

## FEATURES

**Reflective, 50  $\Omega$  design**

**Low insertion loss**

0.6 dB typical to 2.0 GHz

0.7 dB typical to 3.5 GHz

**High isolation**

50 dB typical to 2.0 GHz

46 dB typical to 3.5 GHz

**High power handling**

RF input power, continuous wave (CW) at  $T_{CASE} = 85^{\circ}C$

43 dBm maximum operating

46.5 dBm absolute maximum rating

**High linearity**

0.1 dB compression (P0.1dB): 46 dBm typical

Input third-order intercept (IP3)

68 dBm typical to 2 GHz

65 dBm typical to 3.5 GHz

**ESD ratings**

Human body model (HBM): 2 kV, Class 2

Charged device model (CDM): 1.25 kV

**Single positive supply:  $V_{DD} = 5\text{ V}$**

**Positive control, TTL-compatible:  $V_{CTL} = 0\text{ V}$  or  $V_{DD}$**

**24-lead, 4 mm  $\times$  4 mm LFCSP package (16 mm<sup>2</sup>)**

## APPLICATIONS

**Cellular/4G infrastructure**

**Wireless infrastructure**

**Military and high reliability applications**

**Test equipment**

**Pin diode replacement**

## GENERAL DESCRIPTION

The **ADRF5130** is a high power, reflective, 0.7 GHz to 3.8 GHz, silicon, single-pole, double-throw (SPDT) switch in a leadless, surface-mount package. The switch is ideal for high power and cellular infrastructure applications, like long-term evolution (LTE) base stations.

## FUNCTIONAL BLOCK DIAGRAM

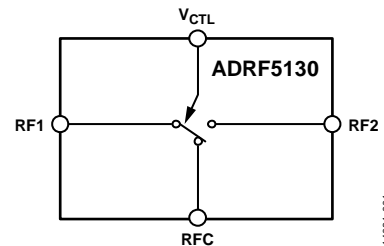


Figure 1.

14081-001

The **ADRF5130** has high power handling of 43 dBm (maximum) and 0.1 dB compression (P0.1dB) of 46 dBm, with a low insertion loss of 0.6 dB at 2 GHz and 0.7 dB at 3.5 GHz. On-chip circuitry operates at a single, positive supply voltage of 5 V and typical supply current of 1.06 mA, making the **ADRF5130** an ideal alternative to pin diode-based switches.

The device comes in a RoHS compliant, compact, 24-lead, 4 mm  $\times$  4 mm LFCSP package.

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## REVISION HISTORY

### 6/2020—Rev. B to Rev. C

|  |            |
|--|------------|
| Changed Operating Frequency from 0.7 GHz to 3.5 GHz to 0.7 GHz to 3.8 GHz .....      | Throughout |
| Changes to Data Sheet Title, Features Section, and General Description Section ..... | 1          |
| Changes to Table 1 .....   | 3          |

### 5/2018—Rev. A to Rev. B

|  |    |
|--|----|
| Change to RFC to RF2 Column, Table 5 ..... | 7  |
| Updated Outline Dimensions .....           | 10 |

### 1/2017—Rev. 0 to Rev. A

|                                 |    |
|---------------------------------|----|
| Changes to Ordering Guide ..... | 10 |
|---------------------------------|----|

### 7/2016—Revision 0: Initial Version

## SPECIFICATIONS

$V_{DD} = 5\text{ V}$ ,  $V_{CTL} = 0\text{ V}$  or  $V_{DD}$ ,  $T_A = 25^\circ\text{C}$ ,  $50\ \Omega$  system, unless otherwise noted.

Table 1.

| Parameter                          | Symbol               | Test Conditions/Comments  | Min | Typ  | Max      | Unit             |
|------------------------------------|----------------------|---|-----|------|----------|------------------|
| FREQUENCY RANGE                    |                      |   | 0.7 |      | 3.8      | GHz              |
| INSERTION LOSS                     |                      | 0.7 GHz to 2.0 GHz  |     | 0.6  |          | dB               |
|                                    |                      | 2.0 GHz to 3.5 GHz  |     | 0.7  |          | dB               |
|                                    |                      | 3.5 GHz to 3.8 GHz  |     | 0.75 |          | dB               |
| ISOLATION                          |                      |   |     |      |          |                  |
| RFC to RF1 or RF2 (Worst Case)     |                      | 0.7 GHz to 2.0 GHz  |     | 50   |          | dB               |
|                                    |                      | 2.0 GHz to 3.8 GHz  |     | 46   |          | dB               |
| RF1 to RF2 (Worst Case)            |                      | 0.7 GHz to 2.0 GHz  |     | 51   |          | dB               |
|                                    |                      | 2.0 GHz to 3.8 GHz  |     | 40   |          | dB               |
| RETURN LOSS                        |                      |   |     |      |          |                  |
| RFC                                |                      | 0.7 GHz to 2.0 GHz  |     | 23   |          | dB               |
|                                    |                      | 2.0 GHz to 3.5GHz   |     | 17   |          | dB               |
|                                    |                      | 3.5 GHz to 3.8 GHz  |     | 15   |          | dB               |
| RFC to RF1 or RF2                  |                      | 0.7 GHz to 2.0 GHz  |     | 21   |          | dB               |
|                                    |                      | 2.0 GHz to 3.5 GHz  |     | 17   |          | dB               |
|                                    |                      | 3.5 GHz to 3.8 GHz  |     | 16   |          | dB               |
| SWITCHING SPEED                    |                      |   |     |      |          |                  |
| Time                               |                      |   |     |      |          |                  |
| Rise and Fall                      | $t_{RISE}, t_{FALL}$ | 90% to 10% of RF output   |     | 155  |          | ns               |
| On and Off                         | $t_{ON}, t_{OFF}$    | 50% $V_{CTL}$ to 10% to 90% of RF output  |     | 750  |          | ns               |
| RADIO FREQUENCY (RF) SETTling TIME |                      | 50% $V_{CTL}$ to 0.1 dB margin of final RF output   |     | 1.8  |          | $\mu\text{s}$    |
| INPUT POWER                        |                      |   |     |      |          |                  |
| 0.1 dB Compression                 | P0.1dB               |   |     | 46   |          | dBm              |
| INPUT THIRD-ORDER INTERCEPT        | IP3                  | Two-tone input power = 25 dBm/tone  |     |      |          |                  |
|                                    |                      | 0.7 GHz to 2 GHz  |     | 68   |          | dBm              |
|                                    |                      | 2 GHz to 3.8 GHz  |     | 65   |          | dBm              |
| RECOMMENDED OPERATING CONDITIONS   |                      |   |     |      |          |                  |
| Voltage Range                      |                      |   |     |      |          |                  |
| Bias                               | $V_{DD}$             |   | 4.5 |      | 5.4      | V                |
| Control                            | $V_{CTL}$            |   | 0   |      | $V_{DD}$ | V                |
| Maximum RF Input Power             |                      |   |     |      |          |                  |
| $T_{CASE} = 105^\circ\text{C}$     |                      | Continuous wave   |     |      | 41       | dBm              |
| $T_{CASE} = 85^\circ\text{C}$      |                      | Continuous wave   |     |      | 43       | dBm              |
|                                    |                      | 8 dB peak to average ratio (PAR) LTE, average   |     |      | 38       | dBm              |
|                                    |                      | 8 dB PAR LTE, single event (<10 sec), average   |     |      | 44       | dBm              |
| $T_{CASE} = 25^\circ\text{C}$      |                      | Continuous wave   |     |      | 44.5     | dBm              |
| Case Temperature Range             | $T_{CASE}$           |   | -40 |      | +105     | $^\circ\text{C}$ |
| DIGITAL INPUT CONTROL VOLTAGE      |                      | $V_{DD} = 4.5\text{ V}$ to $5.4\text{ V}$ , $T_{CASE} = -40^\circ\text{C}$ to $+105^\circ\text{C}$ at $<1\ \mu\text{A}$ typical |     |      |          |                  |
| Low Range                          | $V_{IL}$             |   | 0   |      | 0.8      | V                |
| High Range                         | $V_{IH}$             |   | 1.3 |      | 5.0      | V                |
| SUPPLY CURRENT                     | $I_{DD}$             | $V_{DD} = 5\text{ V}$   |     | 1.06 |          | mA               |

## ABSOLUTE MAXIMUM RATINGS

Table 2.

| Parameter                                      | Rating           |
|--|------------------|
| Bias Voltage Range ( $V_{DD}$ )                | −0.3 V to +5.5 V |
| Control Voltage Range ( $V_{CTL}$ )            | −0.3 V to +5.5 V |
| RF Input Power, <sup>1</sup> Continuous Wave   | 46.5 dBm         |
| Channel Temperature                            | 135°C            |
| Storage Temperature Range                      | −65°C to +150°C  |
| Operating Temperature Range                    | −40°C to +105°C  |
| Peak Reflow Temperature (MSL3) <sup>2</sup>    | 260°C            |
| Thermal Resistance (Channel to Package Bottom) | 17°C/W           |
| Electrostatic Discharge (ESD) Sensitivity      |                  |
| HBM  | 2 kV (Class 2)   |
| CDM  | 1.25 kV          |

<sup>1</sup> For the recommended operating conditions, see Table 1.<sup>2</sup> See the Ordering Guide section.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

### 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.

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

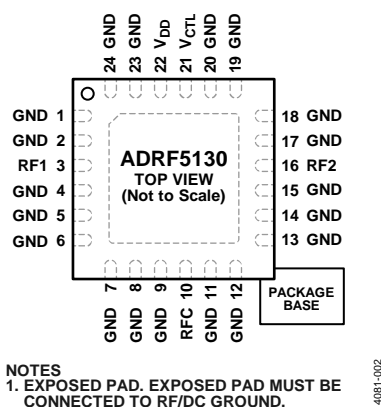


Figure 2. Pin Configuration

Table 3. Pin Function Descriptions

| Pin No.                                  | Mnemonic         | Description  |
|--|------------------|--|
| 1, 2, 4 to 9, 11 to 15, 17 to 20, 23, 24 | GND              | Ground. The package bottom has an exposed metal pad that must connect to the printed circuit board (PCB) RF/dc ground. See Figure 3 for the GND interface schematic. |
| 3  | RF1              | RF Output Port 1. This pin is dc-coupled and matched to 50 $\Omega$ . A dc blocking capacitor is required on this pin.   |
| 10                                       | RFC              | RF Input Common Port. This pin is dc-coupled and matched to 50 $\Omega$ . A dc blocking capacitor is required on this pin.   |
| 16                                       | RF2              | RF Output Port 2. This pin is dc-coupled and matched to 50 $\Omega$ . A dc blocking capacitor is required on this pin.   |
| 21                                       | V <sub>CTL</sub> | Control Input. See Figure 4 for the V <sub>CTL</sub> interface schematic. Refer to Table 4 and the recommended digital input control voltage range in Table 1.       |
| 22                                       | V <sub>DD</sub>  | Supply Voltage. See Figure 4 for the V <sub>DD</sub> interface schematic.  |
|  | EPAD             | Exposed Pad. Exposed pad must be connected to RF/dc ground.  |

Table 4. Truth Table

| Control Input (V <sub>CTL</sub> ) State | Signal Path State |            |
|---|-------------------|------------|
|   | RFC to RF1        | RFC to RF2 |
| Low                                     | Off               | On         |
| High                                    | On                | Off        |

## INTERFACE SCHEMATICS



Figure 3. GND Interface Schematic

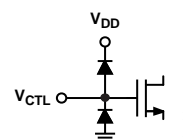


Figure 4. Control Interface Schematic

# TYPICAL PERFORMANCE CHARACTERISTICS

## INSERTION LOSS, ISOLATION, RETURN LOSS, AND IP3

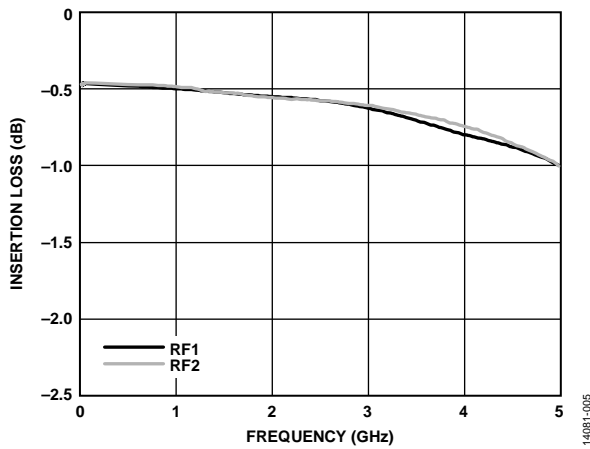


Figure 5. Insertion Loss of RF1 and RF2 vs. Frequency at  $V_{DD} = 5\text{ V}$

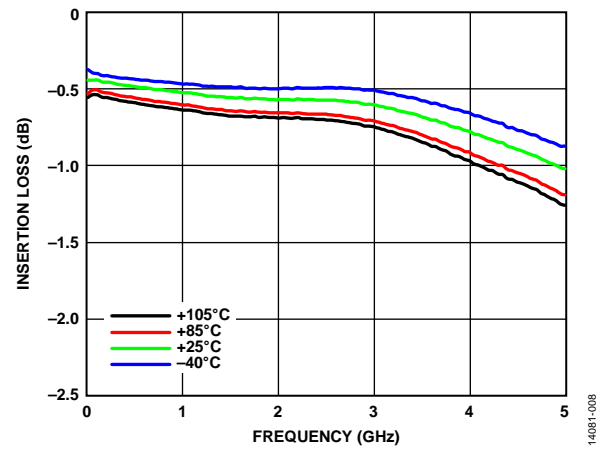


Figure 8. Insertion Loss vs. Frequency over Temperature at  $V_{DD} = 5\text{ V}$

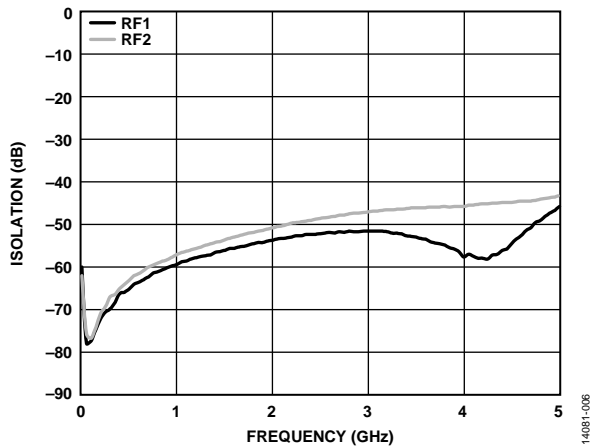


Figure 6. Isolation Between RFC to RF1 or RF2 vs. Frequency at  $V_{DD} = 5\text{ V}$

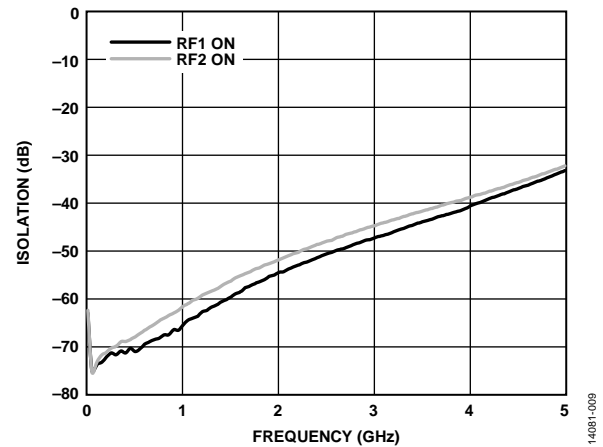


Figure 9. Isolation Between RF1 and RF2 vs. Frequency at  $V_{DD} = 5\text{ V}$ , Switch Mode On

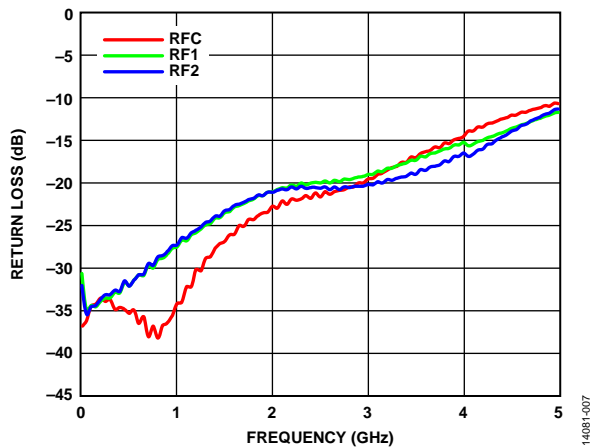


Figure 7. Return Loss vs. Frequency at  $V_{DD} = 5\text{ V}$  (RFC, RF1, and RF2)

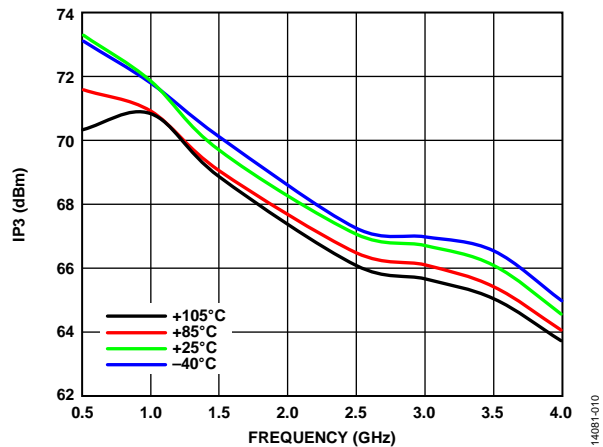


Figure 10. IP3 vs. Frequency over Temperature,  $V_{DD} = 5\text{ V}$

## THEORY OF OPERATION

The [ADRF5130](#) requires a single-supply voltage applied to the  $V_{DD}$  pin. Bypass capacitors are recommended on the supply line to minimize RF coupling.

A digital control voltage applied to the  $V_{CTL}$  pin controls the [ADRF5130](#). A small bypassing capacitor is recommended on these digital signal lines to improve the RF signal isolation.

The [ADRF5130](#) is internally matched to  $50\ \Omega$  at the RF input port (RFC) and the RF output ports (RF1 and RF2); therefore, no external matching components are required. The RFx pins are dc-coupled, and dc blocking capacitors are required on the RF lines. The design is bidirectional; the input and outputs are interchangeable.

The ideal power-up sequence of the [ADRF5130](#) is as follows:

1. Connect to GND.
2. Power up  $V_{DD}$ .
3. Power up the digital control input. Powering the digital control input before the  $V_{DD}$  supply can inadvertently forward-bias and damage the ESD protection structures.
4. Power up the RF input. Depending on the logic level applied to the  $V_{CTL}$  pin, one RF output port (for example, RF1) is set to on mode, by which an insertion loss path is provided from the input to the output, while the other RF output port (for example, RF2) is set to off mode, by which the output is isolated from the input.

**Table 5. Switch Operation Mode**

| Digital Control Input ( $V_{CTL}$ ) | Switch Mode  |   |
|-------------------------------------|--|---|
|                                     | RFC to RF1   | RFC to RF2  |
| 0                                   | Off mode: the RF1 port is isolated from the RFC port and is internally terminated to a $50\ \Omega$ load to absorb the applied RF signals. | On mode: a low insertion loss path from the RFC port to the RF2 port.             |
| 1                                   | On mode: a low insertion loss path from the RFC port to the RF1 port.  | Off mode: the RF2 port is isolated from the RFC port and becomes open reflective. |

## APPLICATIONS INFORMATION

Generate the evaluation PCB used in the application circuit shown in Figure 11 with proper RF circuit design techniques. Signal lines at the RF port must have a 50  $\Omega$  impedance, and the package ground leads and backside ground slug must connect directly to the ground plane, as shown in Figure 14.

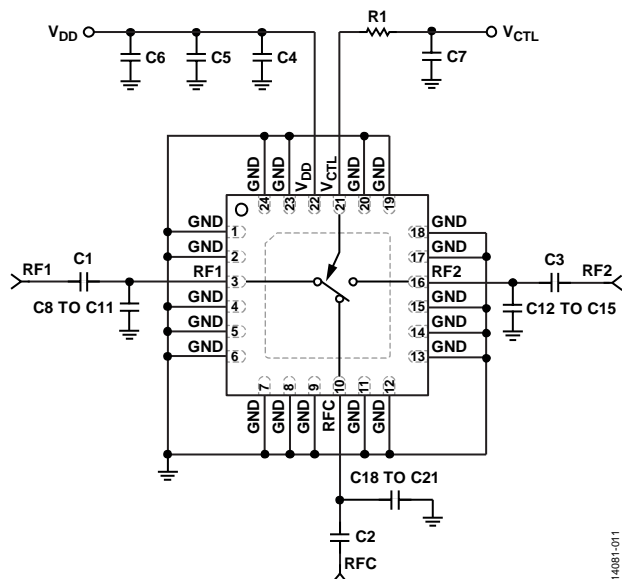


Figure 11. Application Circuit

## EVALUATION BOARD

The ADRF5130 evaluation board has eight metal layers and dielectrics between each layer (see Figure 12). The top and the bottom metal layers have copper thickness of 2 oz (2.7 mil), whereas the metal layers in between them have 1 oz copper (1.3 mil) thickness. The top dielectric material is 10 mil Rogers RO4350, which exhibits a very low thermal coefficient, offering control over thermal rise of the board. The dielectrics between other metal layers are FR-4. The overall board thickness achieved is 62 mil.

Figure 13 shows the top view of the ADRF5130 evaluation board.

The top copper layer has all RF and dc traces, whereas the other seven layers provide good ground and help to handle the thermal rise on the evaluation board caused by the high power of the ADRF5130. In addition, for proper thermal grounding, many via holes are provided around the transmission lines and under the exposed pad of the package. RF transmission lines on the ADRF5130 evaluation board are coplanar wave guide design with an 18 mil width and a ground spacing of 13 mil. For controlling the thermal rise of the ADRF5130 evaluation board at high temperatures and power levels, it is recommended to use a heat sink and a mini dc fan.

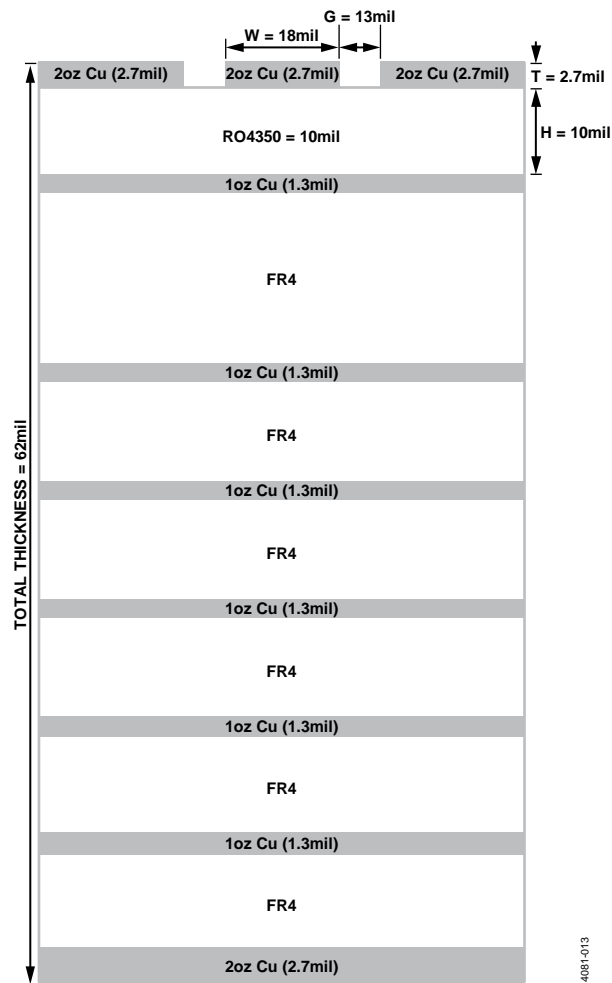


Figure 12. Evaluation Board Cross-Sectional View

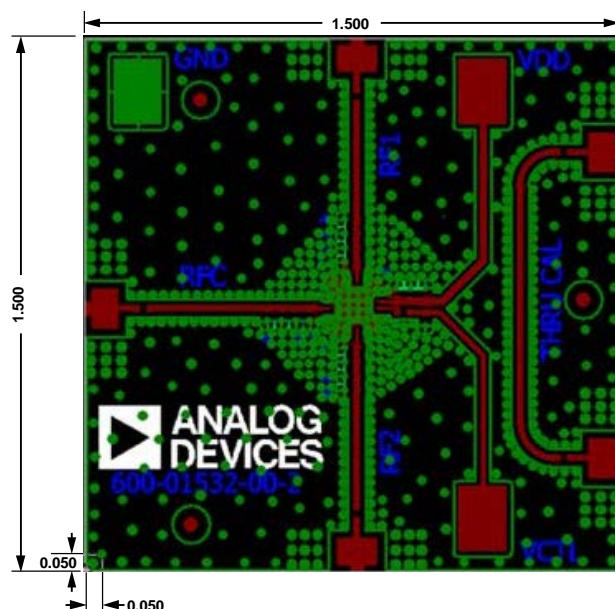


Figure 13. Evaluation Board Top View

Figure 14 shows the [ADRF5130](#) evaluation board with all components populated. The VDD supply port connects to TP1. The VDD supply trace has three bypass capacitors 100 pF, 1  $\mu$ F, and 1 nF. The TP2 test point connects to the control voltage port (VCTL). The control trace has a 100 pF bypass capacitor and 0  $\Omega$  resistor. The ground reference connects to GND. A 100 pF dc blocking capacitor is used on all RF traces that connect the RF1, RF2, and RFC ports to the J1, J2, and J3 connectors,

respectively. The connectors used are 2.9 mm end launch SMA connectors. Unpopulated capacitor positions are available on all RF traces to provide extra matching. A through transmission line (THRU CAL) is available on the [ADRF5130](#) evaluation board that can measure board loss on the printed circuit board (PCB).

Table 6 shows the bill of materials for the [ADRF5130](#) evaluation board. The evaluation board shown in Figure 14 is available from Analog Devices, Inc., upon request.

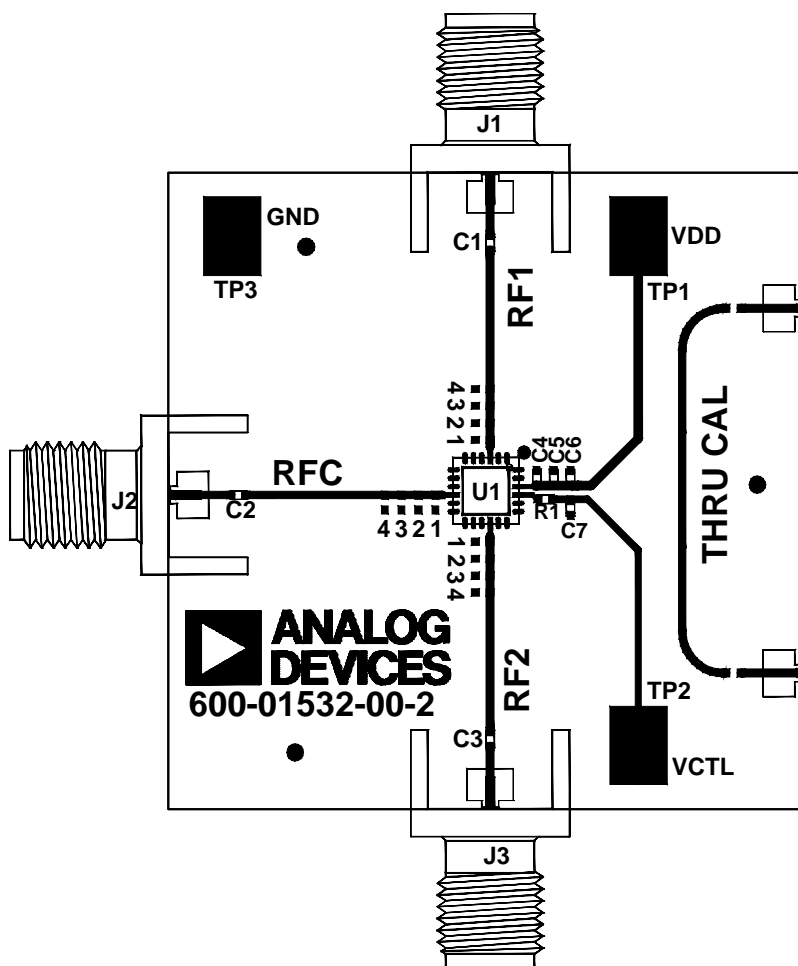


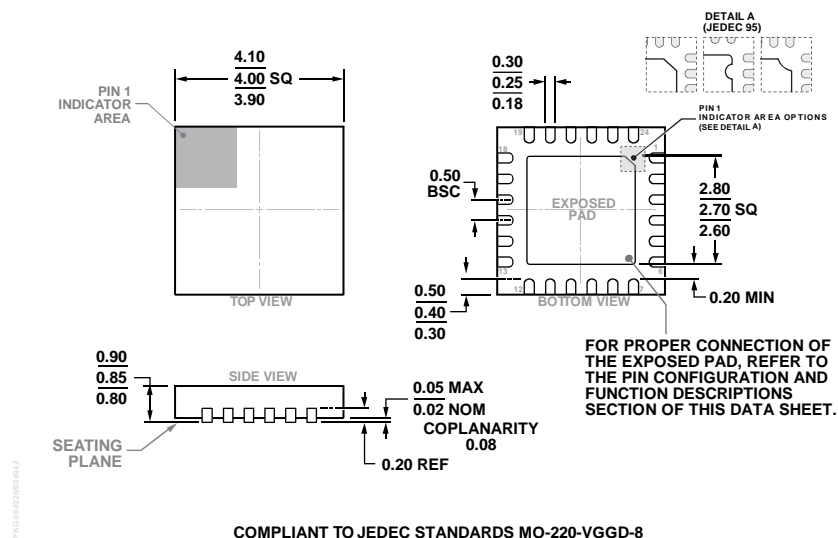
Figure 14. [ADRF5130-EVALZ](#) Evaluation Board

Table 6. Bill of Materials for the [ADRF5130-EVALZ](#) Evaluation Board

| Reference Designator  | Description   |
|-----------------------|---|
| J1 to J3              | PCB mount SMA connectors  |
| C1 to C4, C7          | 100 pF capacitors, 0402 package   |
| C5                    | 1 nF capacitor, 0402 package  |
| C6                    | 1 $\mu$ F capacitor, 0402 package   |
| C8 to C15, C18 to C21 | Do not insert (DNI)   |
| R1                    | 0 $\Omega$ resistor, 0402 package   |
| TP1, TP2, TP3         | Surface-mount test points   |
| U1                    | <a href="#">ADRF5130</a> SPDT switch  |
| PCB                   | 600-01532-00-2 <sup>1</sup> evaluation PCB; circuit board material: Rogers RO4350 or Arlon 25FR |

<sup>1</sup> Reference this evaluation board number when ordering the complete evaluation board.

## OUTLINE DIMENSIONS



## ORDERING GUIDE

| Model <sup>1</sup> | Temperature Range | MSL Rating <sup>2</sup> | Package Description                           | Package Option |
|--------------------|-------------------|-------------------------|---|----------------|
| ADRF5130BCPZ       | −40°C to +105°C   | MSL3                    | 24-Lead Lead Frame Chip Scale Package [LFCSP] | CP-24-16       |
| ADRF5130BCPZ-R7    | −40°C to +105°C   | MSL3                    | 24-Lead Lead Frame Chip Scale Package [LFCSP] | CP-24-16       |
| ADRF5130-EVALZ     | −40°C to +105°C   |                         | Evaluation Board                              |                |

<sup>1</sup> Z = RoHS Compliant Part.

<sup>2</sup> See the Absolute Maximum Ratings section.

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