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ADRF6650-EVALZ User Guide
UG-1026

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Evaluating the ADRF6650 450 MHz to 2700 MHz Dual Downconverter with DVGA and PLL/VCO

FEATURES

Full featured evaluation board for the ADRF6650
Single supply: 5.6 V (1 A capability required)
ACE software for control

EVALUATION KIT CONTENTS

ADRF6650-EVALZ evaluation board

EQUIPMENT NEEDED

SDP-S controller board
Analog signal sources
Power supply of 5.6 V (1 A capability required)
PC running Windows® XP or Windows 7
USB 2.0 port recommended

SOFTWARE NEEDED

Analysis | Control | Evaluation (ACE)

DOCUMENTS NEEDED

ADRF6650 data sheet

GENERAL DESCRIPTION

The ADRF6650-EVALZ is a 4-layer Rogers printed circuit board (PCB) and evaluates the performance of the ADRF6650. A photograph of the evaluation board is shown in Figure 1. The evaluation board contains the ADRF6650, a connector suited for a SDP-S controller board, power supply connectors, regulators, and subminiature Version A (SMA) connectors. The evaluation board requires an SDP-S controller board to allow software programming of the device.

The ADRF6650 is a high performance, dual downconverter that integrates mixers, digital switched attenuators, digital variable gain amplifiers (DVGAs), a phase-locked loop (PLL), and a voltage controlled oscillator (VCO). The device uses broadband, square wave limiting, local oscillator (LO) amplifiers to achieve an RF bandwidth of 450 MHz to 2700 MHz. Unlike conventional, narrow-band, sine wave LO amplifier solutions, the ADRF6650 allows the application of the LO either above or below the RF input, over a bandwidth of 450 MHz to 2900 MHz.

This user guide describes the ADRF6650-EVALZ evaluation board and software. For full details, see the ADRF6650 data sheet, which must be consulted in conjunction with this user guide when using the evaluation board.

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REVISION HISTORY
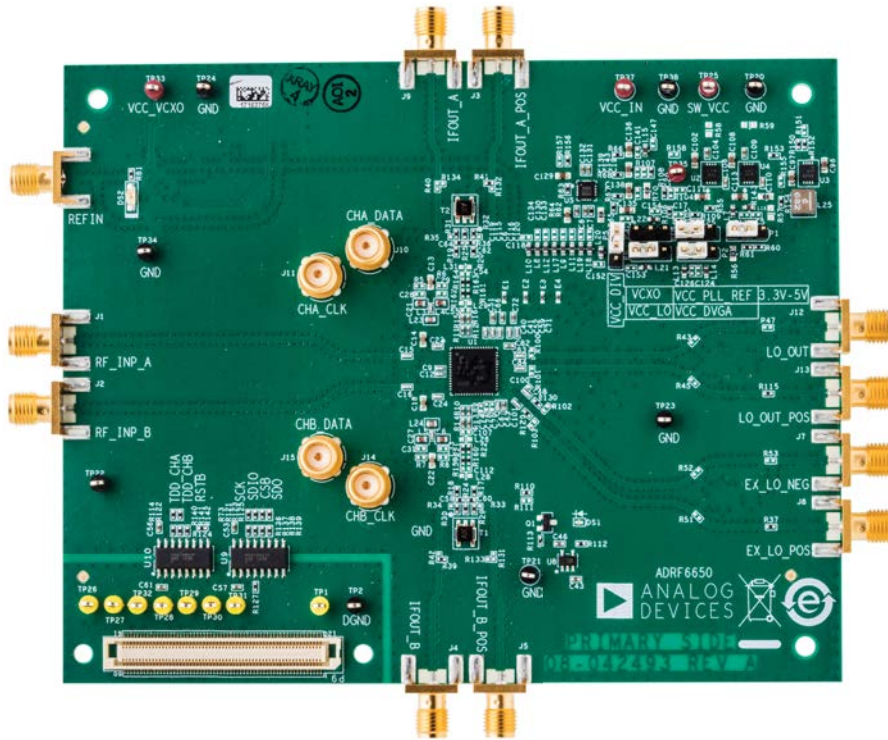
11/2019—Revision A

EVALUATION BOARD PHOTOGRAPH

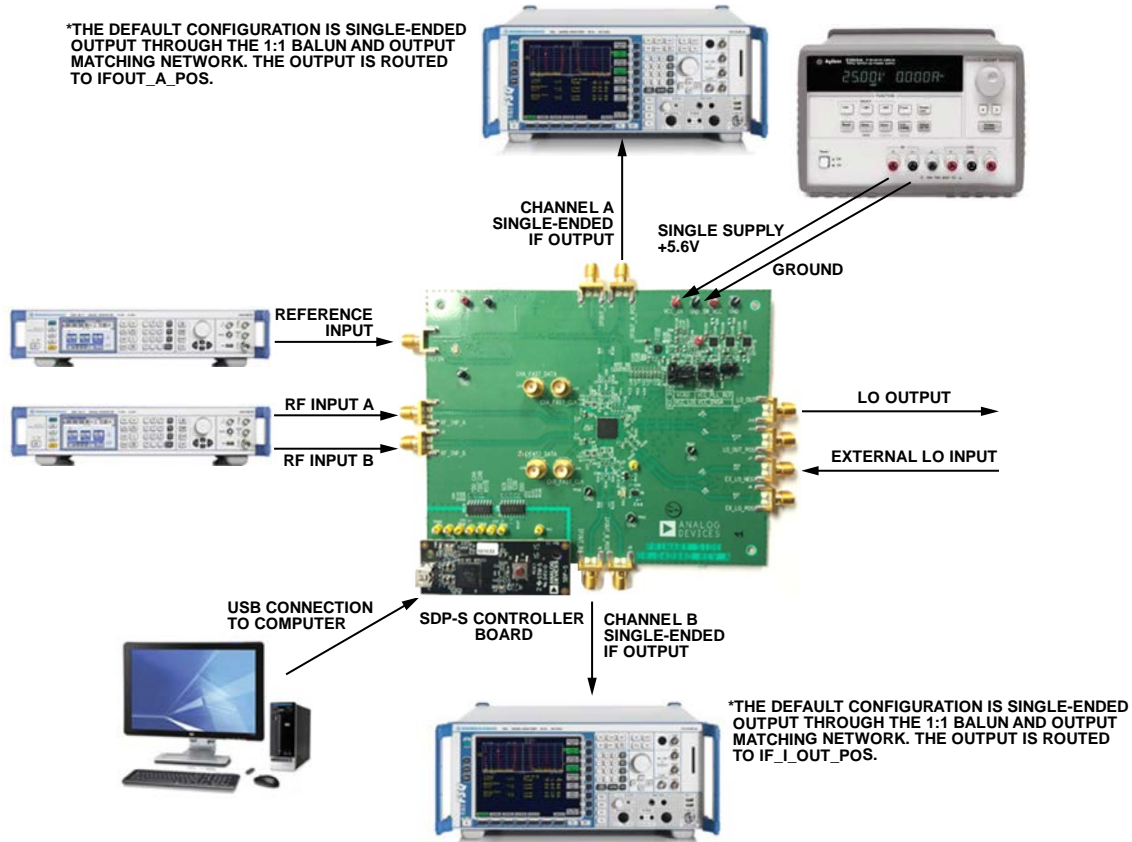*Figure 1. ADRF6650-EVALZ Evaluation Board*

EVALUATION BOARD HARDWARE

Figure 2. ADRF6650-EVALZ Typical Measurement Setup

The ADRF6650-EVALZ provides the support circuitry required to operate the ADRF6650 in various modes and configurations. Figure 2 shows the typical measurement setup that evaluates the performance of the ADRF6650.

POWER SUPPLY

The ADRF6650-EVALZ evaluation board requires a single, 5.6 V power source. The power supply design on the ADRF6650-EVALZ evaluation board consists of low dropout dc regulators that regulate the 5.6 V source to 3.3 V power rails for the main IC.

RF INPUTS

The ADRF6650 supports two single-ended 50 Ω terminated RF inputs. The operational frequency range of the RF inputs is from 450 MHz to 2700 MHz and the inputs must be ac-coupled.

LO GENERATION AND EXTERNAL LO INPUT

The ADRF6650 offers two alternatives to generating the differential LO input signal: externally via a high frequency, low phase noise LO signal or internally via the on-chip, fractional-N synthesizer and on-chip, voltage controlled oscillators (VCOs). In either case, the differential LO signal can be routed off-chip through the balun to the subminiature A (SMA) connector, LO_OUT.

For an internal LO configuration using the on-chip, fractional-N synthesizer, apply a low phase noise reference signal to the reference input, shown in Figure 2. The phase-locked loop (PLL) reference input can support a wide frequency range, because the dividing blocks or multiply blocks can increase or decrease the reference frequency to the desired phase frequency detector (PFD) frequency value. The integrated synthesizer enables continuous LO coverage from 450 MHz to 2900 MHz.

The PLL filter components populated on the evaluation board are for a 20 kHz bandwidth (see Figure 23).

For optimum performance using an external LO source, drive the LO inputs using the EX_LO_NEG and EX_LO_POS connectors on the evaluation board. The wide input range of the external LO input spans from 450 MHz to 2900 MHz. Unless an ac-coupled balun generates the differential LO, the inputs must be ac-coupled. The input impedance of the differential LO signals is 100 Ω and must be taken into account when driving differentially. For the default configuration of the LO inputs on the ADRF6650-EVALZ, apply a single-ended LO input to the SMA labeled EX_LO_NEG, the on-board balun converts the signal to differential.

IF OUTPUTS

The ADRF6650 intermediate frequency (IF) outputs have a differential impedance of 10 Ω as looking into the IF output pins. External series 25 Ω resistors on each differential line optimizes the performance of the ADRF6650. The output impedance with the 25 Ω series resistors displays as 60 Ω differential for both IF outputs. The 60 Ω differential output impedance terminates with 100 Ω differential for optimal performance, providing a good output impedance match and linearity performance.

For measurement purposes with instruments that have 50 Ω input impedance, the evaluation board employs a 1:1 transformer (TC1-1-13MX+) and a resistive matching network, shown in Figure 20. The TC1-1-13MX+ is a wide bandwidth (4.5 MHz to 3000 MHz) 1:1 transformer with a flat passband response and converts single-ended 50 Ω resistance to 50 Ω differential resistance. A resistive matching network converts the 50 Ω differential impedance to 100 Ω differential. The circuit topology allows the 60 Ω IF output impedance to terminate with 100 Ω impedance in a 50 Ω measurement environment. The resistive matching network introduces a loss around 7.5 dB and the user must account for the associated loss in measurements.

The ADRF6650-EVALZ evaluation board is configured for single-ended outputs in default mode. For a single-ended output, use the IFOUT_A_POS connector with the on-board balun. For a single-ended output, use the IFOUT_B connector with the on-board balun.

SERIAL PORT INTERFACE (SPI)

The SPI of the ADRF6650 consisting of the SCLK, SDIO, SDO, and $\overline{CS}$ pins, is controlled via an external SDP-S controller board and the ACE software.

EVALUATION BOARD SOFTWARE AND QUICK START PROCEDURES

The ADRF6650-EVALZ with the SDP-S controller board is configured with a USB friendly interface to allow programmability of the ADRF6650 registers. The Analog Devices, Inc., ACE software provides a user friendly experience for complete control of the evaluation board and features.

SOFTWARE REQUIREMENTS AND INSTALLATION

Installing the ACE Software Suite

Download the ACE installation executable **ACEInstall_ Version.exe** from the Analog Devices website.

Run **ACEInstall_Version.exe** to begin the installation process. The default path where the ACE software is installed on the PC is **C:\Program Files (x86)\Analog Devices\ACE**.

For convenience, create a desktop icon for the ACE software. Find **ACE.exe** under the default path and double-click to run the ACE software. Alternatively, the ACE software can run from the **Start** menu by navigating to the **Analog Devices** folder, and run the ACE software under the **ACE** folder.

ADRF6650 GRAPHICAL USER INTERFACE (GUI) QUICK START

Connect the SDP-S controller board with the USB cable connected to the computer and power up the ADRF6650-EVALZ. Initially, the 5.6 V power supply draws about 210 mA. When the evaluation board is fully configured, the power supply draws about 700 mA. The following steps outline how to begin using the ACE software:

1. Double-click the ACE shortcut (see Figure 3) available under the **C:\Program Files (x86)\Analog Devices\ACE** directory.
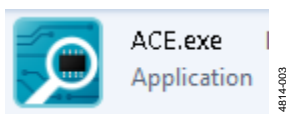
*Figure 3. **ACE.exe** Shortcut Icon*

2. When the software main window opens, it automatically detects the ADRF6650-EVALZ. Double-click the **ADRF6650 Board** icon shown in Figure 4. This brings the user to **ADRF6650 Board** tab (see Figure 5).
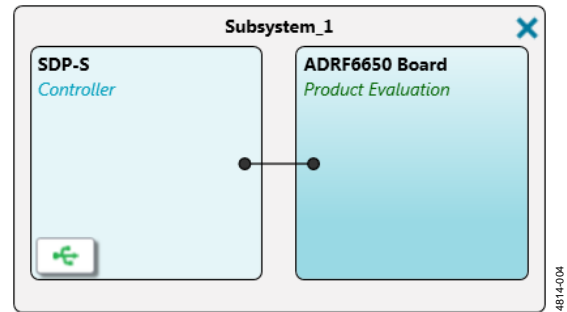
Figure 4. ACE Software Start Page when the ADRF6650-EVALZ Connects

*Figure 5. **ADRF6650 Board** Tab View*

3. From the **ADRF6650 Board** tab, double-click the ADRF6650 icon to open the **ADRF6650 Board** tab (see Figure 7). The **ADRF6650 Board** tab allows the user to configure the ADRF6650 in any desired configuration.
4. Set the **LO Freq** field to the desired LO frequency.
5. Adjust the channel spacing for PLL/VCO steps by using the **Ch Spacing** field.
6. Enter the reference frequency and the R divider value into the fields placed under the **REF In** field in the GUI. Ensure the PFD frequency stays within the data sheet limits.
7. Click **PLL Set** button to lock the PLL and VCO. Check the on-board LED (DS1) or the LOCK_DETECT register on the ADRF6650 to ensure the PLL/VCO is locked.
8. Turn on the LO buffer to quadrature divider by clicking on the triangle buffer icon beneath the **LO Out Level** spin box.
9. Connect an RF input source from a signal generator to SMAs labeled as either RF_INP_A or RF_INP_B, for Channel A and Channel B, respectively.
10. Check the IF output of the corresponding channel on the evaluation board. The resistive matching network at the IF outputs schematic introduces a 7.5 dB loss.
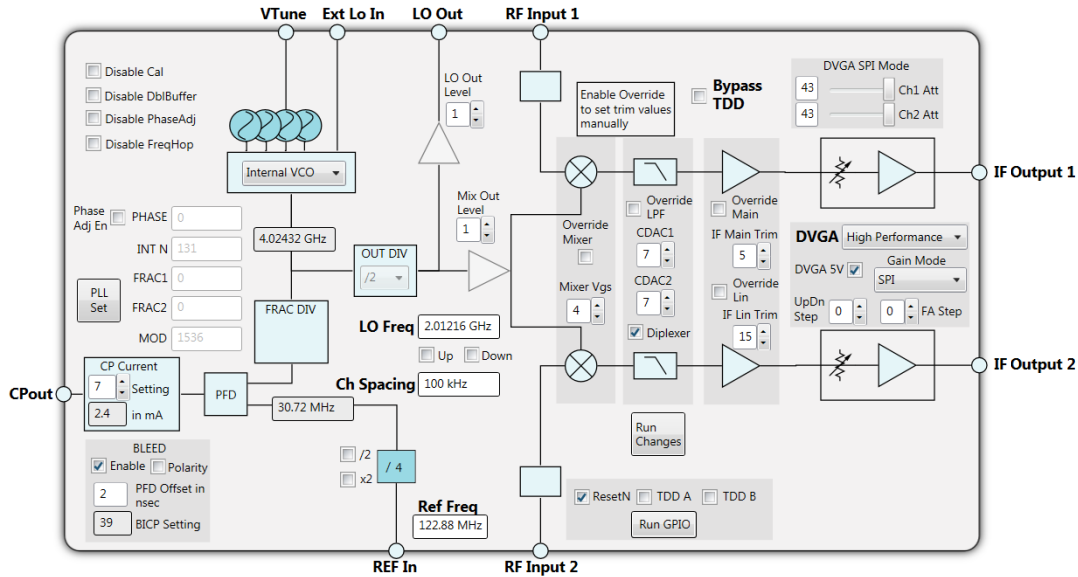
Figure 6. *ADRF6650* GUI Interface

ADRF6650 GUI COMPONENTS

This section describes the components within the ACE software GUI, which enables thorough control of all the elements of the ADRF6650.

ADRF6650 Board Tab

The **ADRF6650 Board** tab includes the **Reset Board** button, the **Poll Device** button, and the **Auto Apply** button (see Figure 7).
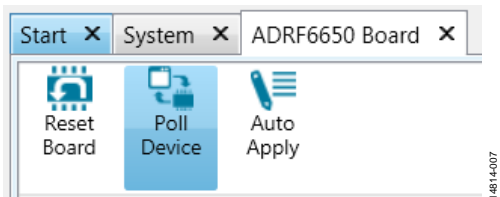

Figure 7. **ADRF6650 Board** *Tab*

The **Reset Board** button applies a soft reset to the device. The **Auto Apply** button applies the changes made to the GUI without the need to click **Apply Changes** after every change. The **Poll Device** button is not employed within the ADRF6650 GUI.

ADRF6650 Tab

Figure 6 shows the **ADRF6650 Board** tab, which displays the main controls required to configure the device.

There are four user-controllable elements within the GUI. The following list describes the four elements:

- Click **PLL Set** (see Figure 8) to activate a series of predefined register writes to initiate an autocalibration to lock the PLL/VCO.

Figure 8. **PLL Set** *Button*

- The entry fields within the GUI enable manual entry of a desired value (for example, see Figure 9). Input values are written and entered by pressing **Enter**. The changes made for the PLL/VCO related controls and fields are applied with the **PLL Set** button to initiate the locking process. For controls other than the PLL/VCO, click the **Apply Changes** button.

Figure 9. **LO Freq** *Field*

- Spin boxes, check boxes, and dropdown menus allow users to select predefined values. These elements do not start a register write operation and users must click the **PLL Set** button to produce the PLL/VCO related register writes and **Apply Changes** button all other controls. Figure 10 shows an example of a spin box. Figure 11 shows a dropdown menu item to select between the internal VCO and external LO configurations.
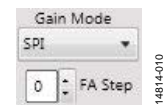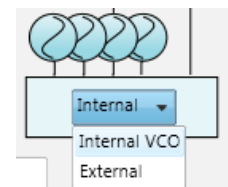

Figure 10. **Gain Mode** *Dropdown Menu and* **FA Step** *Spin Box*

Figure 11. *Configuration Dropdown Menu*

Figure 12. *ADRF6650* **Memory Map** *Tab*

- The user can enable or disable some of the components by clicking associated controllable graphics. Controllable graphics do not automatically start a register write operation and the user must click the **Apply Changes** button or the **PLL Set** button to produce the related register writes. When a controllable graphic displays as gray (see Figure 13), the component is disabled. When a controllable graphic displays as blue (see Figure 14), the component is enabled.

Figure 13. Disabled Component

Figure 14. Enabled Component

Some of the components have a pale blue color (see Figure 15), indicating the graphical object is not controllable by clicking on it.

Figure 15. Noncontrollable

[ADRF6650] Memory Map Tab

The **Proceed to Memory Map** button (see Figure 16) in the **ADRF6650** tab directs the user to the [ADRF6650] memory map for bit control of the register map (see Figure 12).

Figure 16. **Proceed to Memory Map** Button

The register write and reads are performed with the + and − buttons of the [ADRF6650] **Memory Map** tab (see Figure 12). All changes made in the GUI simultaneously apply to the [ADRF6650] **Memory Map** tab and changes made in the [ADRF6650] **Memory Map** tab simultaneously apply to the GUI.

CHECKING THE USB CONNECTIVITY

If the user encounters an error while configuring the device, check the USB connectivity of the evaluation board under the **System** tab (see Figure 7). Figure 17 shows the **Subsystem_1** window where the user can observe the connectivity of the [SDP-S] board and the ADRF6650-EVALZ.
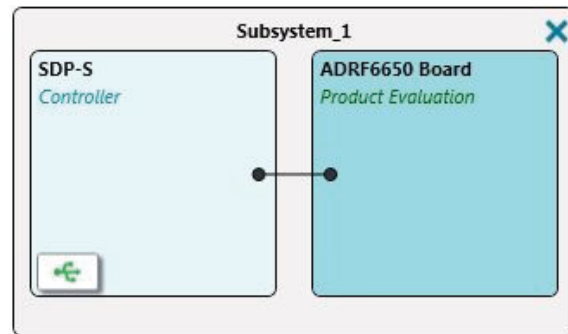

Figure 17. *ADRF6650 ACE* GUI System Tab

In the **SDP-S Controller** pane, there is a USB button. When the button is green, the USB is connected. Clicking the USB button reveals the connection options menu between the [SDP-S] controller board and the evaluation board. Ensure the ADRF6650 **Board** option in the **System** tab is selected. The ADRF6650 **Board** (**Local Only**) option does not provide connectivity.

Users can also check USB connectivity in the status bar of the [ACE] software, located in the bottom left of the GUI. **State**, which indicates the USB connectivity, must show **Good** at all times.

UPDATES TO THE [ACE] SOFTWARE PLUG-INS

Analog Devices periodically updates the [ACE] software and the device plug-ins to ensure the best possible user experience. Update the [ACE] software if there is indication of a new version when running the [ACE] software.

EVALUATION BOARD SCHEMATICS AND ARTWORK

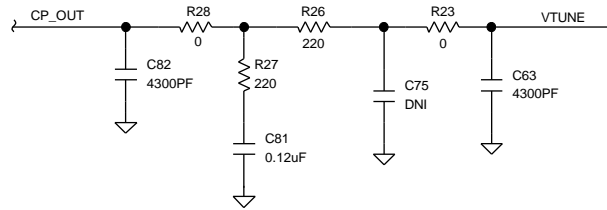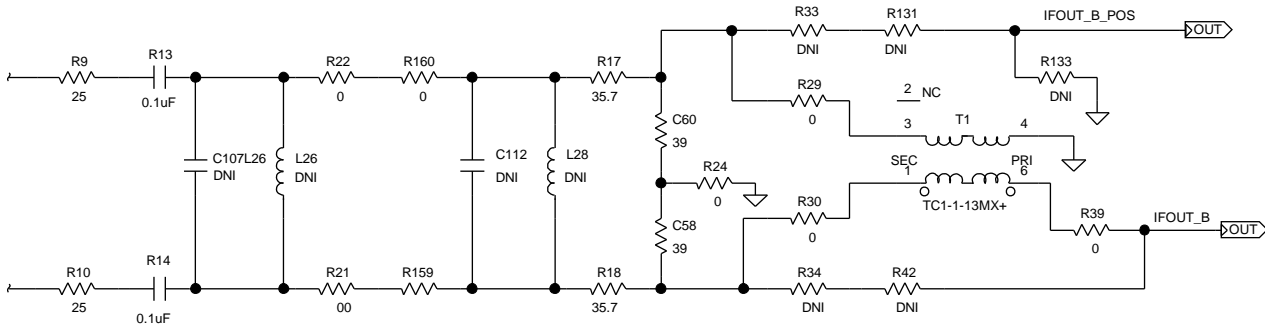*Figure 18. ADRF6650-EVALZ Schematic*

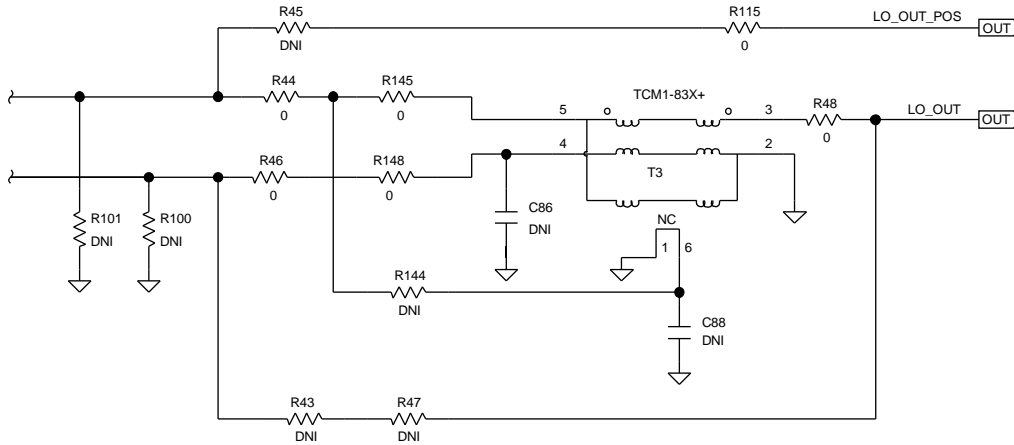Figure 19. PLL Filter

Figure 20. IF Output Schematic

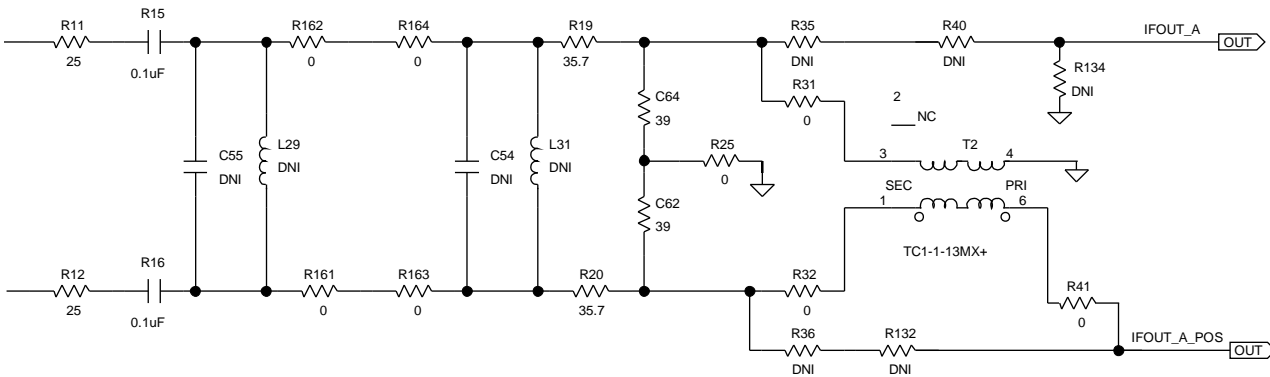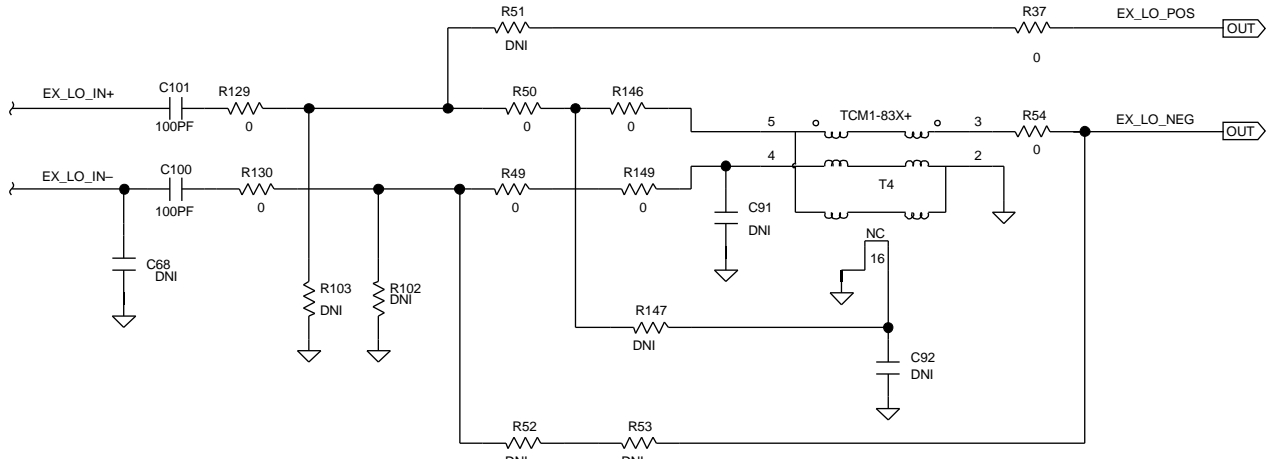
Figure 21. LO Output Schematic

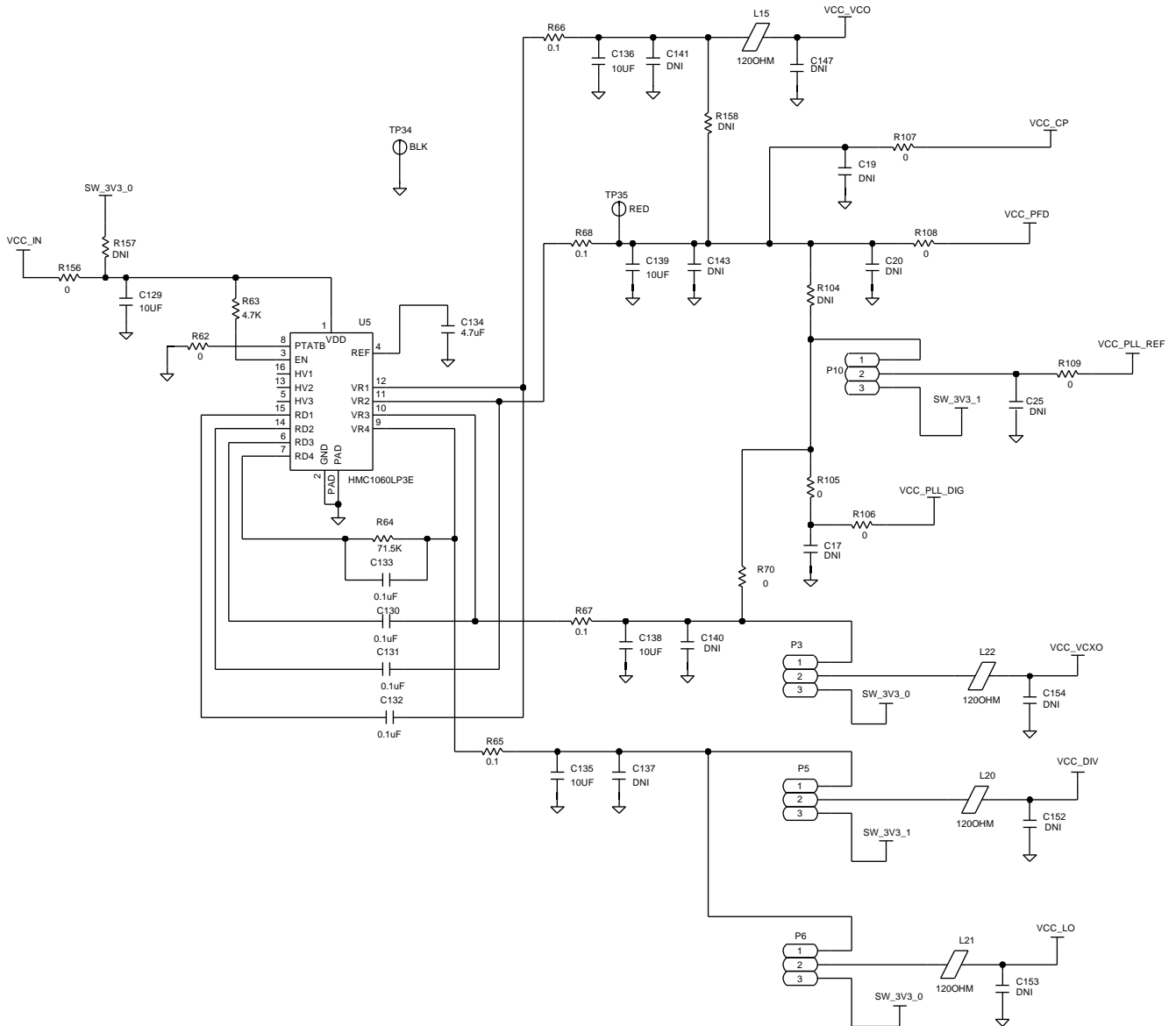Figure 22. External LO Input Schematic

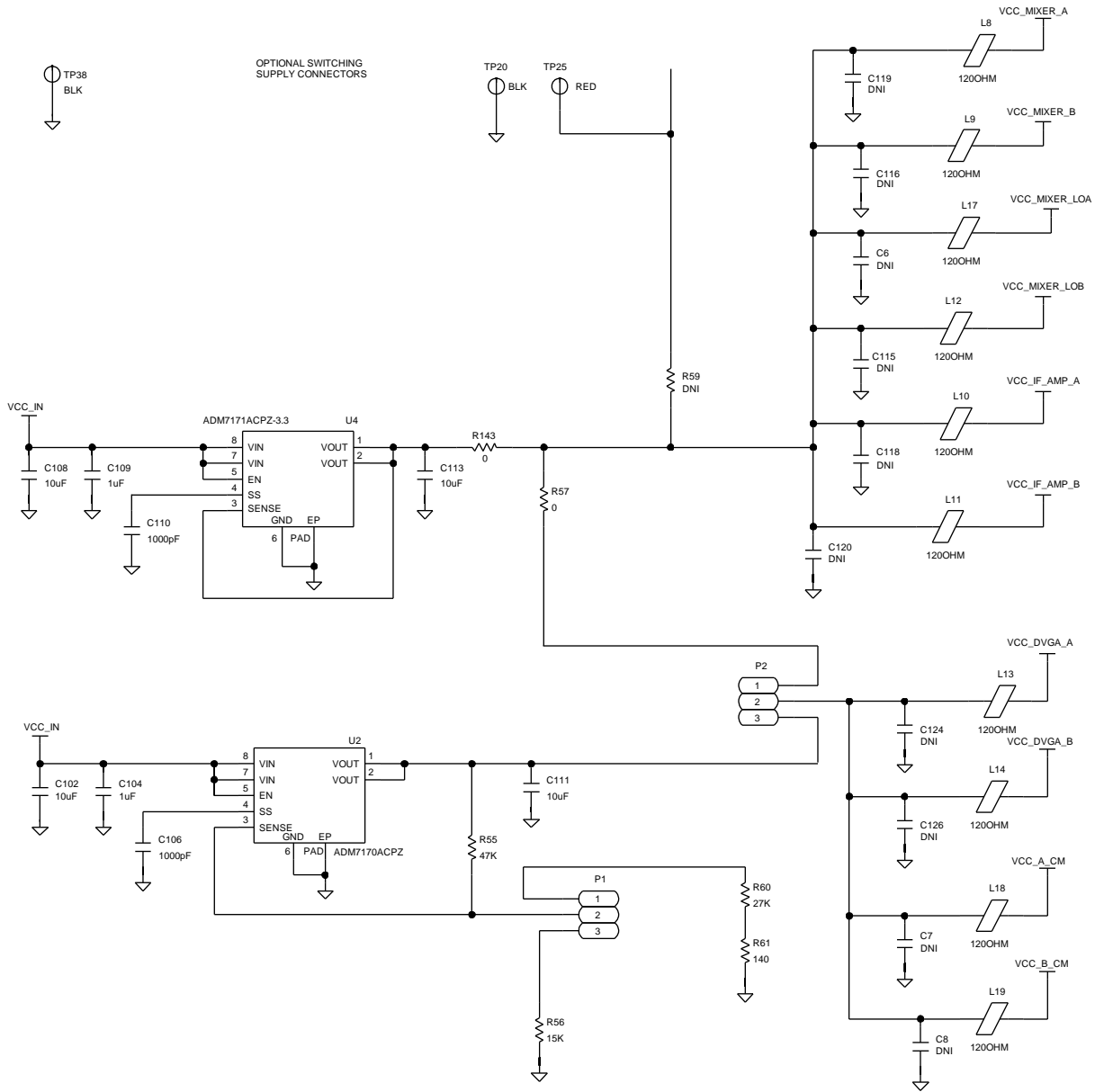Figure 23. *ADRF6650* PLL Schematic

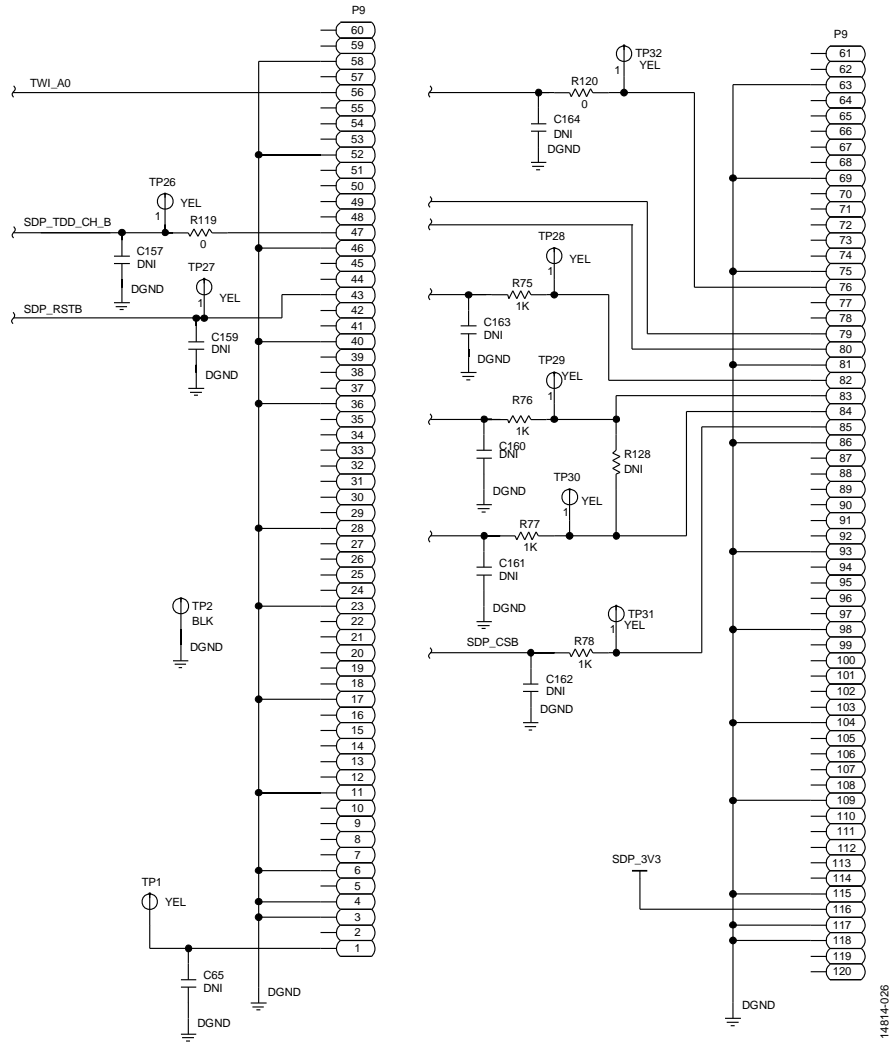Figure 24. PLL/VCO Supply Circuit

Figure 25. RF/IF Supply Circuit

Figure 26. SDP-S Connector
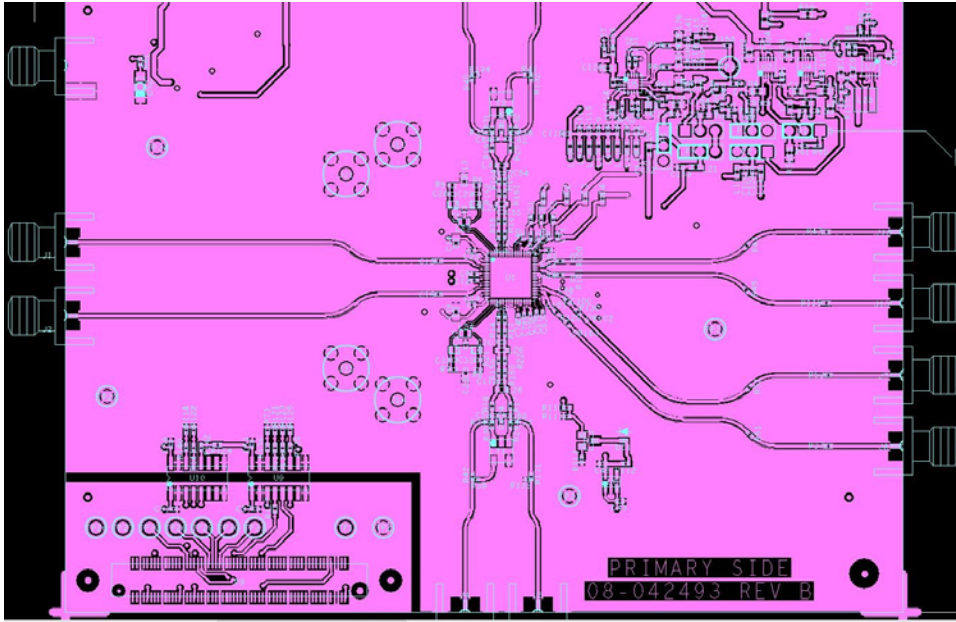

Figure 27. ADRF6650-EVALZ Top Silk Screen

Figure 28. ADRF6650-EVALZ Bottom Silk Screen

ORDERING INFORMATION

BILL OF MATERIALS

Table 1.

Qty.	Reference Designator	Description	Manufacturer	Part Number
26	C1, C4, C26, C32, C35, C51, C53, C56, C57, C61, C66, C72, C80, C90, C93, C94, C130, C131, C132, C133, C158, C170, R13, R14, R15, R16	Ceramic capacitors, X7R, general-purpose, 0.1 µF, C0402, 16 V	Murata	GRM155R71C104KA88D
3	C10, C96, C97	Ceramic capacitors, X5R, general-purpose, 22 µF, C0603, 10 V	Murata	GRM188R61A226ME15D
28	C9, C12, C15, C16, C21, C23, C24, C27, C30, C34, C36, C38, C39, C40, C41, C44, C45, C52, C59, C67, C71, C83, C84, C85, C87, C89, C100, C101	Ceramic capacitors, C0G (NP0), general-purpose, 100 pF, C0402, 50 V	Murata	GRM1555C1H101JA01D
10	C98, C102, C108, C111, C113, C129, C135, C136, C138, C139	Ceramic capacitors, X5R, general-purpose, 10 µF, C0603, 25 V	Murata	GRM188R61E106MA73D
4	C11, C47, C48, C103	Ceramic capacitors, X5R, 10 µF, C0402, 10 V	Samsung	CL05A106MP5NUNC
4	C43, C46, C104, C109	Ceramic capacitors, X5R, general-purpose, 1 µF, C0402, 16 V	Murata	GRM155R61C105MA12
2	C106, C110	Ceramic capacitors, X7R, general-purpose, 1000 pF, C0402, 50 V	Murata	GRM15XR71H102KA86
8	C13, C14, C18, C22, C37, C42, C49, C50	Ceramic capacitors, chip multilayer, X7R, 0.1 µF, C0603, 50 V	Vishay	VJ0603Y104KXA
1	C134	Ceramic capacitor, X5R, 4.7 µF, C0603, 16 V	TDK	C1608X5R1C475K080AC
1	C166	Ceramic capacitor, X6S, general-purpose, 4.7 µF, C0603, 16 V	Murata	GRM188C81C475KE11D
1	C167	Ceramic capacitor, multilayer, X5R, 0.47 µF, C0402, 16 V	TDK	C1005X5R1C474K
1	C168	Ceramic capacitor, 0.033 µF, C0402, 50 V	Panasonic	0402YD333KAT2A
1	C169	Ceramic capacitor, chip, X5R, 2.2 µF, C0402, 6.3 V	TDK	C1005X5R0J225M
1	C172	Ceramic capacitor, X5R, general-purpose, 0.1 µF, C0402, 10 V	Murata	GRM155R61A104KA01D
1	C173	Ceramic capacitor, multilayer, NP0, 10 pF, C0402, 50 V	Yageo	CC0402JRNP09BN100
4	C58, C60, C62, C64	Resistors, film surface-mount device, 39 Ω, R0402, 1/16 W	Panasonic	ERJ-2GEJ390X
2	C63, C82	Ceramic capacitors, U2J, general-purpose, 4300 pF, C0402, 10 V	Murata	GRM1557U1A432JA01D
1	C81	Ceramic capacitors, chip, 0.12 µF, C0402, 50 V	Kemet	C0402C124J5RAC
1	DS1	LED, low current (green)	ROHM	SML-P11MTT86
1	DS2	LED, AllnGaP, 560 nm, green, LED1206H77	Dialight	597-3311-407NF
4	E1 to E4	Inductor chip ferrite beads, 120 Ω, L0402	Murata Manufacturing	BLM15EG121SN1D
2	E10, E11	Inductor chip ferrite beads, 470 Ω, L0402	Murata Manufacturing	BLM15BB470SN1D
11	J1 to J9, J12, J13	PCB connectors, SMA, 50 Ω, end launch jack receptor	Cinch Connectivity Solutions	142-0701-851
4	J10, J11, J14, J15	PCB connectors, coaxial, SMA, standard	Cinch Connectivity Solutions	142-0701-201
2	L1, L2	Inductors, surface mount, 1 nH, L0402-2	Coilcraft	0402CS-1N0XJLW
16	L7 to L22	Inductor chip ferrite beads, 120 Ω, L0603	Murata Manufacturing	BLM18KG121TN1D
2	L23, L24	Inductor surface mounts, 150 nH, 0603CS	Coilcraft	0603CS-R15XJLW
1	L25	Inductors, shielded power, 6.8 µH, LSMSQ157H122	Coilcraft	XAL4030-682MEC

Qty.	Reference Designator	Description	Manufacturer	Part Number
4	L3 to L6	Inductor surface mount, 270 nH, 0603CS	Coilcraft	0603CS-R27XGLW
7	P1 to P6, P10	PCB connectors, BERG header, solder termination, male, 3-pin	Samtec	TSW-103-08-G-S
1	P9	PCB connector, board to board receptacle, solder termination, 0.6 mm pitch	Hirose Electric	FX8-120S-SV(21)
1	Q1	Transistor, NPNj surface mount, small signal, SOT23	Diodes Incorporated	BC848C-7-F
4	R1, R2, R69, R99	Resistors, metal film chip, 5.1 kΩ, R0402, 25 V, 1/16 W	Panasonic	ERA-2AEB512X
4	R9 to R12	Resistor, high frequency thin film chip, 25 Ω, R0402, 0.05 W	Vishay Precision Group	CH0402-25RJFPT
64	R3, R4, R21 to R25, R28 to R32, R37 to R39, R41, R44, R46, R48, R49, R50, R54, R79, R80, R87 to R89, R97, R105 to R109, R112, R113, R115 to R117, R119, R120, R127, R129, R130, R136 to R142, R145, R146, R148 to R150, R152, R154, R156, R159 to R164	Resistors, chip surface mount device jumper, 0 Ω, R0402	Panasonic	ERJ-2GE0R00X
1	R110	Resistor, precision thick film chip, 11 kΩ, R0402, 1/10 W	Panasonic	ERJ-2RKF1102X
9	R72 to R74, R114, R121 to R125	Resistors, thick film chip, 100 kΩ, R0402, 1/10 W	Panasonic	ERJ-2GEJ104X
1	R135	Resistor, film surface mount device, 51 Ω, R0402, 1/16 W	Panasonic	ERJ-2GEJ510X
4	R57, R62, R70, R143	Resistor, film surface mount device, 0 Ω, R0603, 1/10 W	Panasonic	ERJ-3GEY0R00V
3	R82, R84, R153	Resistors, standard thick film chip, 10 kΩ, R0402, 1/16 W	Vishay Precision Group	CRCW040210K0JNED
4	R17 to R20	Resistors, general purpose chip, 35.7 Ω, R0402, 1/16 W	Yageo	RC0402FR-0735R7L
2	R26, R27	Resistors, thick film chip, 220 Ω, R0402, 1/16 W	Multicomp	0402WGF2200TCE
1	R55	Resistor, precision thick film chip, 47 kΩ, R0402, 1/16 W	Panasonic	ERJ-2RKF4702X
1	R56	Resistor, thin film chip, 15 kΩ, R0603, 1/10 W	Yageo	RT0603BRB0715KL
1	R60	Resistor, precision thick film chip, 27 kΩ, R0402, 1/16 W	Panasonic	ERJ-2RKF2702X
1	R61	Resistor, precision thick film chip, 140 Ω, R0402, 1/16 W	Panasonic	ERJ-2RKF1400X
2	R63, R86	Resistor, precision thick film chip, 4.7 kΩ, R0402, 1/16 W	Panasonic	ERJ-2RKF4701X
1	R64	Resistor, standard thick film chip, 71.5 kΩ, R0402, 1/16 W	Vishay Precision Group	CRCW040271K5FKED
4	R65 to R68	Resistors, thick film, 0.1 Ω, R0402, 1/6 W	Panasonic	ERJ-2BSFR10X
4	R75 to R78	Resistors, precision thick film chip, 1 kΩ, R0402, 1/10 W	Panasonic	ERJ-2RKF1001X
1	R81	Resistor, film surface-mount device, 1.1 kΩ, R0402, 1/16 W	Panasonic	ERJ-2GEJ112X
1	R91	Resistors, precision thick film chip, 10 Ω, R0402, 1/16 W	Panasonic	ERJ-2RKF10R0X
1	R93	Resistors, precision thick film chip, 150 Ω, R0402, 1/10 W	Panasonic	ERJ-2RKF1500X
1	R94	Resistors, precision thick film chip, 130 Ω, R0402, 1/16 W	Panasonic	ERJ-2RKF1300X
1	R95	Resistors, precision thick film chip, 100 Ω, R0402, 1/10 W	Panasonic	ERJ-2RKF1000X
1	R96	Resistor, thick film chip, 47 Ω, R0402, 1/10 W	Panasonic	ERJ-2GEJ470X
2	T1, T2	RF transformer	Mini Circuits	TC1-1-13MX+

Qty.	Reference Designator	Description	Manufacturer	Part Number
2	T3, T4	RF transformer 50 Ω, 10 MHz to 8000 MHz	Mini Circuits	TCM1-83X+
8	TP1, TP26 to TP32	PCB connectors, test point, yellow	Components Corporation	TP-104-01-04
8	TP2, TP20 to TP24, TP34, TP38	PCB connector, test point, black	Components Corporation	TP-104-01-00
4	TP25, TP33, TP35, TP37	PCB connector, test point, red	Components Corporation	TP-104-01-02
1	U1	IC, dual downconverter with integrated LO	Analog Devices	ADRF6650
1	U10	IC, quad digital isolator	Analog Devices	ADUM140E0BRZ
1	U2	IC, ultralow noise, high power supply rejection ratio (PSRR), fast transient response complementary metal oxide semiconductor (CMOS), low dropout regulator (LDO)	Analog Devices	ADM7170ACPZ
1	U3	IC low quiescent current buck regulator	Analog Devices	ADP2370ACPZ-3.3
1	U4	IC, ultralow noise, high PSRR, fast transient response CMOS, LDO	Analog Devices	ADM7171ACPZ-3.3
1	U5	IC, quad low noise, high PSRR, linear voltage regulator	Analog Devices	HMC1060LP3E
1	U6	IC, 32 kB serial EEPROM	Microchip Technology	24LC32A-I/MS
1	U7	IC, clock generator with integer-N PLL, 0.1 MHz to 500 MHz	Analog Devices	HMC1031MS8E
1	U8	IC, 150 mA, low quiescent current, CMOS linear regulator, 1.8 V_{OUT}	Analog Devices	ADP121-AUJZ18
1	U9	IC, quad digital isolators	Analog Devices	ADUM141E0BRZ

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.

**ANALOG
DEVICES**

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