Evaluating the ADF4368, Microwave Wideband Synthesizer with Integrated VCO

FEATURES

- Self-contained board, including ADF4368 frequency synthesizer with integrated VCO, loop filter, USB interface, on-board reference oscillator, propagation delay calibration paths, and voltage regulators
- Windows®-based software allows control of synthesizer functions from a PC
- Externally powered by 6 V

EVALUATION BOARD CONTENTS

- EV-ADF4368SD1Z 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 or phase noise analyzer
- 50 Ω terminators
- Low noise REFIN source (optional)

DOCUMENTS NEEDED

- ADF4368 data sheet

EV-ADF4368SD1Z EVALUATION BOARD PHOTOGRAPH

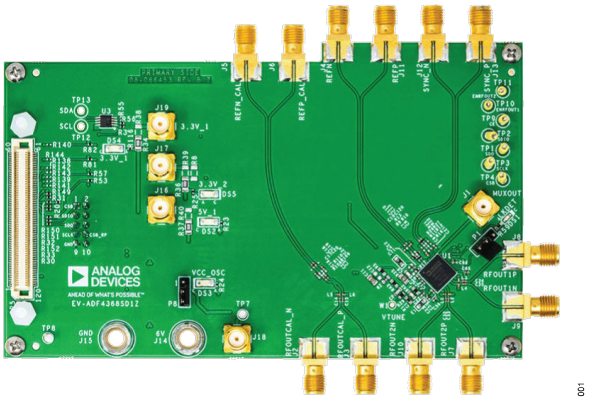

Figure 1. EV-ADF4368SD1Z Evaluation Board Photograph

SOFTWARE REQUIRED

- ACE software, Version 1.26 or newer
- ADF4368 plugin, Version 1.2022.35100 or newer

GENERAL DESCRIPTION

The EV-ADF4368SD1Z evaluates the performance of the ADF4368 fractional frequency synthesizer with an integrated voltage controlled oscillator (VCO) for phase-locked loops (PLLs). A photograph of the EV-ADF4368SD1Z is shown in Figure 1. The EV-ADF4368SD1Z contains the ADF4368 frequency synthesizer with an integrated VCO, a USB interface, power supply connectors, on-board reference oscillator, propagation delay calibration paths, and Subminiature Version A (SMA) connectors. The outputs are AC-coupled with 50 Ω transmission lines making the outputs suitable to drive 50 Ω impedance instruments. The EV-ADF4368SD1Z requires an SDP-S board (not supplied with the kit). The SDP-S allows software programming of the EV-ADF4368SD1Z with ACE software.

Full specifications on the ADF4368 frequency synthesizer are available in the ADF4368 data sheet available from Analog Devices, Inc., and must be consulted with this user guide when using the EV-ADF4368SD1Z evaluation board.

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REVISION HISTORY

3/2023—Revision 0: Initial Version

GETTING STARTED

SOFTWARE INSTALLATION PROCEDURES

To install the ACE software and ADF4368 plugin, do the following steps:

1. Install the latest version of the ACE software platform.
2. If the ADF4368 plugin appears automatically, proceed to Step 4.
3. Double click the ADF4368 plugin file, **Board.ADF4368.1.2022.35100.acezip**.
4. Check that the ADF4368 plugin appears when the EV-ADF4368SD1Z is attached through the system demonstration platform (SDP) connector to the PC, as shown in Figure 3.

EVALUATION BOARD SETUP PROCEDURES

The EV-ADF4368SD1Z setup diagram is shown in Figure 2. The EV-ADF4368SD1Z uses a single 6 V power supply with J14 and J15 banana plugs or a J12 SMA connector by default. On-board low noise LDO regulators are used to generate nominal 3.3 V and 5 V supplies.

For more details on the power supply circuitry, see the Power Supplies section.

To power-up the EV-ADF4368SD1Z, do the following steps:

1. Set the voltage of the power supply to 6 V and the current limit to 1 A.
2. Connect power cables to J14 and J15 (two banana cables) or to J18 (single SMA cable).
3. Turn on the power.

To run the software, do the following steps:

1. Select **Start** > **All Programs** > **Analog Devices** > **ACE**.
2. On the **Select Device and Connection** tab, choose **ADF4368** and the EV-ADF4368SD1Z appears as shown in Figure 3 under **Attached Hardware**.
3. When connecting the EV-ADF4368SD1Z, allow 5 sec to 10 sec for the label on the status bar to change.

EVALUATION BOARD HARDWARE

The EV-ADF4368SD1Z requires the SDP-S platform that uses the EVAL-SDP-CS1Z.

The EV-ADF4368SD1Z schematics are shown in Figure 7, Figure 8, Figure 9, and Figure 10.

POWER SUPPLIES

The EV-ADF4368SD1Z is powered by a 6 V power supply connected to the J18 SMA, or the banana plug, J14, and GND to the banana plug, J15.

The power supply circuitry has three LT3045 and one LT3042 high performance, low noise, and low dropout (LDO) regulators.

One LT3045 is used to generate 5 V to drive the VCO supply pins. The other two LT3045 provides 3.3 V supplies for Supply Group 1 and Supply Group 2.

Component placement for single 6 V supply is given in Table 1. The EV-ADF4368SD1Z provides the flexibility to use external 3.3 V and 5 V supplies with component placement changes shown in Table 2.

Table 1. Component Placement for Power Supplies for Single 6 V Supply

	3.3 V Supply Group 1		3.3 V Supply Group 2		5 V Supply Group 1	
6 V	**R34**	**R38**	**R36**	**R39**	**R37**	**R40**
Component	0 Ω	Do not install (DNI)	0 Ω	DNI	0 Ω	DNI
Connector	J14 and J15 banana plug or J18 SMA connector					

Table 2. Component Placement for Power Supplies for External Supplies

	3.3 V Supply Group 1		3.3 V Supply Group 2		5 V Supply Group 1	
External Supply	**R34**	**R38**	**R36**	**R39**	**R37**	**R40**
Component	DNI	0 Ω	DNI	0 Ω	DNI	0 Ω
Connector	J19		J17		J16	

The LT3042 is used to generate 5 V to drive the on-board ultra-low phase noise sine wave oscillator.

REFERENCE INPUT

The EV-ADF4368SD1Z has an on-board 122.88 MHz ultra-low phase noise sine wave oscillator to drive the ADF4368 reference input. The single-ended oscillator output is connected to the REFP pin, and the REFN pin is AC grounded.

The Y2 reference footprint supports 5 mm x 7.5 mm and 14 mm x 9 mm packages in the 4-pin or 6-pin format. The R87 and R91 resistors can be populated if there is a need to set the control voltage of an alternative voltage controlled crystal oscillator (VCXO).

The default oscillator supply voltage is set to 5 V. If an alternative oscillator requires a different supply voltage, the resistor of the LT3042, R2, can be changed to provide the required supply voltage.

The reference input can also be driven externally by a pair of SMA connectors, REFN (J4), and REFP (J11). The on-board oscillator supply must be disabled when using an external reference.

Table 3 provides the required EV-ADF4368SD1Z modifications for the external reference clock.

The ADF4368 has a configurable reference input buffer whose performance can be optimized for different reference slew rates, amplitudes, and frequencies. For more information on the REF_SEL bit, BST_REF bit, and FILT_REF bit, refer to the ADF4368 data sheet.

For detailed reference buffer amplitude and frequency considerations, refer to the ADF4368 data sheet.

Table 3. Component Placement for Different Reference Sources

	Default On-Board Oscillator	Single-Ended External Reference	Differential External Reference	
Component			**CML/LVPECL**	**LVDS**
P8	Short Pin 1 and Pin 2	Short Pin 2 and Pin 3	Short Pin 2 and Pin 3	Short Pin 2 and Pin 3
C120	1 µF	Remove C120	Remove C120	Remove C120
C13	DNI	1 µF	1 µF	1 µF
C110	DNI	DNI	1 µF	1 µF
R9	0 Ω	0 Ω	Remove R9	Remove R9
R10	49.9 Ω	49.9 Ω	Remove R10	Remove R10
R13	DNI	DNI	100 Ω	100 Ω

CLOCK OUTPUTS

The EV-ADF4368SD1Z has two pairs of SMA connectors for the RFOUT1P/RFOUT1N and RFOUT2P/RFOUT2N differential clock outputs.

The output power of clock output channels can be adjusted by the software, individually.

The clock output channels can be powered-down separately by the software or hardware.

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). For more information on output termination examples, refer to the ADF4368 data sheet.

CALIBRATION PATH

The EV-ADF4368SD1Z calibration path has two pairs of SMA connectors, which are labeled REFN_CAL/REFP_CAL and RFOUTCAL_N/RFOUTCAL_P. The calibration path is used to measure and calibrate out the EV-ADF4368SD1Z effect on reference to output delay.

LOOP FILTER

The loop filter schematic is included in Figure 7. The fifth order loop filter on the EV-ADF4368SD1Z is optimized for the ADF4368 low noise amplifier (LNA) reference amplifier, a 6 dBm sine-wave reference frequency of 122.88 MHz, a phase/frequency detector

EVALUATION BOARD HARDWARE

(PFD) frequency of 245.76 MHz, and an 11.1 mA charge pump current. A fourth order loop filter can be used with faster slew-rate reference signals that allow for use of the delay matched amplifier (DMA) reference amplifier of the ADF4368. For more information on loop filter design, refer to the ADF4368 data sheet.

SERIAL-PERIPHERAL INTERFACE (SPI)

Connector P5 interfaces with the SDP-S to evaluate the ADF4368 using the ACE GUI software. A second connector, P2, is provided for software development. The P2 connector allows for a common open source hardware (OSH) board, such as a peripheral module (Pmod™), Raspberry Pi, and SDP-K1, to interface directly with the EV-ADF4368SD1Z.

DEFAULT CONFIGURATION

All components necessary for local oscillator (LO) generation are installed on the EV-ADF4368SD1Z. The EV-ADF4368SD1Z is shipped with an 122.88 MHz crystal oscillator (XO), the ADF4368 synthesizer with an integrated VCO, and a 650 kHz loop filter (charge pump current (I_{CP}) = 11.1 mA) at 10.6 GHz. When the EV-ADF4368SD1Z is powered-up and connected to the ACE software, clicking the **Write All Registers/ Initialize** button, shown in Figure 5, provides a 10.6 GHz output clock on both clock output channels.

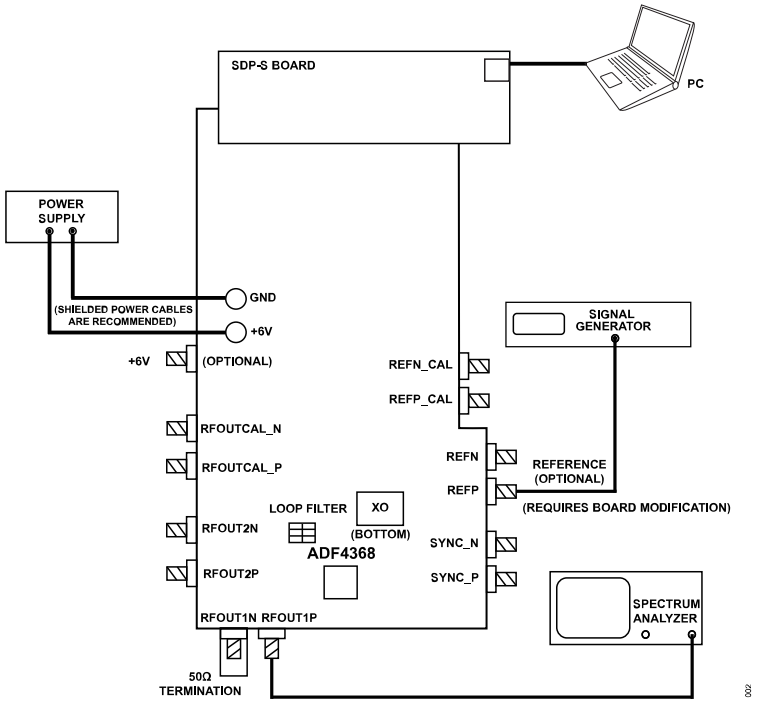

Figure 2. EV-ADF4368SD1Z Setup Diagram

EVALUATION BOARD SOFTWARE

The ACE software is the main platform that is used to control the EV-ADF4368SD1Z. The ADF4368 plugin includes user interfaces that relate to the ADF4368 and allow evaluation of the device. Do the following steps to open the main control window for the ADF4368:

1. Launch the ACE application. With the SDP-S board connected to the EV-ADF4368SD1Z, the attached hardware appears in the graphical user interface (GUI), as shown in Figure 3.
2. Double click the **ADF4368 Board** button, and the tab shown in Figure 4 appears.
3. Double click the **ADF4368** button that appears in Figure 4 to open the main control window shown in Figure 5.

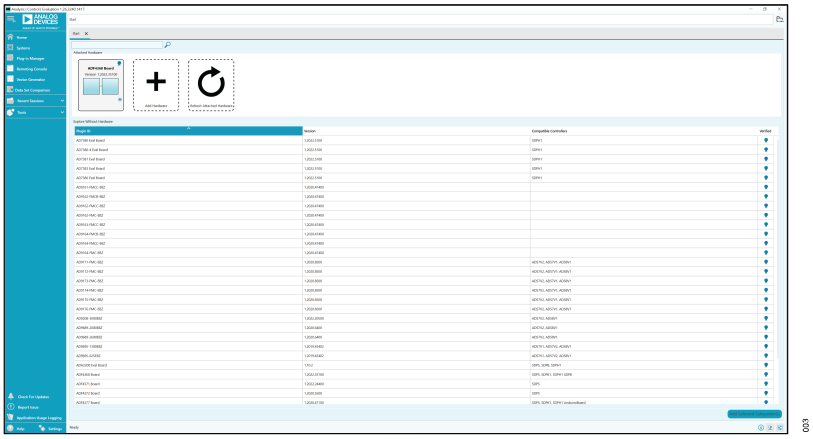

Figure 3. ACE Start Page, Attached Hardware (ADF4368 Board Button)

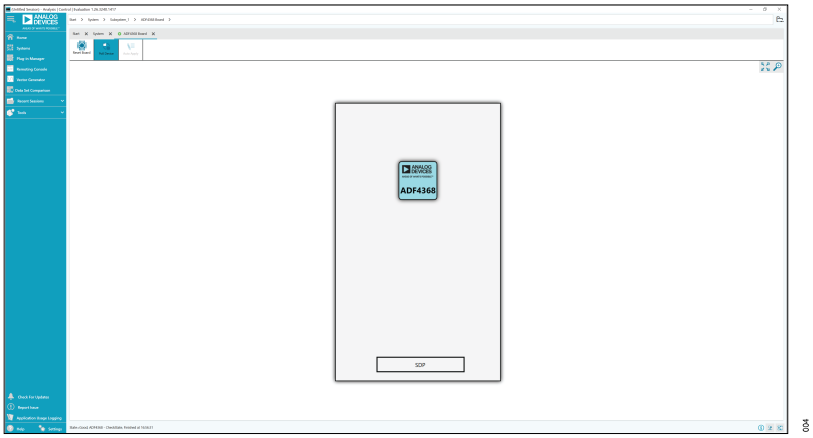

Figure 4. ACE Board Page, Device Selection

EVALUATION BOARD SOFTWARE

MAIN CONTROLS

The main controls are available in the high level register map, shown in Figure 5. To modify registers, perform the following steps:

1. ACE plugin is opened with register configuration, which is set to generate 10.6 GHz output with 122.88 MHz reference clock and 245.76 MHz PFD frequency.
2. Any changes to the configuration can be made before writing to device.
3. Click **Write All Registers/ Initialize** to load all registers and initialize the device.
4. Modify the registers as desired.

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.

The following list provides some miscellaneous tips to aid in executed common task:

- If VCO frequency or output frequency is outside of the operational range, an error message appears under the **ERRORS** box of the window.
- To power down specific ADF4368 blocks, refer to the **POWER-DOWN** list in the window.
- To save a specific ADF4368 register configuration, click **Memory Map Side-By-Side** and then click **Export**. This exports the register values to a .csv file.

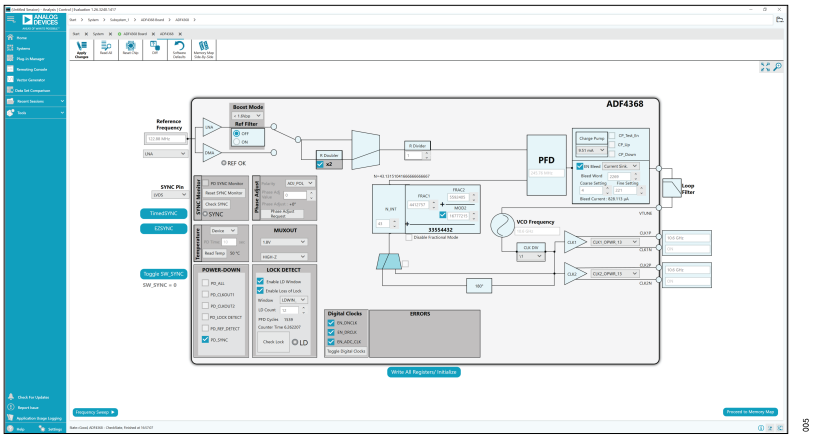

Figure 5. Main Page

EVALUATION AND TEST

To evaluate and test the performance of the ADF4368, prepare the hardware and software setup as explained in the Evaluation Board Hardware and the Evaluation Board Software sections.

Run the software and follow the steps shown in the Evaluation Board Software section to open the main page as shown in Figure 5.

Click the **Write All Registers/ Initialize** button, which provides an 10.6 GHz clock at both the RFOUT1P/RFOUT1N and RFOUT2P/RFOUT2N outputs. Measure the output spectrum and single sideband phase noise on a spectrum analyzer.

Bright plot in Figure 6 shows a phase noise plot of the SMA RFOUT1P output equal to 12.8 GHz with on-board ultra-low noise sine wave oscillator (245.76 MHz PFD frequency, Buffer Selection: LNA Buffer, Doubler: Enabled).

Faded plot in Figure 6 shows a phase noise plot of the SMA RFOUT1P output equal to 12.8 GHz with external 250 MHz reference signal (250 MHz PFD frequency, Buffer Selection: DMA Buffer, Doubler: Disabled).

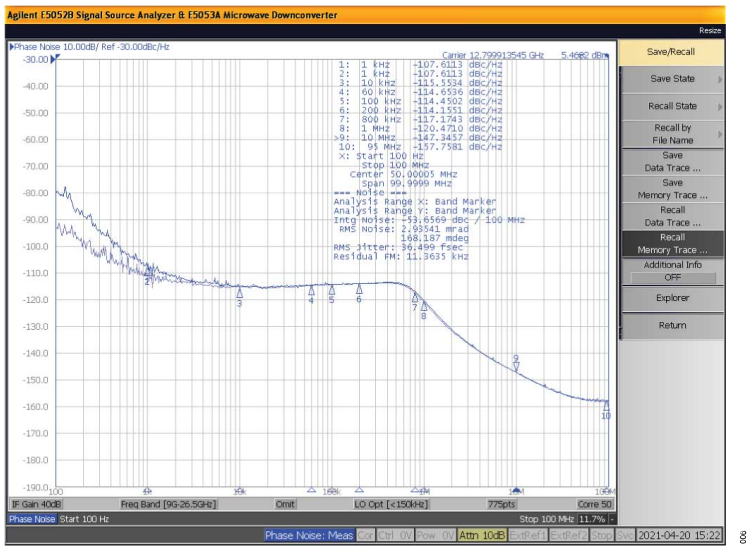

Figure 6. Single Sideband Phase Noise of 12.8 GHz Output with On-Board 122.88 MHz Oscillator and SMA100B External Reference

EVALUATION BOARD SCHEMATIC AND ARTWORK

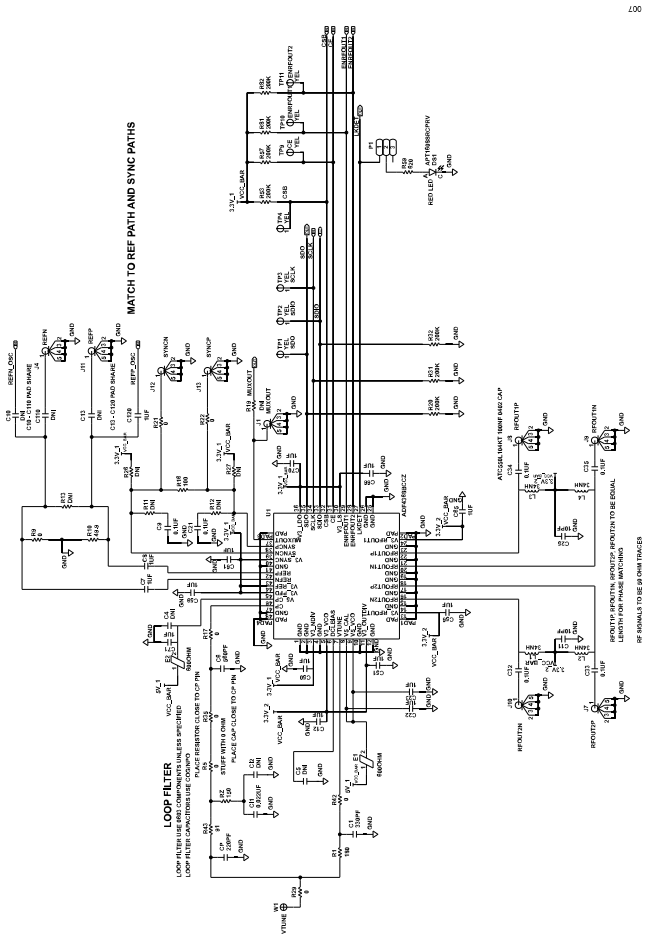

Figure 7. EV-ADF4368SD1Z Schematic, ADF4368 Connections, and Loop Filter

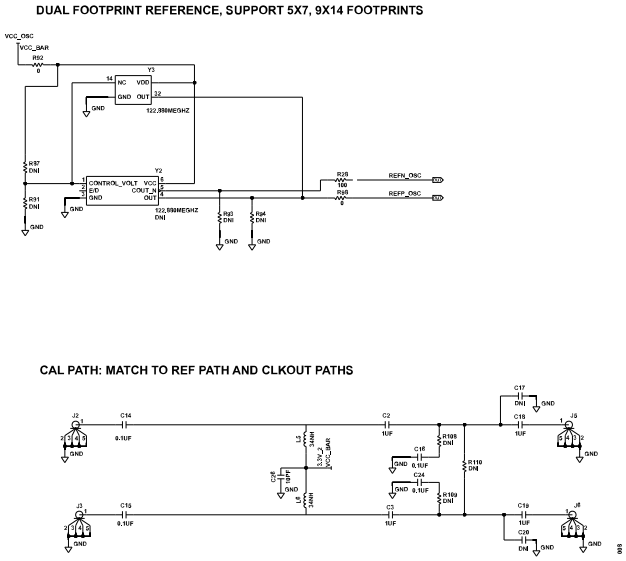

Figure 8. EV-ADF4368SD1Z Schematic, On-Board Ultra-Low Noise Oscillator, and Calibration Path

EVALUATION BOARD SCHEMATIC AND ARTWORK

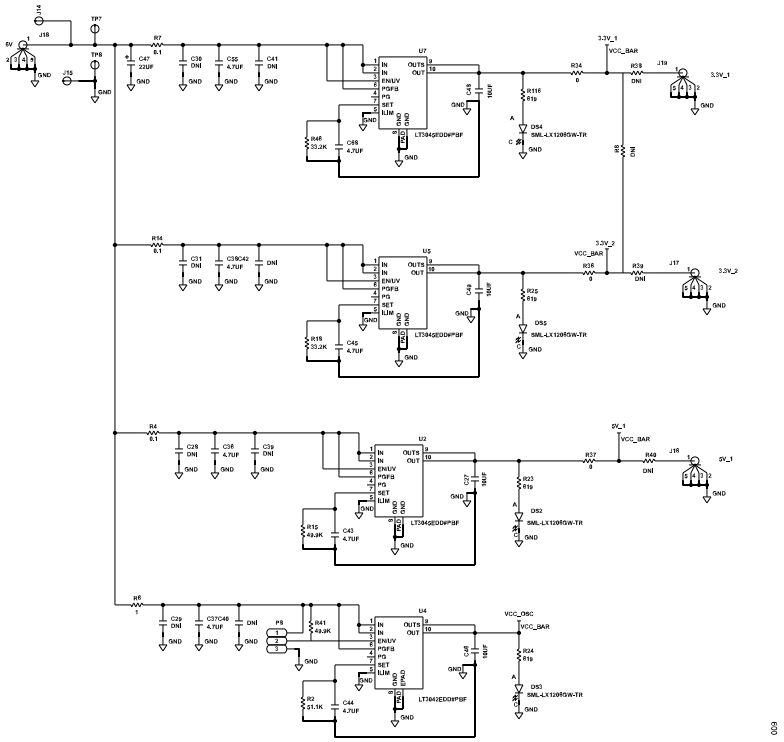

Figure 9. EV-ADF4368SD1Z Schematic, LDO Regulators

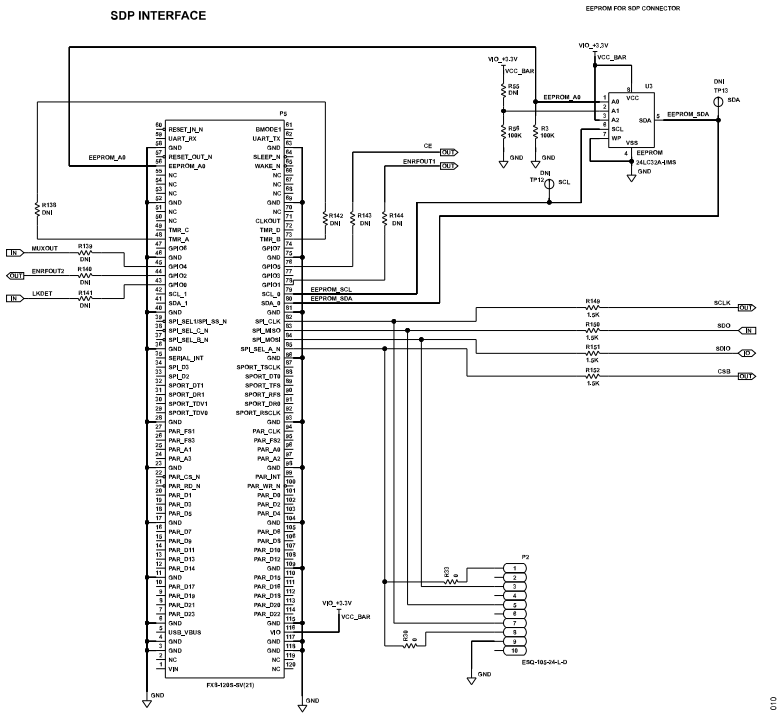

Figure 10. EV-ADF4368SD1Z Schematic, SDP Interface

EVALUATION BOARD SCHEMATIC AND ARTWORK

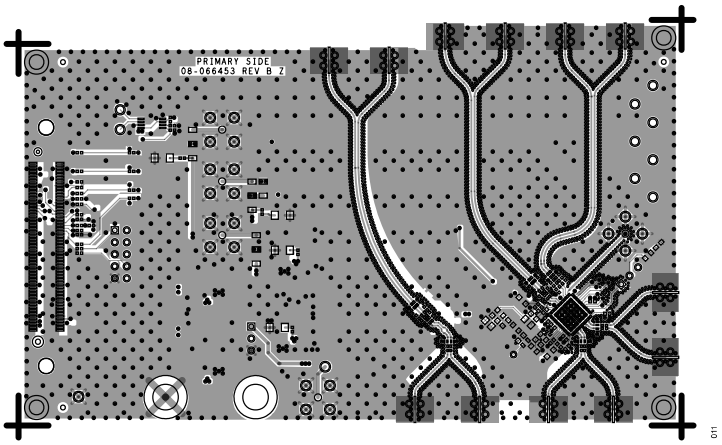

Figure 11. EV-ADF4368SD1Z Layer 1, Primary

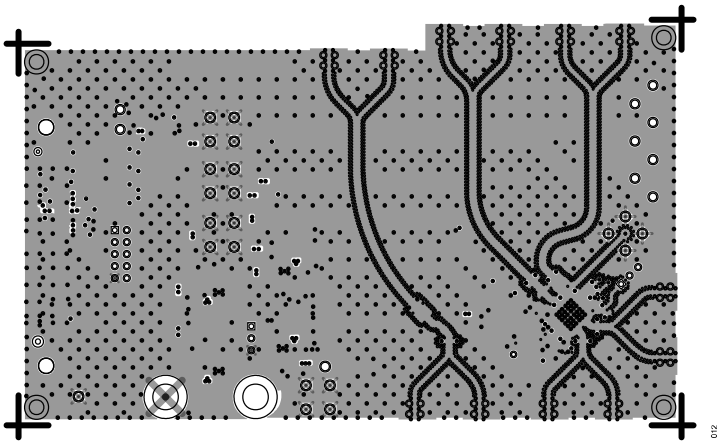

Figure 12. EV-ADF4368SD1Z Layer 2, Ground

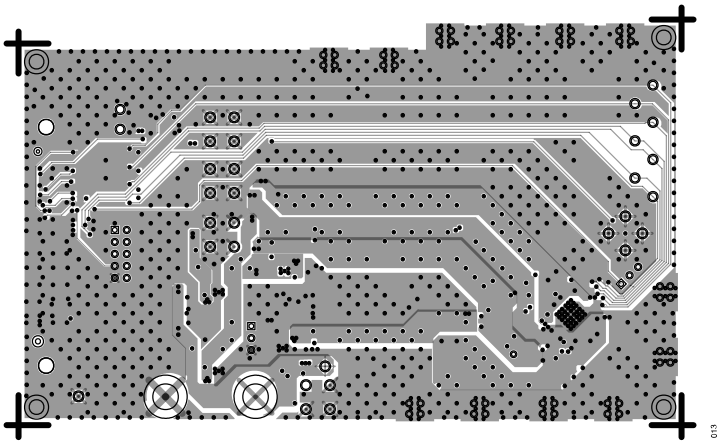

Figure 13. EV-ADF4368SD1Z Layer 3, Power

EVALUATION BOARD SCHEMATIC AND ARTWORK

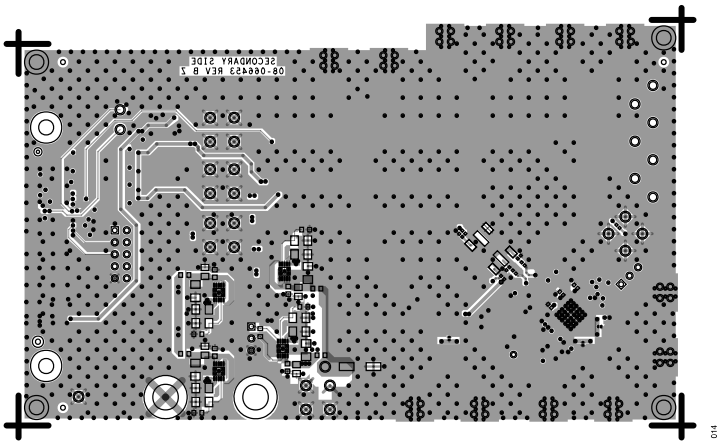

Figure 14. EV-ADF4368SD1Z Layer 4, Secondary

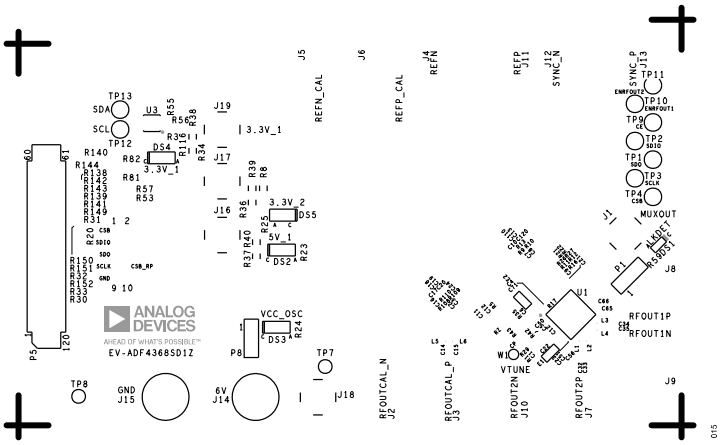

Figure 15. EV-ADF4368SD1Z Silkscreen, Top Side

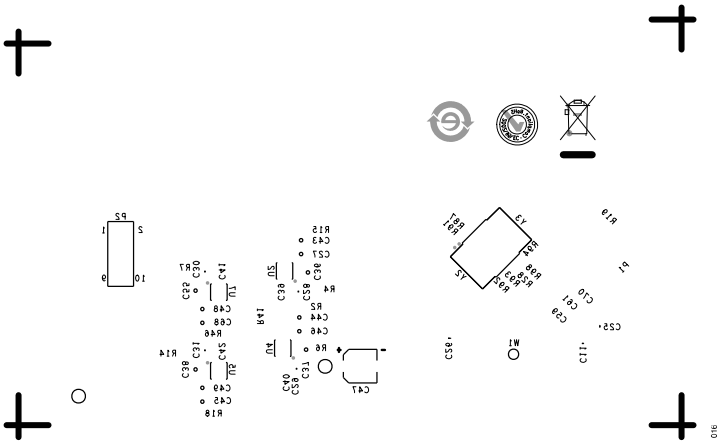

Figure 16. EV-ADF4368SD1Z Silkscreen, Bottom Side

ORDERING INFORMATION

BILL OF MATERIALS

Quantity	Reference Designator	Description	Manufacturer	Part Number
1	C1	Capacitor, 330 pF, 50 V, 5%, C0G, 0603	Kemet	C0603C331J5GACTU
3	C11, C25, C26	Capacitors, 10 pF, 25 V, 5%, C0G, 0201	Murata	GRM0335C1E100JA01D
12	C12, C22, C23, C50, C51, C56, C59, C61, C65, C66, C70, C71	Capacitors, 1 µF, 16 V, 10%, 0402	TDK	C1005X6S1C105K050BC
7	C2, C3, C7, C8, C18, C19, C120	Capacitors, 1 µF, 6.3 V, 10%, X7R, 0402	Murata	GRM155R70J105KA12D
10	C9, C14, C15, C16, C21, C24, C32, C33, C34, C35	Capacitors, 0.1 µF, 16 V, 10%, X7R, 0402	Kemet	C0402C104K4RACTU
4	C27, C46, C48, C49	Capacitors, 10 µF, 35 V, 10%, X7R, 1206	Taiyo Yuden	GMK316AB7106KL-TR
8	C36, C37, C38, C43, C44, C45, C55, C68	Capacitors, 4.7 µF, 25 V, 10%, X7R, 1206	Kemet	C1206C475K3RACTU
1	C47	Aluminum electrolytic capacitor, 22 µF, 63 V, 20%, 6.3 mm × 7.7 mm, AEC-Q200	Sun Electronic Ind. Corp.	63CE22BSA
1	C6	Capacitor, 560 pF, 50 V, 5%, C0G, 0603, AEC-Q200, low ESR	TDK	CGA3E2C0G1H561J080AA
1	CI1	Capacitor, 0.022 µF, 50 V, 1%, C0G, 0805	Kemet	C0805C223F5GACTU
1	CP	Capacitor, 220 pF, 50 V, 5%, C0G, 0603	Yageo	CC0603JRNPO9BN221
1	DS1	LED red surface-mount	Kingbright	APT1608SRCPRV
4	DS2, DS3, DS4, DS5	LED green surface-mounts	Lumex	SML-LX1206GW-TR
2	E1, E2	Ferrite beads	Taiyo Yuden	FBMH1608HL601-T
5	J1, J16, J17, J18, J19	SMA jacks, 50 Ω, contact center surface-mount with thru hole legs	Amphenol RF	132134-15
12	J2, J3, J4, J5, J6, J7, J8, J9, J10, J11, J12, J13	SMA edge mounts	Emerson Network Power	142-0761-811
2	J14, J15	Banana jacks	Keystone Electronics	575-4
6	L1, L2, L3, L4, L5, L6	Inductors, Unshielded wirewound 34 nH, 0.53 Ω DCR, 0.31 A	Coilcraft Inc.	0302CS-34NXJRW
2	P1, P8	3-position male headers, 2.54 mm pitch	Samtec Inc.	TSW-103-08-T-S
1	P2	10-position female header, 2.54 mm pitch	Samtec Inc.	ESQ-105-24-L-D
1	P5	SDP-S connector	HRS	FX8-120S-SV(21)
1	R1	Resistor, 18 Ω, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ-3EKF18R0V
1	R10	Resistor, 49.9 Ω, 1%, 1/10 W, 0402, AEC-Q200	Panasonic	ERJ-2RKF49R9X
4	R23, R24, R25, R116	Resistors, 619 Ω, 1%, 1/10 W, 0402, AEC-Q200	Panasonic	ERJ-2RKF6190X
3	R4, R7, R14	Resistors, 0.1 Ω, 1%, 1/3 W, 0603, AEC-Q200	Panasonic	ERJ-3BWFR100V
4	R149, R150, R151, R152	Resistors, 1.5 kΩ, 1%, 1/16 W, 0402, AEC-Q200	Stackpole Electronics, Inc.	RMCF0402FT1K50
2	R15, R41	Resistors, 49.9 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ-3EKF4992V
2	R16, R28	Resistors, 100 Ω, 1%, 1/10 W, 0402, AEC-Q200	Panasonic	ERJ-2RKF1000X
8	R9, R17, R21, R22, R30, R33, R92, R98	Resistors, 0 Ω jumper, 1/10 W, 0402, AEC-Q200	Panasonic	ERJ-2GE0R00X
2	R18, R46	Resistors, 33.2 kΩ 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ-3EKF3322V
1	R2	Resistor, 51.1 kΩ, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ-3EKF5112V
7	R20, R31, R32, R53, R57, R81, R82	Resistors, 200 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic	ERJ-2RKF2003X
3	R5, R29, R42	Resistors, 0 Ω jumper, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ-3GEY0R00V
2	R3, R56	Resistors, 100 kΩ, 1%, 1/10 W, 0402, AEC-Q200	Panasonic	ERJ-2RKF1003X
3	R34, R36, R37	Resistors, 0 Ω, 5%, 1/4 W, 1206, AEC-Q200	Vishay	CRCW12060000Z0EA
1	R35	Resistor, 0 Ω, 1/8 W, 0805, for combo footprint use alt_symbols	Vishay	RCG08050000Z0EA
1	R43	Resistor, 91 Ω, 1%, 1/10 W, 0603	Yageo	RC0603FR-0791RL
1	R59	Resistor, 620 Ω, 1%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ-3EKF6200V
1	R6	Resistor, 1 Ω, 5%, 1/10 W, 0603, AEC-Q200	Panasonic	ERJ-3GEYJ1R0V

ORDERING INFORMATION

Quantity	Reference Designator	Description	Manufacturer	Part Number
1	RZ	Resistor, 150 Ω, 1%, 1/10 W, 0603	Yageo	RC0603FR-07150RL
7	TP1, TP2, TP3, TP4, TP9, TP10, TP11	Test points, yellow	Components Corporation	TP-104-01-04
2	TP7, TP8	Solder terminal turrets for clip leads	Mill-Max	2308-2-00-80-00-00-07-0
1	U1	Microwave wideband synthesizer with integrated VCO	Analog Devices	ADF4368BCCZ
3	U2, U5, U7	20 V, 500 mA, ultra-low noise, ultra-high power supply rejection ratio (PSRR) linear regulator	Linear Technology	LT3045EDD#PBF
1	U3	IC 32 kb serial electronically erasable programmable read-only memory (EEPROM)	Microchip Technology	24LC32A-I/MS
1	U4	20 V, 200 mA, ultra-low noise, ultra-high PSRR RF linear regulator	Analog Devices	LT3042EDD#PBF
1	Y3	Crystal oscillator, ultra-low noise sinewave clock oscillator	Crystek Corp.	CCSS-945X-25-122.880

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.