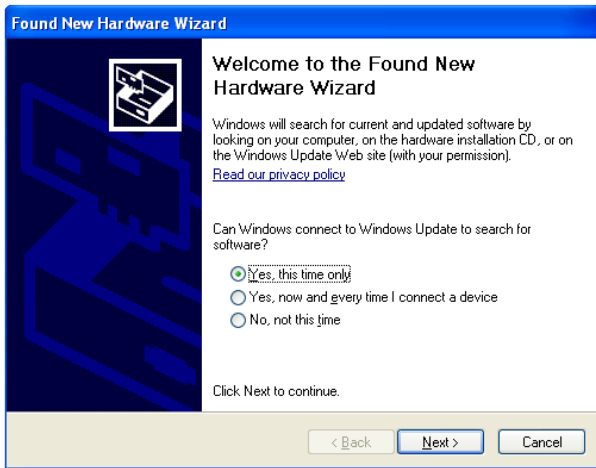


Figure 13. Windows XP USB Adapter Board Driver Installation, Found New Hardware Wizard

1. Choose **Yes, this time only**, and click **Next**.

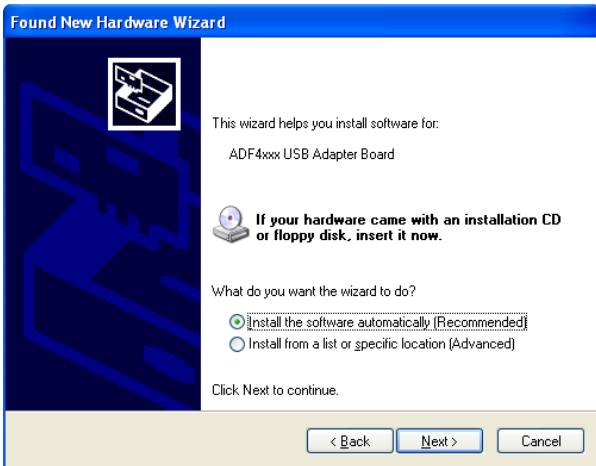


Figure 14. Windows XP USB Adapter Board Driver Installation, Installation Options

2. Click **Next**.

Note that Figure 14 may list **Analog Devices RFG.L Eval Board** instead of **ADF4xxx USB Adapter Board**.

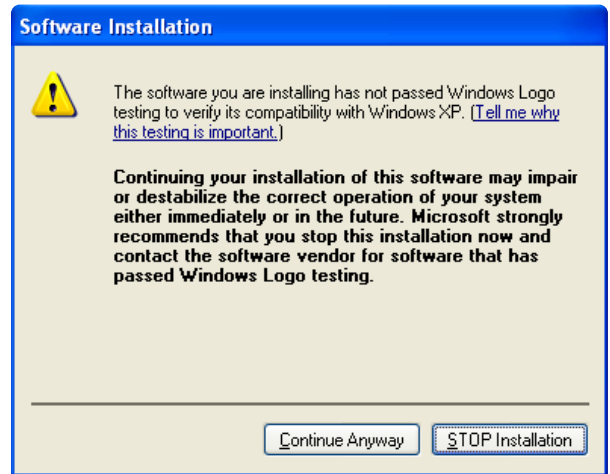


Figure 15. Windows XP USB Adapter Board Driver Installation, Logo Testing

3. Click **Continue Anyway**.

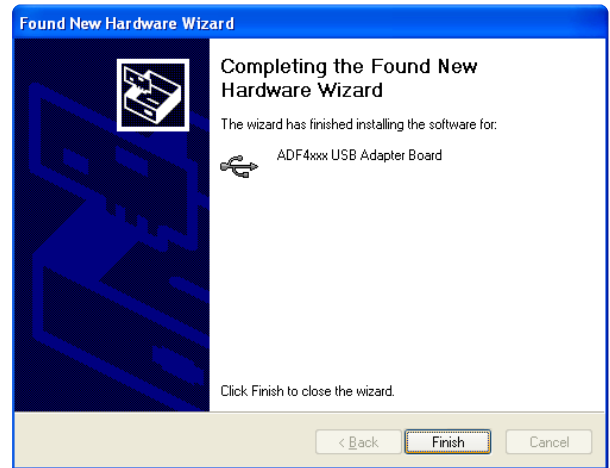


Figure 16. Windows XP USB Adapter Board Driver Installation, Complete Installation

4. Click **Finish**.

## EVALUATION BOARD SOFTWARE

The control software for the EV-ADF4156SD1Z accompanies the [EV-ADF4156SD1Z](#) on a CD. To install the software, see the Software Installation section.

To run the software, click the **ADI ADF4153-4-6-7** file on the desktop or in the **Start** menu.

On the **Select Device and Connection** tab, choose your device, your connection method, and click **Connect**.

Confirm that **SDP board connected**, **ADF4xxx USB Adapter Board connected**, or **Analog Devices RFG.L Eval Board connected** is displayed at the bottom left of the window. 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.

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

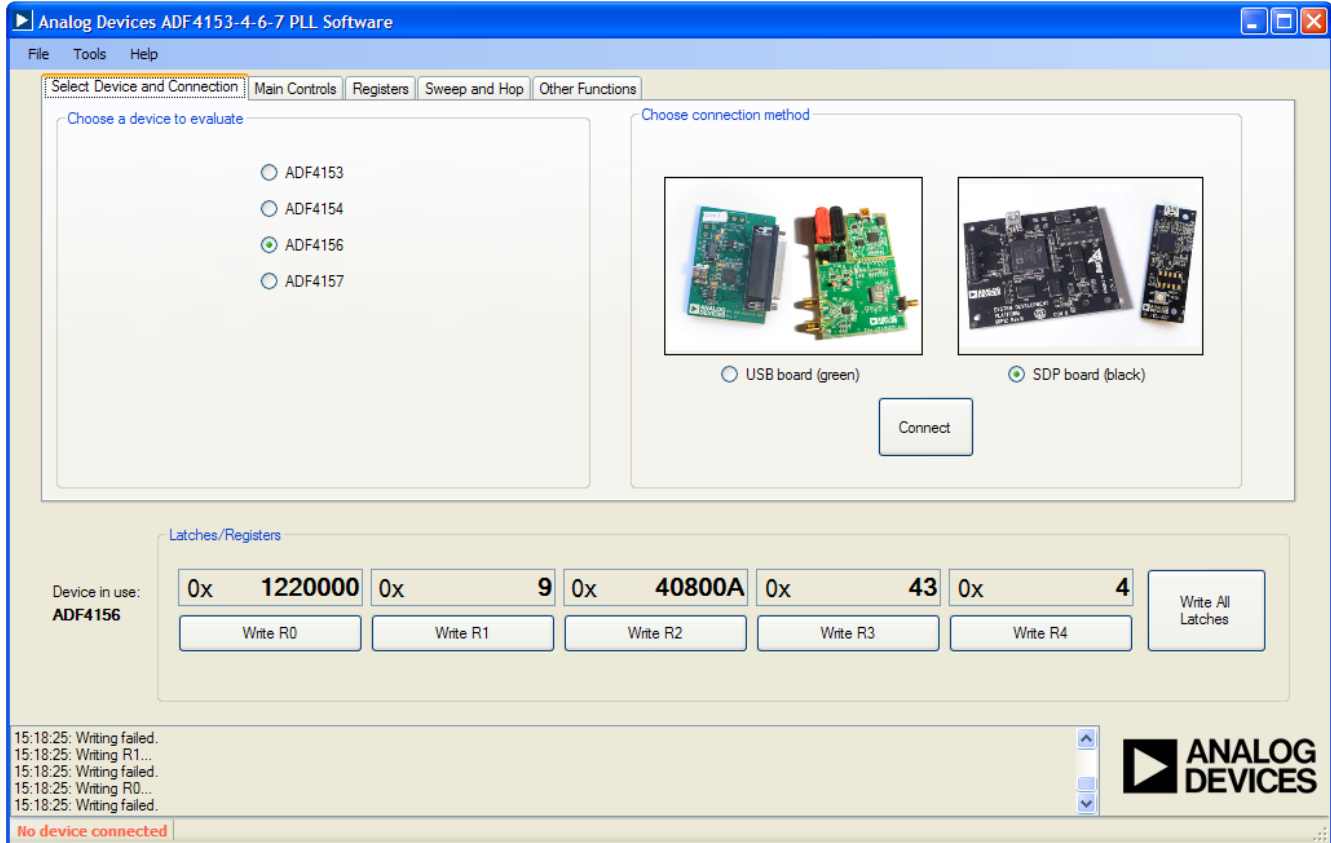


Figure 17. Software Front Panel Display—Select Device and Connection

The **Main Controls** tab controls the PLL settings (see Figure 18).

Use the **Reference Frequency** text box to set the correct reference frequency and the reference frequency divider. The default reference on the software window is at 10 MHz.

Use the **RF Settings** section to control the output frequency. You can type the desired output frequency in the **RF VCO Output 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.

In the **Latches/Registers** section at the bottom of the window, the values to be written to each register are displayed. 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 4) to write that value to the device.

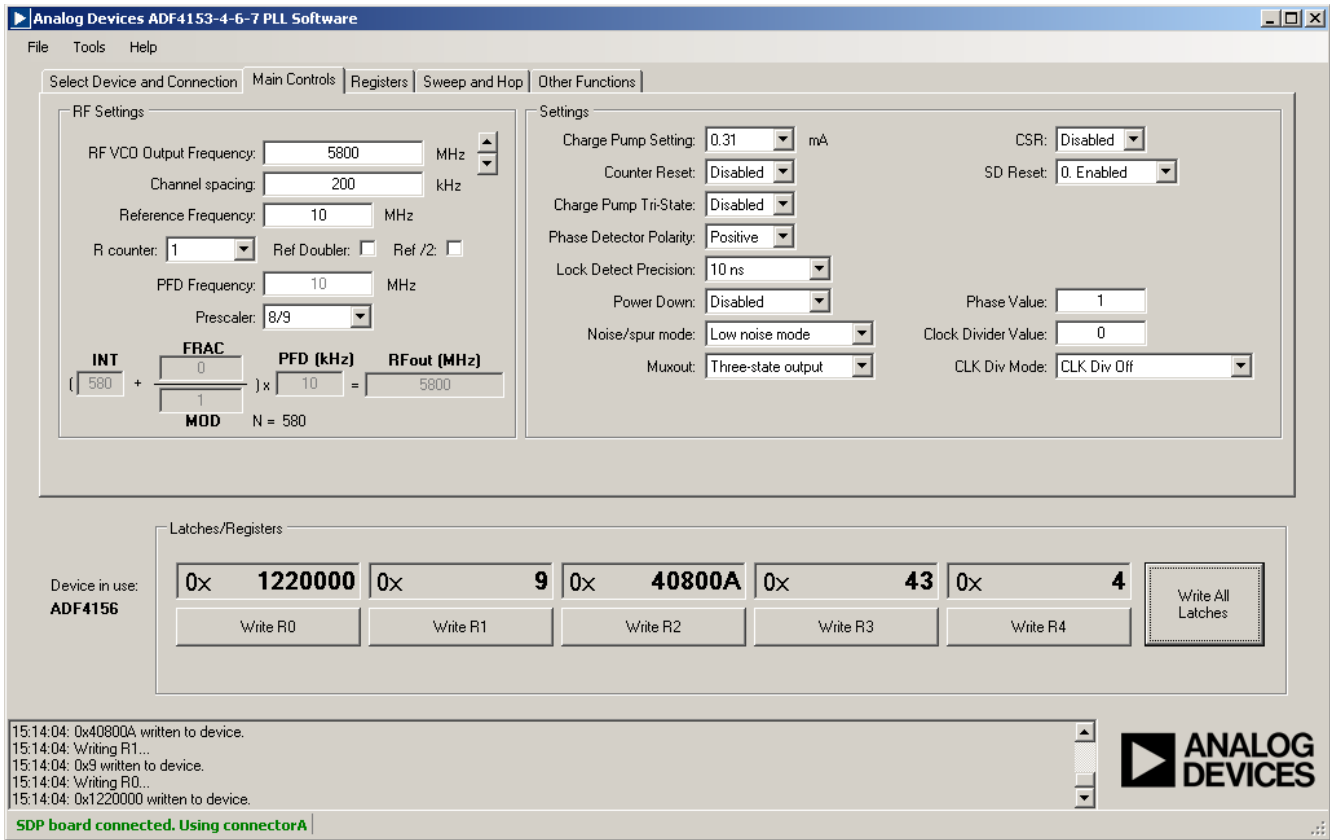


Figure 18. Software Front Panel Display—Main Controls

## EVALUATION AND TEST

To evaluate and test the performance of the [ADF4156](#), use the following procedure:

1. Install SDP-S software drivers and ADF4153-4-6-7 software. Connect the evaluation board to a PC using the supplied USB cable. Follow the hardware driver installation procedure that appears.
2. Connect SDP-S connector to [EV-ADF4156SD1Z](#).
3. Connect spectrum analyzer to Connector J2.
4. Run the ADF4153-4-6-7 software.
5. Select the SDP board and the [ADF4156](#) device in the **Select Device and Connection** tab of the software front panel window.
6. In the software window, set the VCO center frequency (the example in Figure 19 uses 5800 MHz). Set the PFD frequency to 10 MHz, and program the reference frequency to equal 10 MHz. The charge pump current should equal 0.31 mA. See Figure 20 for the suggested setup.
7. Measure the output spectrum. Figure 19 shows a 5800 MHz output.

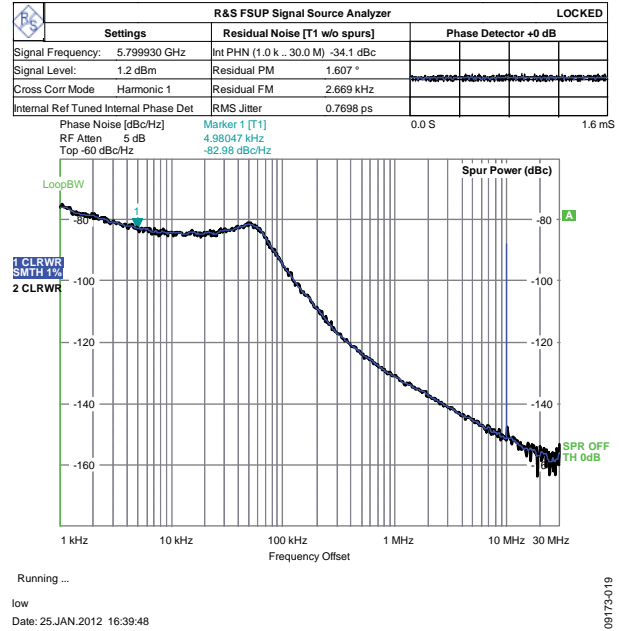


Figure 19. Spectrum Analyzer Display

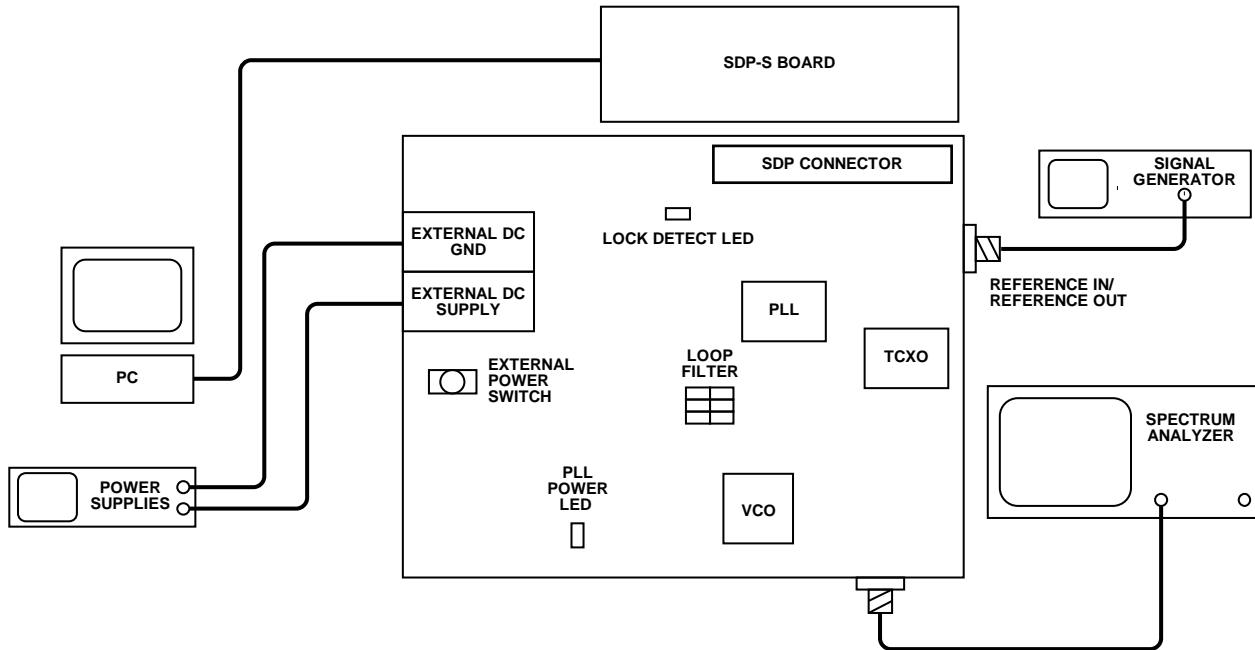
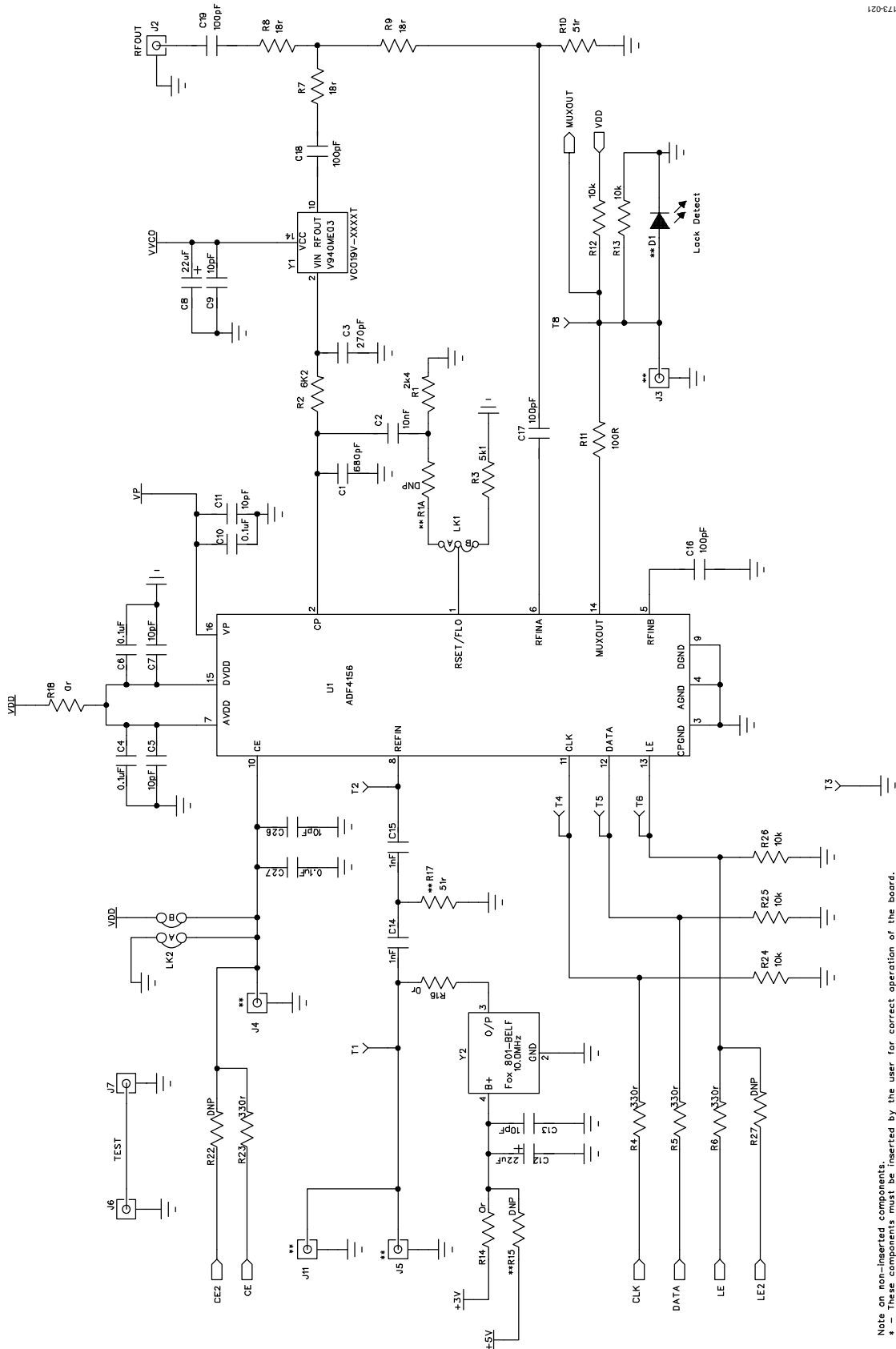


Figure 20. Typical Evaluation Setup

EVALUATION BOARD SCHEMATICS AND ARTWORK



09173-021

Figure 21. Evaluation Board Schematic (Page 1)  
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Note on non-inserted components.  
 \* - These components must be inserted by the user for correct operation of the board.  
 \*\* - These components can be inserted by the user for expansion purposes.

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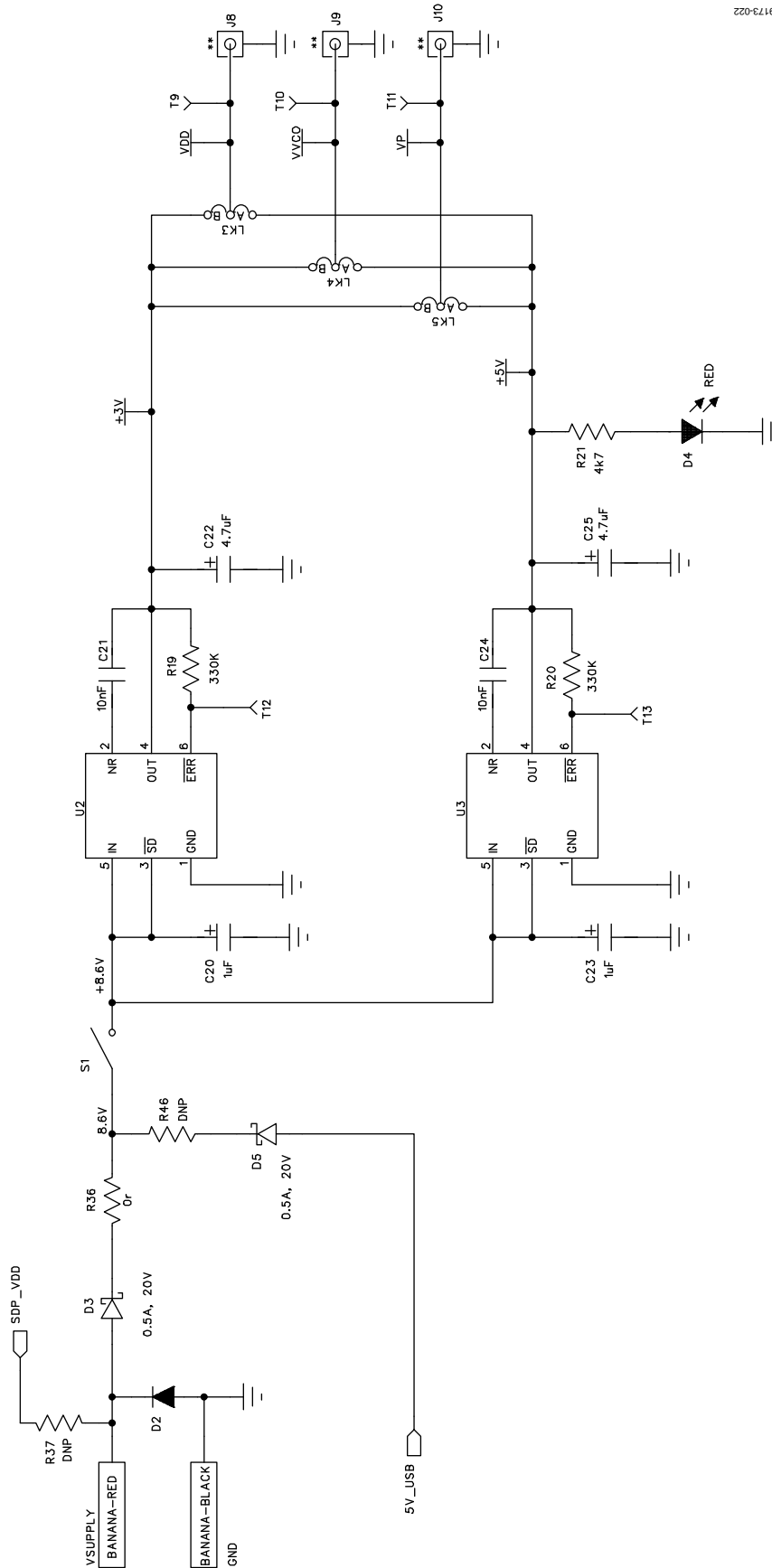


Figure 22. Evaluation Board Schematic (Page 2)

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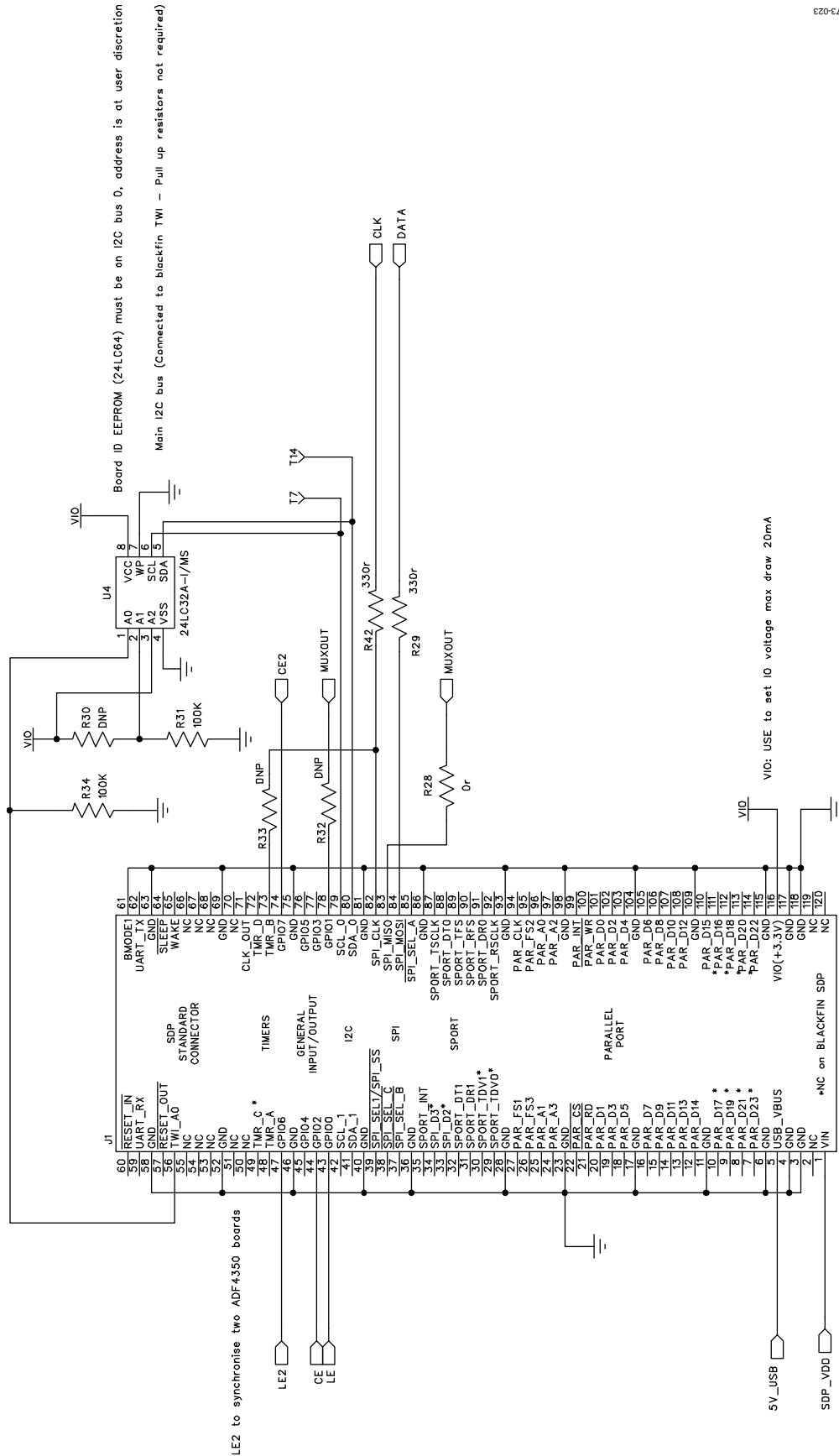
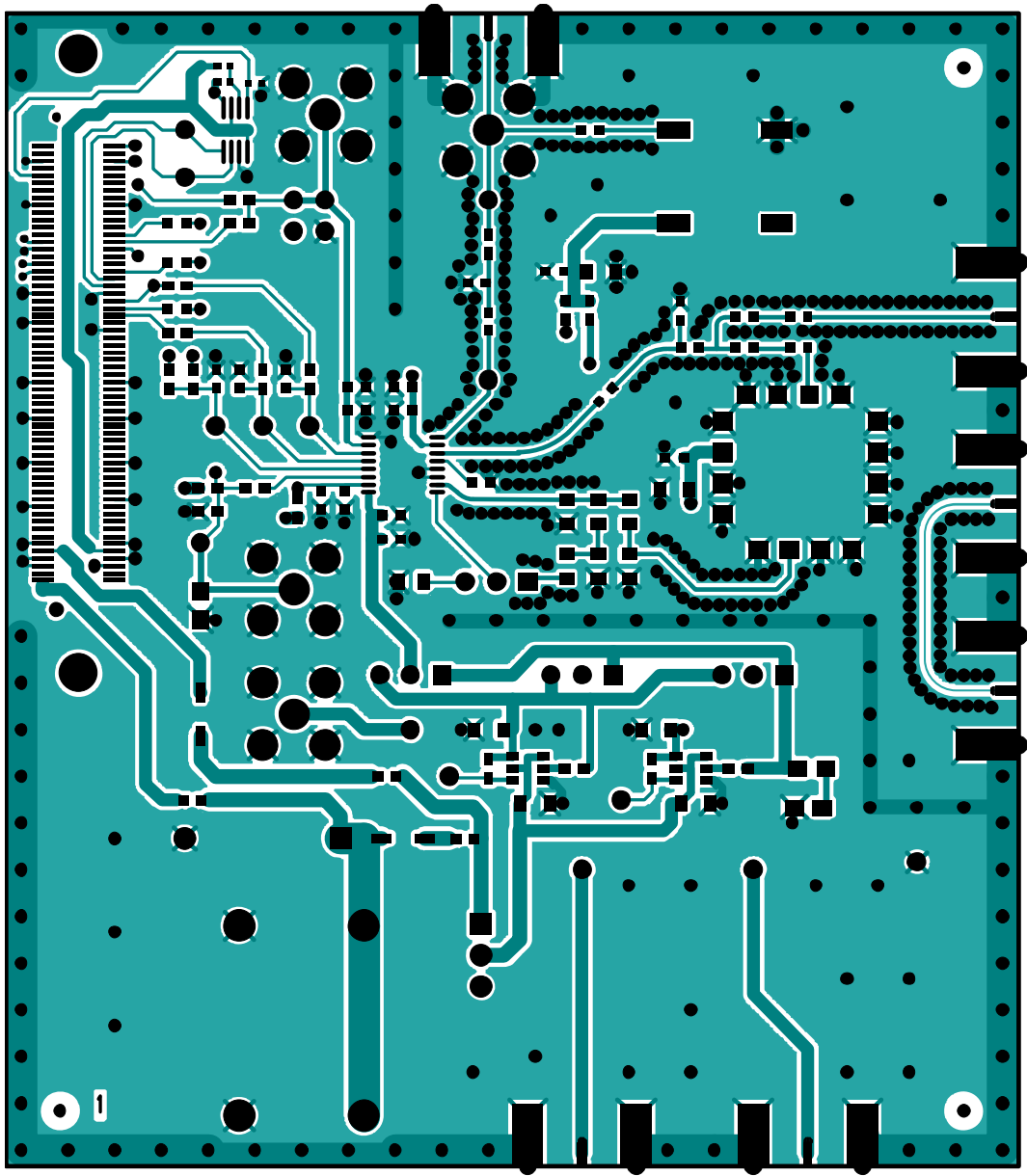


Figure 23. Evaluation Board Schematic (Page 3)



09179-024

Figure 24. Top Side



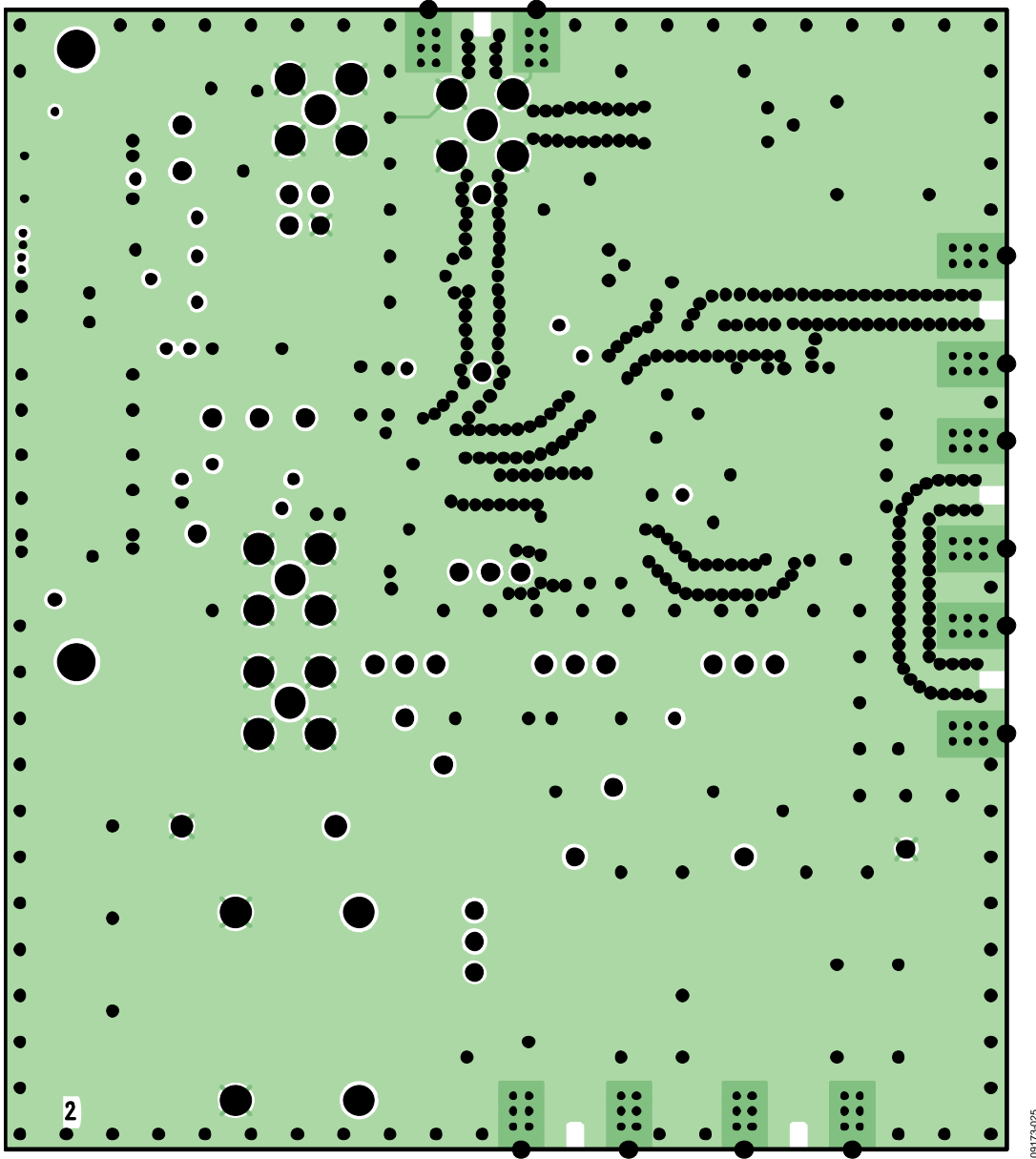
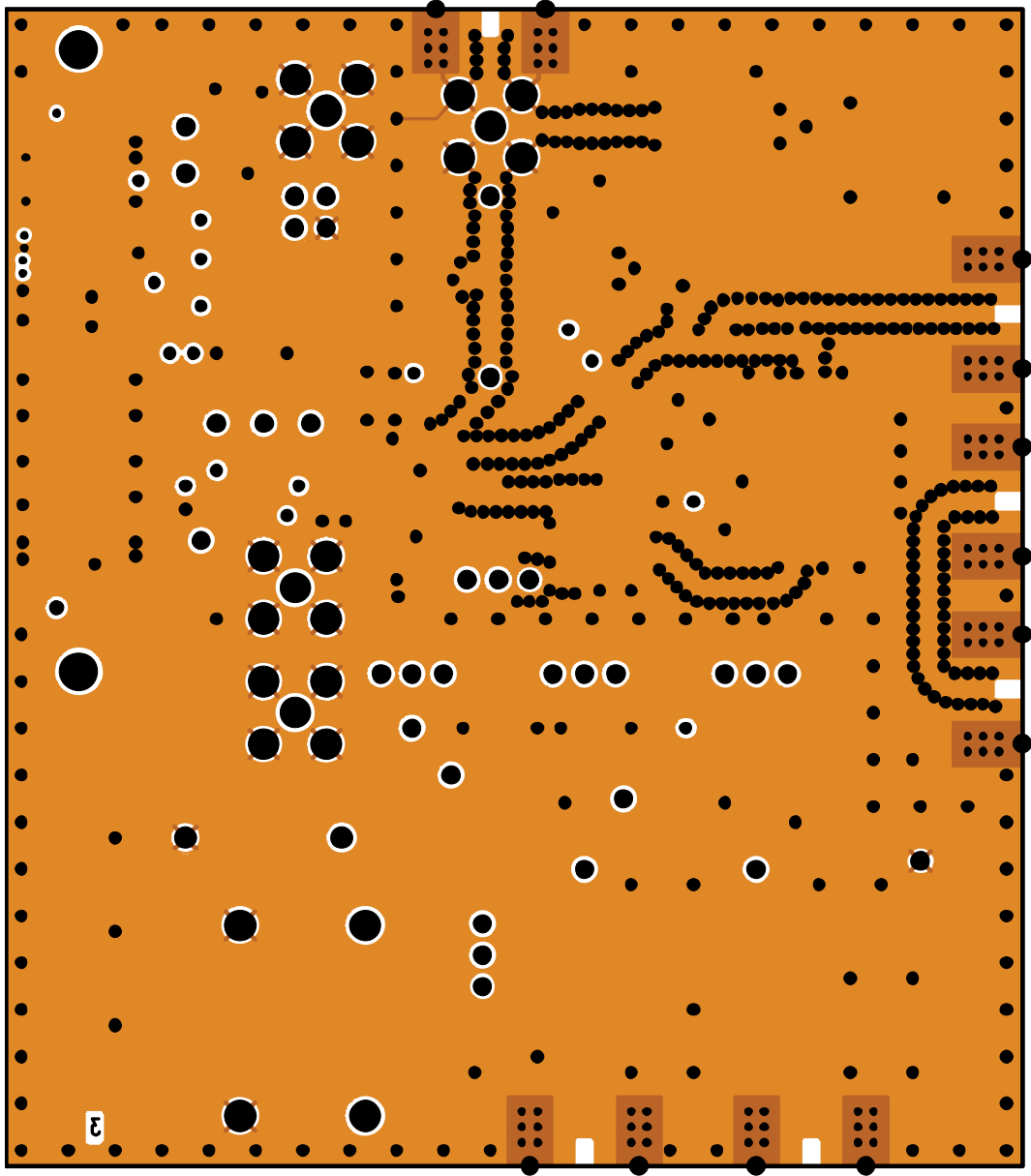


Figure 25. Layer 2 (GND Plane)



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Figure 26. Layer 3 (Power Plane)

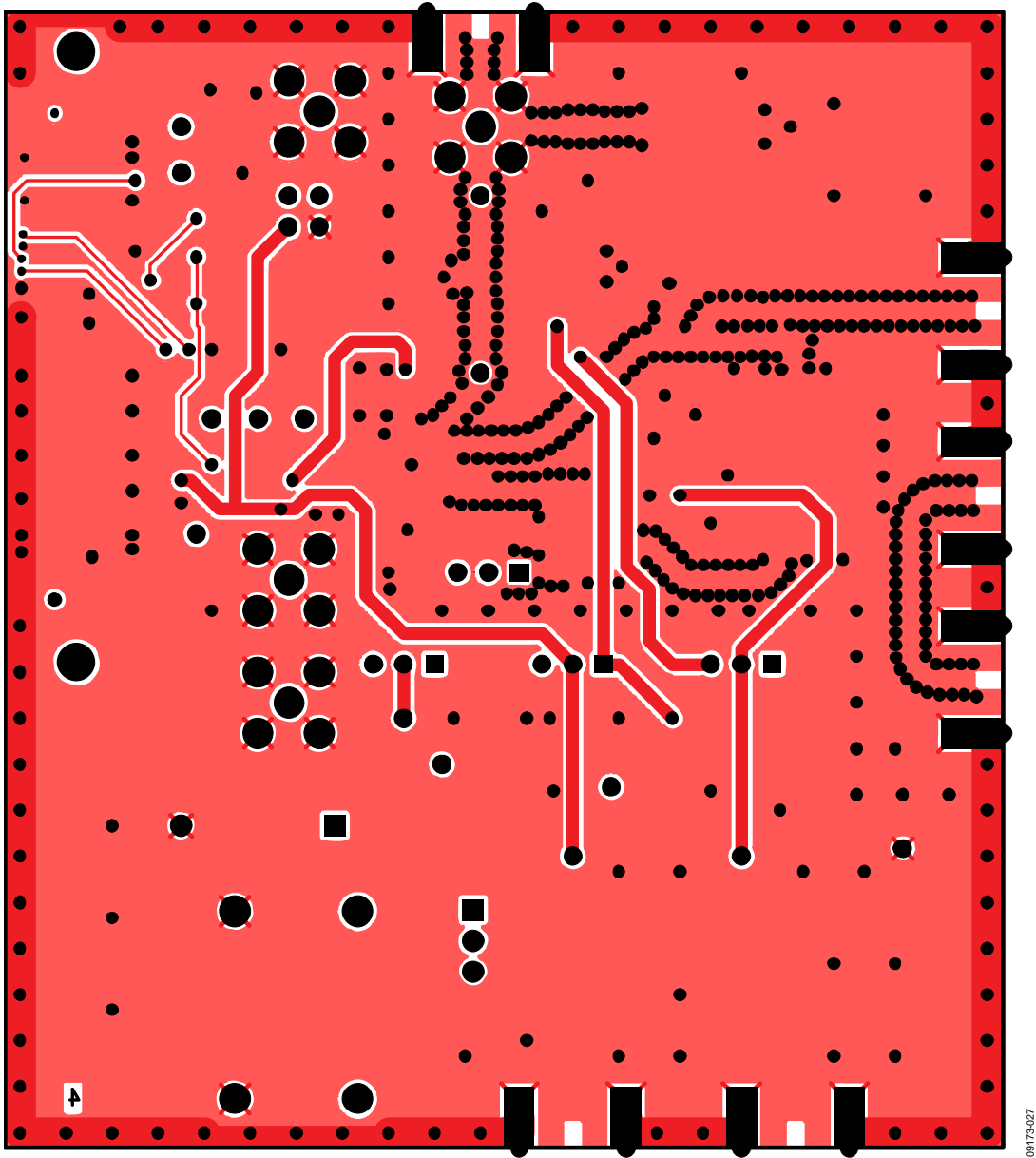


Figure 27. Bottom Side

09179-027

## ORDERING INFORMATION

## BILL OF MATERIALS

Table 2.

Reference Designator	Part Description	Manufacturer/Part No.
C1	Capacitor, 0805, 680 pF	PHYCOMP 2238 861 15681
C2	Capacitor, 0805, 10 nF	MURATA GRM2195C1H103JA01D
C3	Capacitor, 0805, 270 pF	PHYCOMP 2238 861 15271
C4, C6, C10	Capacitor, 0402, 0.1 $\mu$ F, 16 V	AVX CM105X7R104K16AT
C5, C7, C9, C11, C13	Capacitor, 0603, 10 pF, 50 V, SMD	AVX 06035A100JAT2A
C8, C12	Capacitor, Case A, 22 $\mu$ F, 6.3 V	AVX TAJA226K006R
C14, C15	Capacitor, 0603, 1 nF, 50 V	AVX 06035A102JAT2A
C16, C17, C18, C19	Capacitor, 0603, 100 pF, 50 V	AVX 06035A101JAT2A
C20, C23	Capacitor, Case A, 1 $\mu$ F, 16 V	AVX TAJA105K016R
C21, C24	Capacitor, 0603, 10 nF, 50 V	AVX 06035C103JAT2A
C22, C25	Capacitor, Case A, 4.7 $\mu$ F, 10 V	AVX TAJA475K010R
C26, C27	Capacitor, 0603, 10 nF, 50 V	Not inserted
D1	LED, green	OSRAM LGR971-Z
D2	Diode, DO41, 1 A, 50 V	Multicomp 1N4001
D3, D5	SD103C, 6.2 V	ON Semiconductor MBR0520LT1G
D4	LED, red	Avago HSMS-C170
J1	120-way connector, 0.6 mm pitch	Hirose FX8-120S-SV(21)
J2	Jack, SMA, SMA_EDGE	Johnson Components 142-0701-851
J3, J4, J10	JACK SMA receptacle straight PCB	Not inserted
J5, J6, J7, J8, J9	Jack, SMA, SMA_EDGE	Not inserted
J11	Jack SMA receptacle straight PCB	Pomona 72963
LK1, LK3, LK4, LK5	Jumper2\SIP3, Link-3P	Harwin M20-9990345 and M7566-05
LK2	Jumper-2	Harwin M20-9990245 and M7566-05
GND	Black 4 mm banana socket	Deltron 571-0100-01
VSUPPLY	Red 4 mm banana socket	Deltron 571-0500-01
R1A	Resistor, 0805	User supplied
R1	Resistor, 0805, 2.4 k $\Omega$	MULTICOMP MC 0.1W 0805 1% 2K4
R2	Resistor, 0805, 5.1 k $\Omega$	MULTICOMP MC 0.1W 0805 1% 5K1
R3	Resistor, 0805, 5.1 k $\Omega$ , $\pm$ 1%, 0.1 W	Multicomp MC 0.1 0805 1% 5K1
R4, R5, R6, R23, R29, R42	Resistor, 0603, 330 $\Omega$	Multicomp MC 0.063W 0603 1% 330R
R7, R8, R9	Resistor, 0603, 18 $\Omega$	Multicomp MC 0.063W 0603 1% 18R
R10	Resistor, 0603, 51 $\Omega$	Multicomp MC 0.063W 0603 1% 51R
R11	Resistor, 0603 100 $\Omega$	Multicomp MC 0.0625W 0402 1% 100R
R12, R13, R24, R25, R26	Resistor, 0603, 10 k $\Omega$	Multicomp MC 0.063W 0603 1% 10K
R14, R16, R18, R28, R36	Resistor, 0603, 0 $\Omega$	Multicomp MC 0.063W 0603 1% 0R
R15, R17, R22, R27, R32, R33, R37, R46	Resistor, 0603, 0 $\Omega$	Not inserted
R19, R20	Resistor, 0603, 330 k $\Omega$ , $\pm$ 1%, 0.063 W	Multicomp MC 0.063W 0603 1% 330K
R21	Resistor, 0603, 4.7 k $\Omega$ , $\pm$ 1%, 0.063 W	Multicomp MC 0.063W 0603 1% 4K7
R30	Resistor, 0402	Not inserted
R31, R34	Resistor, RC31, 0402, 100 k $\Omega$	YAGEO (Phycomp) RC0402JR-07100KL
S1	Switch, PCB, SPDT, 20 V	APEM TL36P0050
T1 to T14	Test point, PCB, red PK_100	Vero 20-313137
U1	16-lead TSSOP <a href="#">ADF4156</a>	<a href="#">ADF4156BRUZ</a>
U3	6-lead SOT-23 <a href="#">ADP3300</a>	<a href="#">ADP3300ART-5</a>
U2	6-lead SOT-23 <a href="#">ADP3300</a>	<a href="#">ADP3300ART-3</a>
U4	32k I <sup>2</sup> C serial EEPROM, MSOP8	Microchip 24LC32A-I/MS
Y1	VCO V940ME03	Z-Communications V940ME03
Y2	Low profile/temperature compensated crystal oscillator, OSC_TCXO, 10 W	Fox 801-BELF

## NOTES

**NOTES**

## NOTES

## NOTES

I<sup>2</sup>C 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 NON-INFRINGEMENT 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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