

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

Supply Voltage .....5.5V

Common Mode Level of BBPI, BBMI

and BBPQ, BBMQ.....0.6V

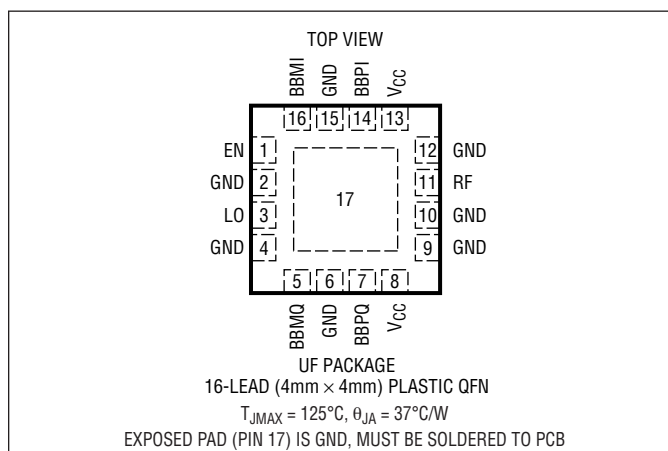
Voltage on Any Pin

Not to Exceed..... $-500\text{mV}$  to  $(V_{CC} + 500\text{mV})$ 

Operating Ambient Temperature Range

(Note 2)..... $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ Storage Temperature Range..... $-65^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ 

## PACKAGE/ORDER INFORMATION



ORDER PART NUMBER

UF PART MARKING

LT5572EUF

5572

Order Options Tape and Reel: Add #TR

Lead Free: Add #PBF Lead Free Tape and Reel: Add #TRPBF

Lead Free Part Marking: <http://www.linear.com/leadfree/>

Consult LTC Marketing for parts specified with wider operating temperature ranges.

## ELECTRICAL CHARACTERISTICS

 $V_{CC} = 5\text{V}$ ,  $EN = \text{High}$ ,  $T_A = 25^{\circ}\text{C}$ ,  $f_{LO} = 2\text{GHz}$ ,  $f_{RF} = 2002\text{MHz}$ ,  $P_{LO} = 0\text{dBm}$ .  
 BBPI, BBMI, BBPQ, BBMQ inputs  $0.5V_{DC}$ , baseband input frequency =  $2\text{MHz}$ , I and Q  $90^{\circ}$  shifted (upper sideband selection).  
 $P_{RF(OUT)} = -10\text{dBm}$ , unless otherwise noted. (Note 3)

| SYMBOL                   | PARAMETER                           | CONDITIONS                                                                                                    | MIN | TYP                        | MAX | UNITS                      |
|--------------------------|-------------------------------------|---------------------------------------------------------------------------------------------------------------|-----|----------------------------|-----|----------------------------|
| <b>RF Output (RF)</b>    |                                     |                                                                                                               |     |                            |     |                            |
| $f_{RF}$                 | RF Frequency Range                  | -3dB Bandwidth<br>-1dB Bandwidth                                                                              |     | 1.5 to 2.5<br>1.7 to 2.15  |     | GHz<br>GHz                 |
| $S_{22(ON)}$             | RF Output Return Loss               | $EN = \text{High}$ (Note 6)                                                                                   |     | -13.5                      |     | dB                         |
| $S_{22(OFF)}$            | RF Output Return Loss               | $EN = \text{Low}$ (Note 6)                                                                                    |     | -12.5                      |     | dB                         |
| NFloor                   | RF Output Noise Floor               | No Input Signal (Note 8)<br>$P_{OUT} = 4\text{dBm}$ (Note 9)<br>$P_{OUT} = 4\text{dBm}$ (Note 10)             |     | -158.6<br>-152.5<br>-152.2 |     | dBm/Hz<br>dBm/Hz<br>dBm/Hz |
| $G_V$                    | Conversion Voltage Gain             | $20 \cdot \log(V_{OUT(50\Omega)}/V_{IN(DIFF)} I \text{ or } Q)$                                               |     | -2.5                       |     | dB                         |
| $P_{OUT}$                | Output Power                        | $1V_{PP(DIFF)}$ CW Signal, I and Q                                                                            |     | 1.4                        |     | dBm                        |
| $G_{3LO \text{ VS } LO}$ | 3 • LO Conversion Gain Difference   | (Note 17)                                                                                                     |     | -29.5                      |     | dB                         |
| OP1dB                    | Output 1dB Compression              | (Note 7)                                                                                                      |     | 9.3                        |     | dBm                        |
| OIP2                     | Output 2nd Order Intercept          | (Notes 13, 14)                                                                                                |     | 53.2                       |     | dBm                        |
| OIP3                     | Output 3rd Order Intercept          | (Notes 13, 15)                                                                                                |     | 21.6                       |     | dBm                        |
| IR                       | Image Rejection                     | (Note 16)                                                                                                     |     | -41.2                      |     | dBc                        |
| LOFT                     | Carrier Leakage<br>(LO Feedthrough) | $EN = \text{High}$ , $P_{LO} = 0\text{dBm}$ (Note 16)<br>$EN = \text{Low}$ , $P_{LO} = 0\text{dBm}$ (Note 16) |     | -39.4<br>-58               |     | dBm<br>dBm                 |

## ELECTRICAL CHARACTERISTICS

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 BBPI, BBMI, BBPQ, BBMQ inputs  $0.5V_{DC}$ , baseband input frequency =  $2\text{MHz}$ , I and Q  $90^\circ$  shifted (upper sideband selection).  
 $P_{RF(OUT)} = -10\text{dBm}$ , unless otherwise noted. (Note 3)

| SYMBOL               | PARAMETER                      | CONDITIONS                                           | MIN | TYP        | MAX | UNITS |
|----------------------|--------------------------------|------------------------------------------------------|-----|------------|-----|-------|
| <b>LO Input (LO)</b> |                                |                                                      |     |            |     |       |
| $f_{LO}$             | LO Frequency Range             |                                                      |     | 1.5 to 2.5 |     | GHz   |
| $P_{LO}$             | LO Input Power                 |                                                      | -10 | 0          | 5   | dBm   |
| $S_{11(ON)}$         | LO Input Return Loss           | $EN = \text{High}$ , $P_{LO} = 0\text{dBm}$ (Note 6) |     | -15        |     | dB    |
| $S_{11(OFF)}$        | LO Input Return Loss           | $EN = \text{Low}$ (Note 6)                           |     | -5.3       |     | dB    |
| $NF_{LO}$            | LO Input Referred Noise Figure | at $2\text{GHz}$ (Note 5)                            |     | 14.5       |     | dB    |
| $G_{LO}$             | LO to RF Small-Signal Gain     | at $2\text{GHz}$ (Note 5)                            |     | 25         |     | dB    |
| $IIP3_{LO}$          | LO Input 3rd Order Intercept   | at $2\text{GHz}$ (Note 5)                            |     | -0.5       |     | dBm   |

### Baseband Inputs (BBPI, BBMI, BBPQ, BBMQ)

|                     |                               |                                         |  |      |     |                 |
|---------------------|-------------------------------|-----------------------------------------|--|------|-----|-----------------|
| $BW_{BB}$           | Baseband Bandwidth            | -3dB Bandwidth                          |  | 460  |     | MHz             |
| $V_{CMBB}$          | DC Common Mode Voltage        | Externally Applied (Note 4)             |  | 0.5  | 0.6 | V               |
| $R_{IN}$            | Differential Input Resistance |                                         |  | 90   |     | k $\Omega$      |
| $I_{DC(IN)}$        | Baseband Static Input Current | (Note 4)                                |  | -20  |     | $\mu\text{A}$   |
| $P_{LOBB}$          | Carrier Feedthrough to BB     | $P_{OUT} = 0$ (Note 4)                  |  | -39  |     | dBm             |
| $IP1\text{dB}$      | Input 1dB Compression Point   | Differential Peak-to-Peak (Notes 7, 18) |  | 2.8  |     | $V_{P-P(DIFF)}$ |
| $\Delta G_{I/Q}$    | I/Q Absolute Gain Imbalance   |                                         |  | 0.07 |     | dB              |
| $\Delta \phi_{I/Q}$ | I/Q Absolute Phase Imbalance  |                                         |  | 0.9  |     | Deg             |

### Power Supply ( $V_{CC}$ )

|               |                            |                                     |     |      |      |               |
|---------------|----------------------------|-------------------------------------|-----|------|------|---------------|
| $V_{CC}$      | Supply Voltage             |                                     | 4.5 | 5    | 5.25 | V             |
| $I_{CC(ON)}$  | Supply Current             | $EN = \text{High}$                  |     | 120  | 145  | mA            |
| $I_{CC(OFF)}$ | Supply Current, Sleep Mode | $EN = 0V$                           |     |      | 50   | $\mu\text{A}$ |
| $t_{ON}$      | Turn-On Time               | $EN = \text{Low to High}$ (Note 11) |     | 0.25 |      | $\mu\text{s}$ |
| $t_{OFF}$     | Turn-Off Time              | $EN = \text{High to Low}$ (Note 12) |     | 1.3  |      | $\mu\text{s}$ |

### Enable (EN), Low = Off, High = On

|        |                    |                    |   |     |     |               |
|--------|--------------------|--------------------|---|-----|-----|---------------|
| Enable | Input High Voltage | $EN = \text{High}$ | 1 |     |     | V             |
|        | Input High Current | $EN = 5V$          |   | 230 |     | $\mu\text{A}$ |
| Sleep  | Input Low Voltage  | $EN = \text{Low}$  |   |     | 0.5 | V             |

**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** Specifications over the  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  temperature range are assured by design, characterization and correlation with statistical process controls.

**Note 3:** Tests are performed as shown in the configuration of Figure 7.

**Note 4:** At each of the four baseband inputs BBPI, BBMI, BBPQ and BBMQ.

**Note 5:**  $V_{BBPI} - V_{BBMI} = 1V_{DC}$ ,  $V_{BBPQ} - V_{BBMQ} = 1V_{DC}$ .

**Note 6:** Maximum value within -1dB bandwidth.

**Note 7:** An external coupling capacitor is used in the RF output line.

**Note 8:** At 20MHz offset from the LO signal frequency.

**Note 9:** At 20MHz offset from the CW signal frequency.

**Note 10:** At 5MHz offset from the CW signal frequency.

**Note 11:** RF power is within 10% of final value.

**Note 12:** RF power is at least 30dB lower than in the ON state.

**Note 13:** Baseband is driven by 2MHz and 2.1MHz tones. Drive level is set in such a way that the two resulting RF tones are -10dBm each.

**Note 14:** IM2 measured at LO frequency + 4.1MHz

**Note 15:** IM3 measured at LO frequency + 1.9MHz and LO frequency + 2.2MHz.

**Note 16:** Amplitude average of the characterization data set without image or LO feedthrough nulling (unadjusted).

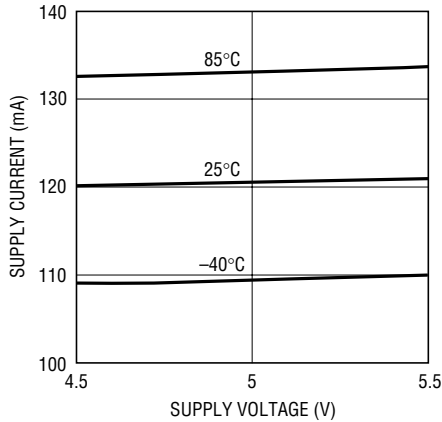
**Note 17:** The difference in conversion gain between the spurious signal at  $f = 3 \cdot LO - BB$  versus the conversion gain of the desired signal at  $f = LO + BB$  for  $BB = 2\text{MHz}$  and  $LO = 2\text{GHz}$ .

**Note 18:** The input voltage corresponding to the output P1dB.

# TYPICAL PERFORMANCE CHARACTERISTICS

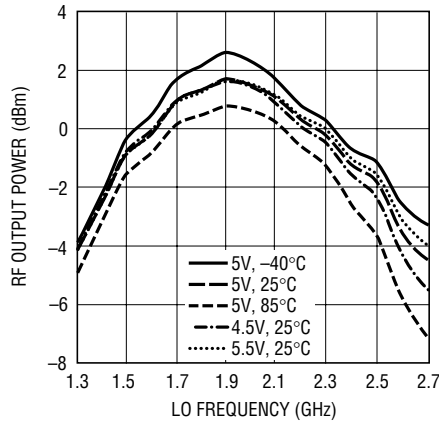
$V_{CC} = 5V$ ,  $EN = \text{High}$ ,  $T_A = 25^\circ\text{C}$ ,  $f_{LO} = 2.14\text{GHz}$ ,  $P_{LO} = 0\text{dBm}$ . BBPI, BBMI, BBPQ, BBMQ inputs  $0.5V_{DC}$ , baseband input frequency  $f_{BB} = 2\text{MHz}$ , I and Q  $90^\circ$  shifted, without image or LO feedthrough nulling.  $f_{RF} = f_{BB} + f_{LO}$  (upper sideband selection).  $P_{RF(OUT)} = -10\text{dBm}$  ( $-10\text{dBm}/\text{tone}$  for 2-tone measurements), unless otherwise noted. (Note 3)

Supply Current vs Supply Voltage



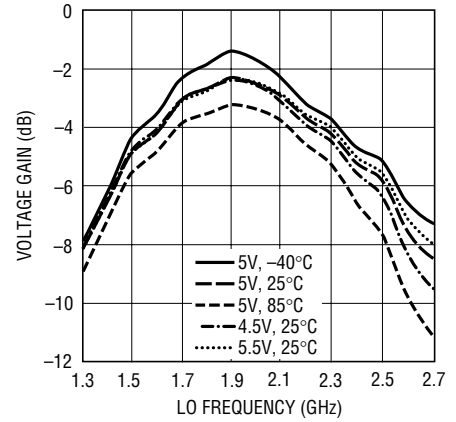
5572 G01

RF Output Power vs LO Frequency at  $1V_{P-P}$  Differential Baseband Drive



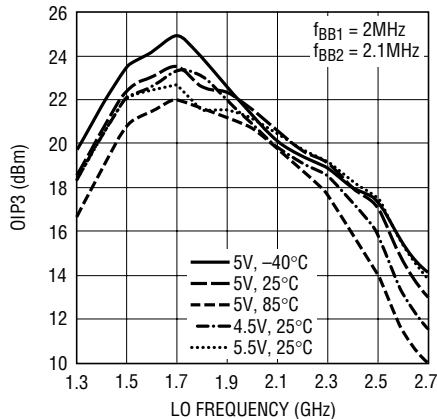
5572 G02

Voltage Gain vs LO Frequency



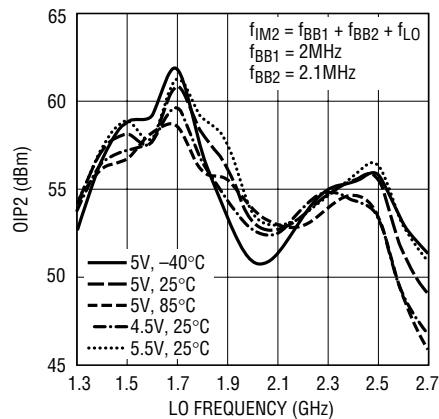
5572 G03

Output IP3 vs LO Frequency



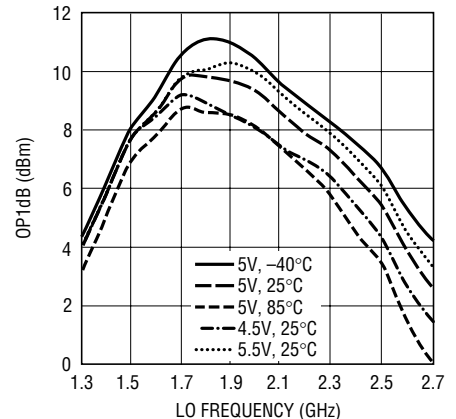
5572 G04

Output IP2 vs LO Frequency



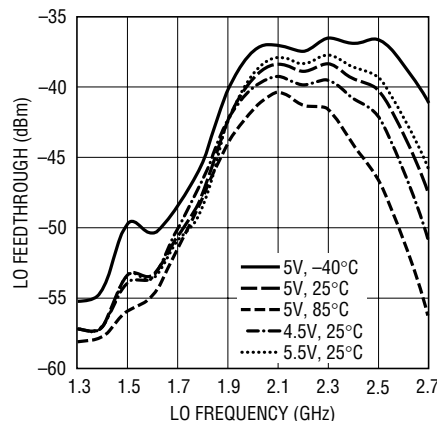
5572 G05

Output 1dB Compression vs LO Frequency



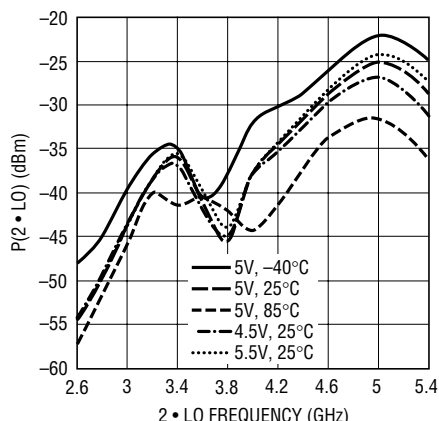
5572 G06

LO Feedthrough to RF Output vs LO Frequency



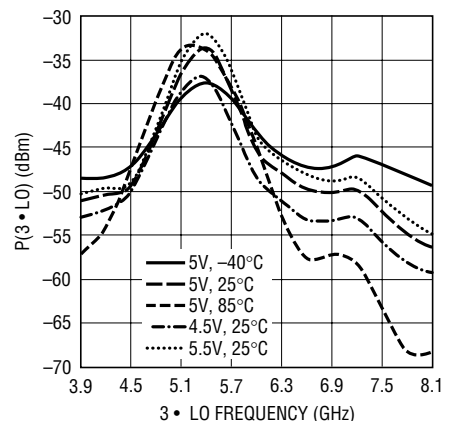
5572 G07

2 • LO Leakage to RF Output vs 2 • LO Frequency



5572 G08

3 • LO Leakage to RF Output vs 3 • LO Frequency

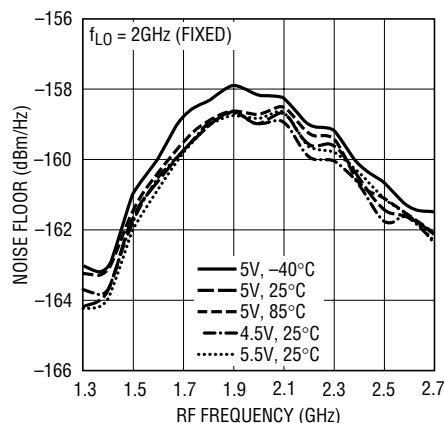


5572 G09

5572f

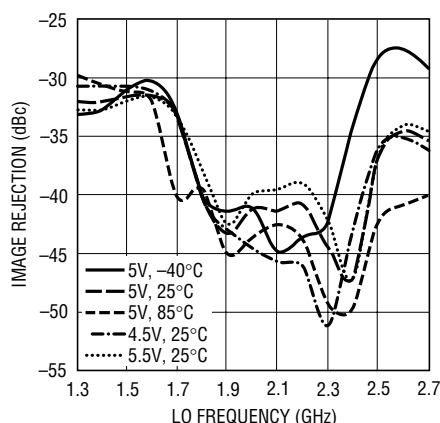
**TYPICAL PERFORMANCE CHARACTERISTICS**  $V_{CC} = 5V$ ,  $EN = \text{High}$ ,  $T_A = 25^\circ\text{C}$ ,  $f_{LO} = 2.14\text{GHz}$ ,  $P_{LO} = 0\text{dBm}$ . BBPI, BBMI, BBPQ, BBMQ inputs  $0.5V_{DC}$ , baseband input frequency  $f_{BB} = 2\text{MHz}$ , I and Q  $90^\circ$  shifted, without image or LO feedthrough nulling.  $f_{RF} = f_{BB} + f_{LO}$  (upper sideband selection).  $P_{RF(OUT)} = -10\text{dBm}$  ( $-10\text{dBm}/\text{tone}$  for 2-tone measurements), unless otherwise noted. (Note 3)

Noise Floor vs RF Frequency



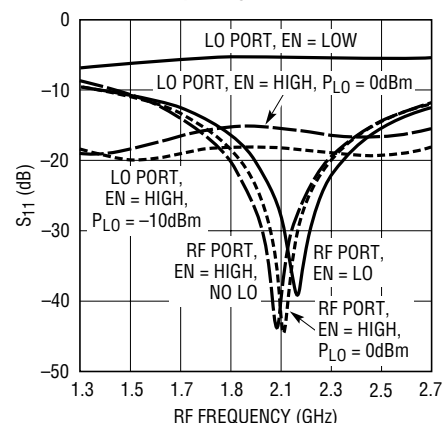
5572 G10

Image Rejection vs LO Frequency



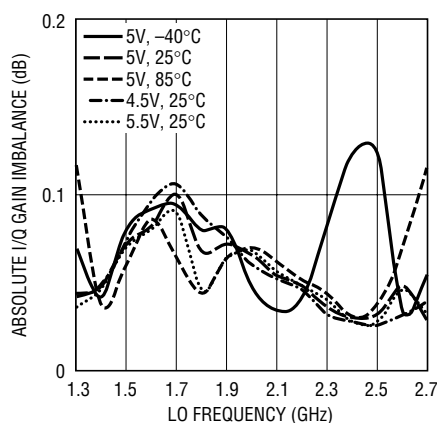
5572 G11

LO and RF Port Return Loss vs RF Frequency



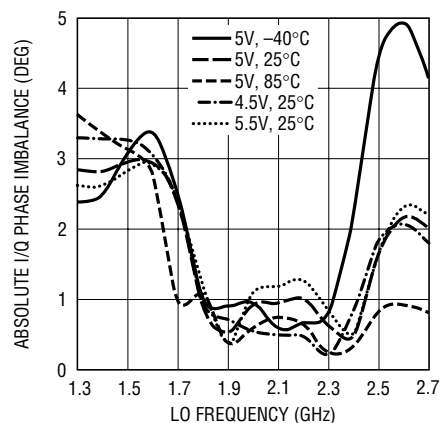
5572 G12

Absolute I/Q Gain Imbalance vs LO Frequency



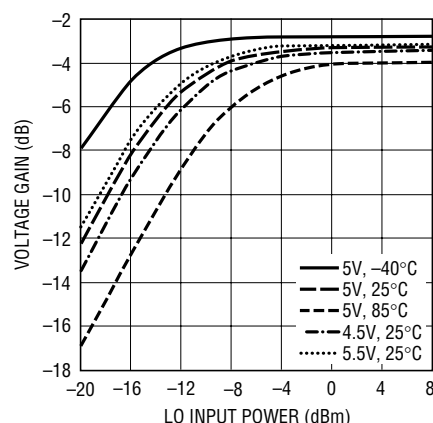
5572 G13

Absolute I/Q Phase Imbalance vs LO Frequency



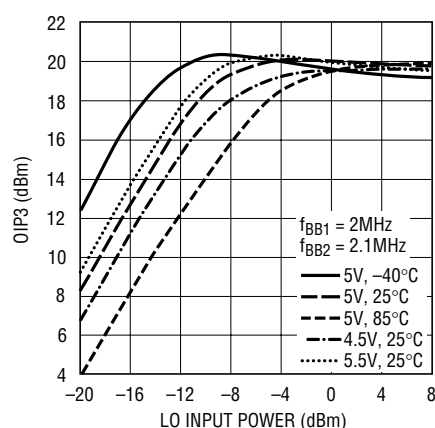
5572 G14

Voltage Gain vs LO Power



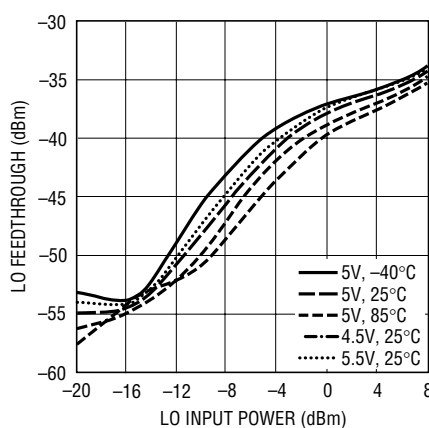
5572 G15

Output IP3 vs LO Power



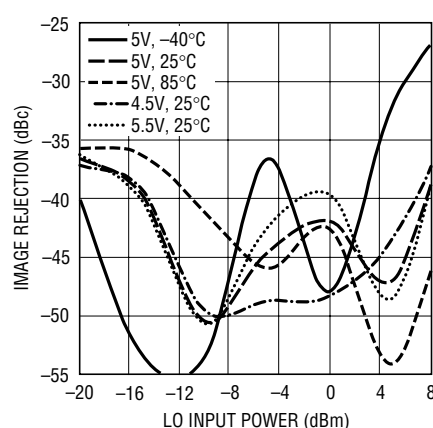
5572 G16

LO Feedthrough vs LO Power



5572 G17

Image Rejection vs LO Power



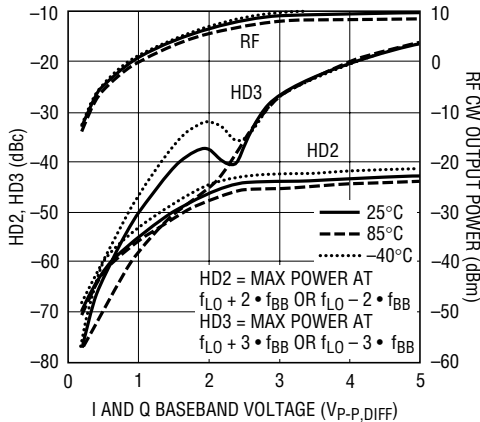
5572 G18

5572f

# TYPICAL PERFORMANCE CHARACTERISTICS

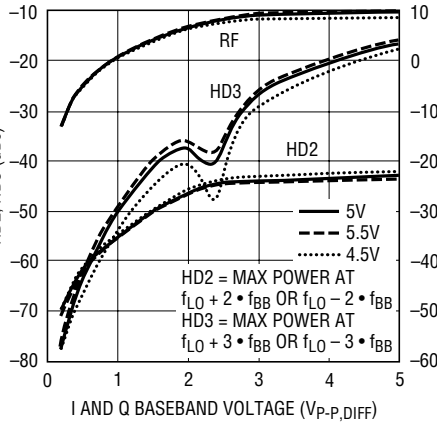
$V_{CC} = 5V$ ,  $EN = \text{High}$ ,  $T_A = 25^\circ\text{C}$ ,  $f_{LO} = 2.14\text{GHz}$ ,  $P_{LO} = 0\text{dBm}$ . BBPI, BBMI, BBPQ, BBMQ inputs  $0.5V_{DC}$ , baseband input frequency  $f_{BB} = 2\text{MHz}$ , I and Q  $90^\circ$  shifted, without image or LO feedthrough nulling.  $f_{RF} = f_{BB} + f_{LO}$  (upper sideband selection).  $P_{RF(OUT)} = -10\text{dBm}$  ( $-10\text{dBm}/\text{tone}$  for 2-tone measurements), unless otherwise noted. (Note 3)

**RF CW Output Power, HD2 and HD3 vs CW Baseband Voltage and Temperature**



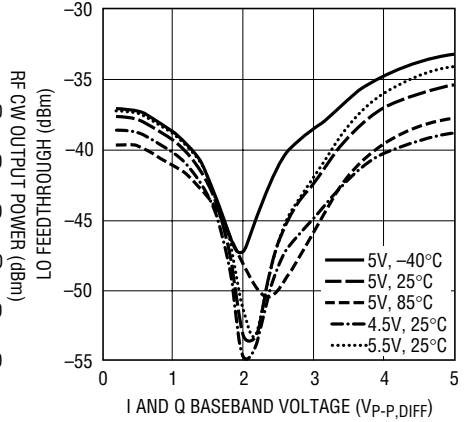
5572 G19

**RF CW Output Power, HD2 and HD3 vs CW Baseband and Supply Voltage**



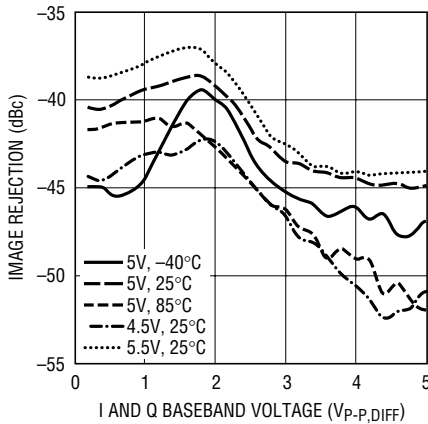
5572 G20

**LO Feedthrough to RF Output vs CW Baseband Voltage**



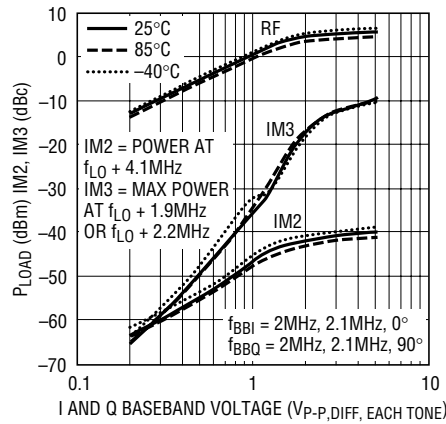
5572 G21

**Image Rejection vs CW Baseband Voltage**



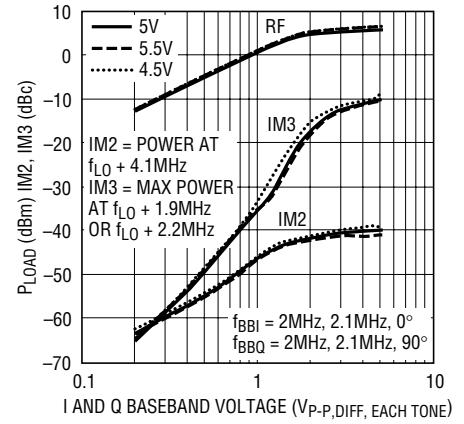
5572 G22

**RF 2-Tone Power (Each Tone), IM2 and IM3 vs Baseband Voltage and Temperature**



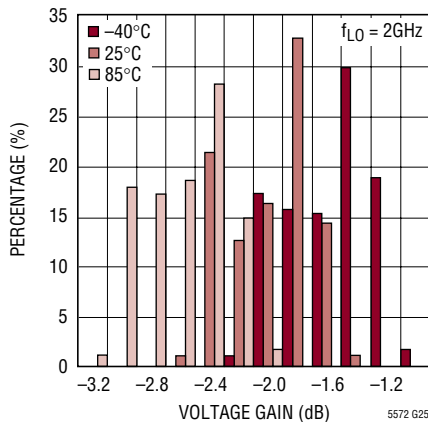
5572 G23

**RF 2-Tone Power (Each Tone), IM2 and IM3 vs Baseband and Supply Voltage**



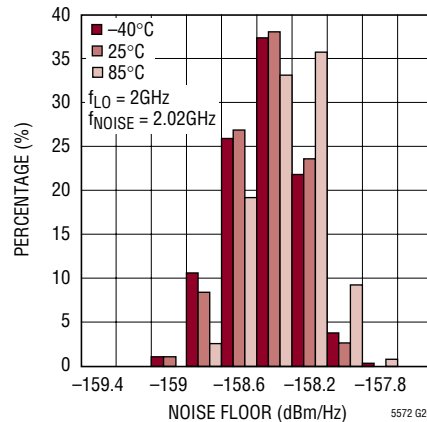
5572 G24

**Voltage Gain Distribution**



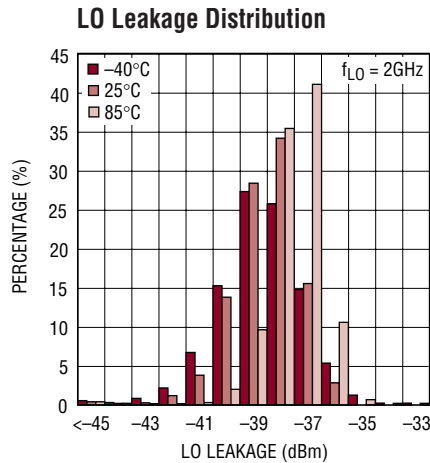
5572 G25

**Noise Floor Distribution**

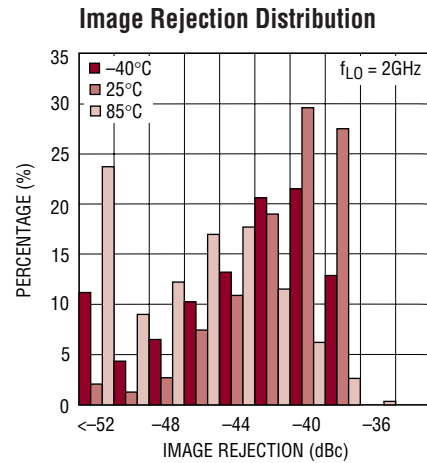


5572 G26

**TYPICAL PERFORMANCE CHARACTERISTICS**  $V_{CC} = 5V$ ,  $EN = \text{High}$ ,  $T_A = 25^\circ\text{C}$ ,  $f_{LO} = 2.14\text{GHz}$ ,  $P_{LO} = 0\text{dBm}$ . BBPI, BBMI, BBPQ, BBMQ inputs  $0.5V_{DC}$ , baseband input frequency  $f_{BB} = 2\text{MHz}$ , I and Q  $90^\circ$  shifted, without image or LO feedthrough nulling.  $f_{RF} = f_{BB} + f_{LO}$  (upper sideband selection).  $P_{RF(OUT)} = -10\text{dBm}$  ( $-10\text{dBm/tone}$  for 2-tone measurements), unless otherwise noted. (Note 3)



5572 G27



5572 G28

## PIN FUNCTIONS

**EN (Pin 1):** Enable Input. When the EN pin voltage is higher than 1V, the IC is turned on. When the input voltage is less than 0.5V, the IC is turned off.

**GND (Pins 2, 4, 6, 9, 10, 12, 15, 17):** Ground. Pins 6, 9, 15 and the Exposed Pad, Pin 17, are connected to each other internally. Pins 2 and 4 are connected to each other internally and function as the ground return for the LO signal. Pins 10 and 12 are connected to each other internally and function as the ground return for the on-chip RF balun. For best RF performance, Pins 2, 4, 6, 9, 10, 12, 15 and the Exposed Pad, Pin 17, should be connected to the printed circuit board ground plane.

**LO (Pin 3):** LO Input. The LO input is an AC-coupled single-ended input with approximately  $50\Omega$  input impedance at RF frequencies. Externally applied DC voltage should be within the range  $-0.5V$  to  $(V_{CC} + 0.5V)$  in order to avoid turning on ESD protection diodes.

**BBPQ, BBMQ (Pins 7, 5):** Baseband Inputs for the Q channel with about  $90k\Omega$  differential input impedance. These pins should be externally biased at about 0.5V. Applied common mode voltage must stay below 0.6V.

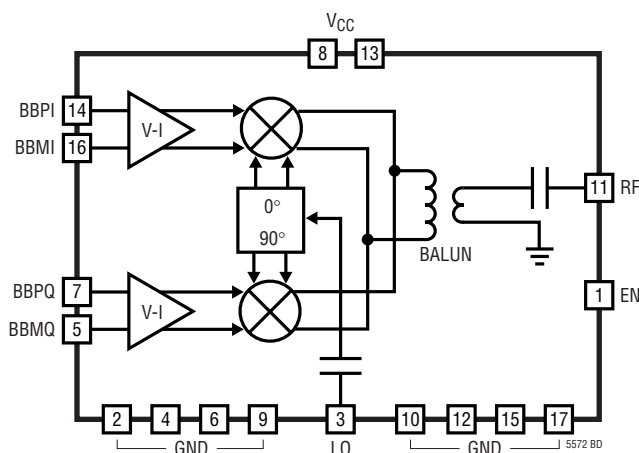
**$V_{CC}$  (Pins 8, 13):** Power Supply. Pins 8 and 13 are connected to each other internally. It is recommended to use  $0.1\mu\text{F}$  capacitors for decoupling to ground on each of these pins.

**RF (Pin 11):** RF Output. The RF output is an AC-coupled single-ended output with approximately  $50\Omega$  output impedance at RF frequencies. Externally applied DC voltage should be within the range  $-0.5V$  to  $(V_{CC} + 0.5V)$  in order to avoid turning on ESD protection diodes.

**BBPI, BBMI (Pins 14, 16):** Baseband Inputs for the I channel with about  $90k\Omega$  differential input impedance. These pins should be externally biased at about 0.5V. Applied common mode voltage must stay below 0.6V.



## BLOCK DIAGRAM



## APPLICATIONS INFORMATION

The LT5572 consists of I and Q input differential voltage-to-current converters, I and Q up-conversion mixers, an RF output balun, an LO quadrature phase generator and LO buffers.

External I and Q baseband signals are applied to the differential baseband input pins, BBPI, BBMI, and BBPQ, BBMQ. These voltage signals are converted to currents and translated to RF frequency by means of double-balanced up-converting mixers. The mixer outputs are combined in an RF output balun, which also transforms the output impedance to 50Ω. The center frequency of the resulting RF signal is equal to the LO signal frequency. The LO input drives a phase shifter which splits the LO signal into in-phase and quadrature LO signals. These LO signals are then applied to on-chip buffers which drive the up-conversion mixers. Both the LO input and RF output are single-ended, 50Ω matched and AC coupled.

### Baseband Interface

The baseband inputs (BBPI, BBMI) and (BBPQ, BBMQ) present a differential input impedance of about 90kΩ. At each of the four baseband inputs, a capacitor of 1.8pF to ground and a PNP emitter follower is incorporated (see Figure 1), which limits the baseband -1dB bandwidth to approximately 250MHz. The circuit is optimized for an externally applied common mode voltage of 0.5V. The baseband input pins should not be left floating because

the internal PNP's base current will pull the common mode voltage higher than the 0.6V limit. This may damage the part if continued indefinitely. The PNP's base current is about 20μA in normal operation. On the LT5572 demo board, external 50Ω resistors to ground are included at each baseband input to prevent this condition and to serve as a termination resistance for the baseband connections.

The I/Q input signals to the LT5572 should be DC coupled with an applied common mode voltage level of about 0.5V in order to bias the LT5572 at its optimum operating point. Some I/Q test generators allow setting the common mode voltage independently. In this case, the common mode voltage of those generators must be set to 0.5V (See Figure 2).

The baseband inputs should be driven differentially; otherwise, the even-order distortion products will degrade the overall linearity severely. Typically, a DAC will be the signal source for the LT5572. Reconstruction filters should be placed between the DAC outputs and the LT5572's baseband inputs.

In Figure 3, a typical baseband interface is shown including a 5th-order lowpass ladder filter for reconstruction. For each baseband pin, a 0V to 1V swing is developed corresponding to a DAC output current of 0mA to 20mA. The maximum sinusoidal single sideband RF output power at 2.14GHz is about +6.2dBm for full 0V to 1V swing on each baseband

# APPLICATIONS INFORMATION

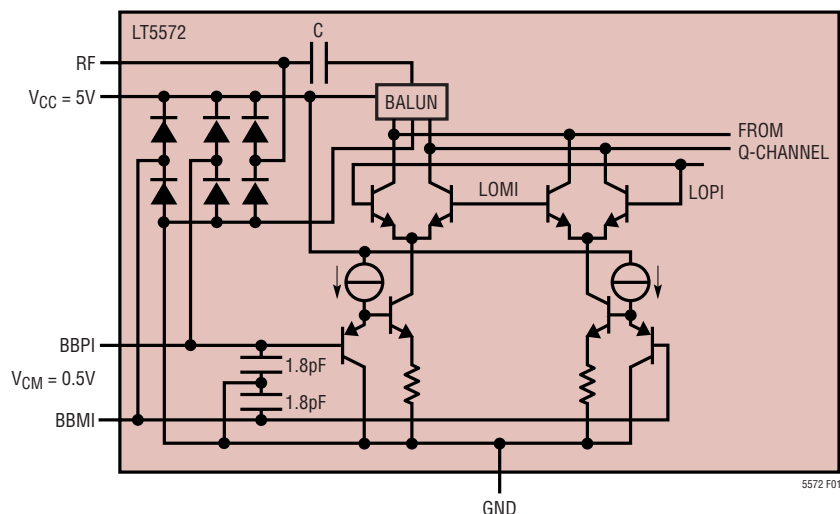


Figure 1. Simplified Circuit Schematic of the LT5572 (Only I Channel is Drawn)

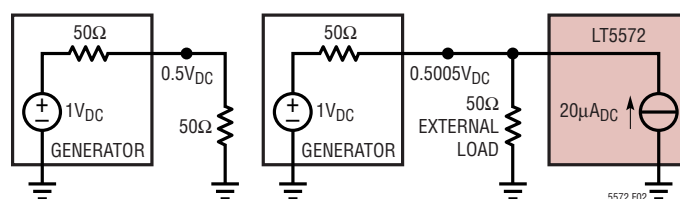


Figure 2. DC Voltage Levels for a Generator Programmed at  $0.5V_{DC}$  for a  $50\Omega$  Load Without and With the LT5572 as a Load

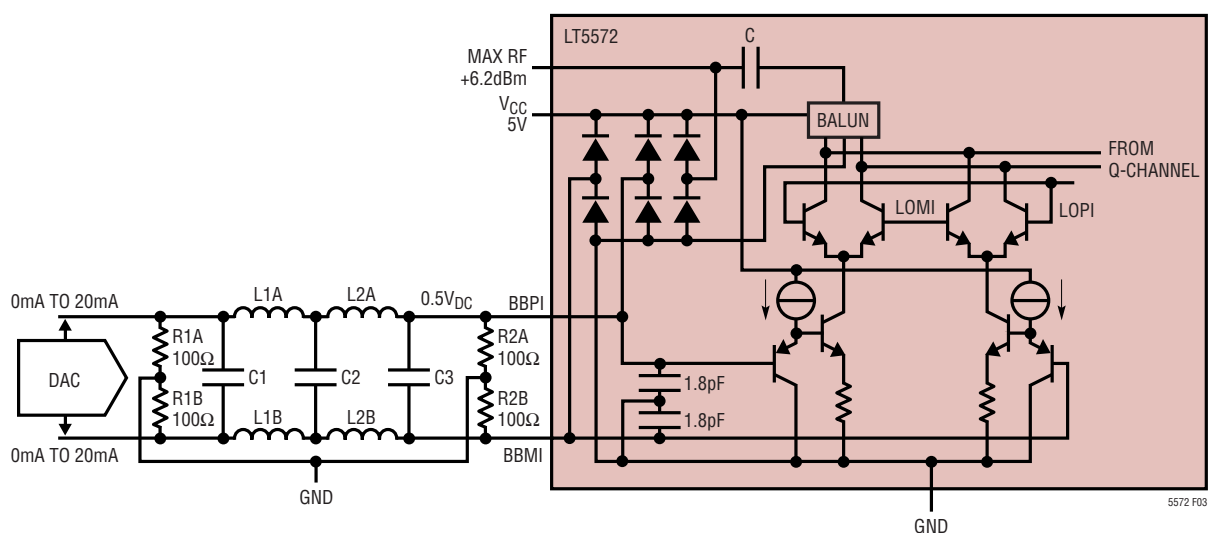


Figure 3. LT5572 Baseband Interface with 5th Order Filter and  $0.5V_{CM}$  DAC (Only I Channel is Shown)



## APPLICATIONS INFORMATION

**Table 1. Typical Performance Characteristics vs  $V_{CM}$  for  $f_{LO} = 2\text{GHz}$ ,  $P_{LO} = 0\text{dBm}$**

| $V_{CM}$ (V) | $I_{CC}$ (mA) | $G_V$ (dB) | OP1dB (dBm) | OIP2 (dBm) | OIP3 (dBm) | NFloor (dBm/Hz) | LOFT (dBm) | IR (dBc) |
|--------------|---------------|------------|-------------|------------|------------|-----------------|------------|----------|
| 0.1          | 77            | -1.3       | 0.0         | 47         | 8.3        | -163.2          | -45.6      | -42.2    |
| 0.2          | 89            | -2.7       | 4.7         | 45         | 11.4       | -162.2          | -42.6      | -36.2    |
| 0.3          | 101           | -2.1       | 7.1         | 49         | 15.0       | -160.9          | -42.0      | -37.0    |
| 0.4          | 113           | -2.0       | 8.6         | 51         | 18.2       | -160.2          | -42.4      | -39.3    |
| 0.5          | 126           | -1.9       | 9.3         | 52         | 21.2       | -159.2          | -42.4      | -41.5    |
| 0.6          | 138           | -1.9       | 9.1         | 52         | 21.1       | -158.6          | -42.1      | -44.4    |

input ( $2V_{P-P,DIFF}$ ). This maximum RF output level is limited by the  $0.5V_{PEAK}$  maximum baseband swing possible for a  $0.5V_{DC}$  common mode voltage level (assuming no extra negative supply voltage available).

It is possible to bias the LT5572 to a common mode baseband voltage level other than  $0.5V$ . Table 1 shows the typical performance for different common mode voltages.

### LO section

The internal LO input amplifier performs single-ended to differential conversion of the LO input signal. Figure 4 shows the equivalent circuit schematic of the LO input.

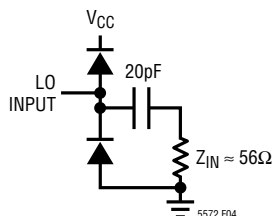
The internal, differential LO signal is split into in-phase and quadrature ( $90^\circ$  phase shifted) signals that drive LO buffer sections. These buffers drive the double balanced I and Q mixers. The phase relationship between the LO input and the internal in-phase LO and quadrature LO signals is fixed, and is independent of start-up conditions. The phase shifters are designed to deliver accurate quadrature signals for an LO frequency near  $2\text{GHz}$ . For frequencies significantly below  $1.8\text{GHz}$  or above  $2.4\text{GHz}$ , the quadrature accuracy will diminish, causing the image rejection

to degrade. The LO pin input impedance is about  $50\Omega$  and the recommended LO input power is  $0\text{dBm}$ . For lower LO input power, the gain, OIP2, OIP3 and dynamic range will degrade, especially below  $-5\text{dBm}$  and at  $T_A = 85^\circ\text{C}$ . For high LO input power (e.g.,  $5\text{dBm}$ ), the LO feedthrough will increase, without improvement in linearity or gain. Harmonics present on the LO signal can degrade the image rejection, because they introduce a small excess phase shift in the internal phase splitter. For the second (at  $4\text{GHz}$ ) and third harmonics (at  $6\text{GHz}$ ) at  $-20\text{dBc}$  level, the introduced signal at the image frequency is about  $-57\text{dBc}$  or lower, corresponding to an excess phase shift much less than  $1$  degree. For the second and third harmonics at  $-10\text{dBc}$ , still the introduced signal at the image frequency is about  $-47\text{dBc}$ . Higher harmonics than the third will have less impact. The LO return loss typically will be better than  $14\text{dB}$  over the  $1.7\text{GHz}$  to  $2.4\text{GHz}$  range. Table 2 shows the LO port input impedance vs frequency.

**Table 2. LO Port Input Impedance vs Frequency for EN = High and  $P_{LO} = 0\text{dBm}$**

| FREQUENCY<br>(MHz) | INPUT IMPEDANCE<br>( $\Omega$ ) | $S_{11}$ |       |
|--------------------|---------------------------------|----------|-------|
|                    |                                 | Mag      | Angle |
| 1000               | $45.9+j15.7$                    | 0.167    | 95    |
| 1400               | $60.8+j2.1$                     | 0.099    | 9.4   |
| 1600               | $63.2-j6.0$                     | 0.128    | -22   |
| 1800               | $61.8-j14.2$                    | 0.163    | -44   |
| 2000               | $56.4-j16.8$                    | 0.165    | -61   |
| 2200               | $51.7-j14.7$                    | 0.144    | -75   |
| 2400               | $47.3-j11.3$                    | 0.119    | -97   |
| 2600               | $42.5-j8.6$                     | 0.122    | -126  |

The input impedance of the LO port is different if the part is in shutdown mode. The LO input impedance for EN = Low is given in Table 3.



**Figure 4. Equivalent Circuit Schematic of the LO Input**

## APPLICATIONS INFORMATION

**Table 3. LO Port Input Impedance vs Frequency for EN = Low and  $P_{LO} = 0\text{dBm}$**

| FREQUENCY<br>(MHz) | INPUT IMPEDANCE<br>( $\Omega$ ) | $S_{11}$ |       |
|--------------------|---------------------------------|----------|-------|
|                    |                                 | Mag      | Angle |
| 1000               | 51.2+j45.6                      | 0.409    | 64    |
| 1400               | 133-j11.8                       | 0.456    | -4.5  |
| 1600               | 97.8-j65.8                      | 0.502    | -30   |
| 1800               | 58.6-j67.8                      | 0.534    | -51   |
| 2000               | 39.0-j55.6                      | 0.540    | -69   |
| 2200               | 29.6-j43.2                      | 0.527    | -87   |
| 2400               | 23.7-j30.8                      | 0.506    | -108  |
| 2600               | 19.7-j20.5                      | 0.503    | -130  |

### RF Section

After up-conversion, the RF outputs of the I and Q mixers are combined. An on-chip balun performs internal differential to single-ended output conversion, while transforming the output signal impedance to  $50\Omega$ . Table 4 shows the RF port output impedance vs frequency.

**Table 4. RF Port Output Impedance vs Frequency for EN = High and  $P_{LO} = 0\text{dBm}$**

| FREQUENCY<br>(MHz) | OUTPUT IMPEDANCE<br>( $\Omega$ ) | $S_{22}$ |       |
|--------------------|----------------------------------|----------|-------|
|                    |                                  | Mag      | Angle |
| 1000               | 20.7+j9.9                        | 0.434    | 153   |
| 1400               | 32.2+j20.3                       | 0.319    | 117   |
| 1600               | 44.9+j21.8                       | 0.230    | 90    |
| 1800               | 56.4+j12.2                       | 0.129    | 56    |
| 2000               | 52.6+j0.5                        | 0.025    | 10    |
| 2200               | 43.0+j0.5                        | 0.075    | 176   |
| 2400               | 36.8+j5.6                        | 0.164    | 153   |
| 2600               | 32.9+j11.0                       | 0.243    | 140   |

The RF output  $S_{22}$  with no LO power applied is given in Table 5.

**Table 5. RF Port Output Impedance vs Frequency for EN = High and No LO Power Applied**

| FREQUENCY<br>(MHz) | OUTPUT IMPEDANCE<br>( $\Omega$ ) | $S_{22}$ |       |
|--------------------|----------------------------------|----------|-------|
|                    |                                  | Mag      | Angle |
| 1000               | 21.2+j10.1                       | 0.424    | 153   |
| 1400               | 35.3+j18.4                       | 0.270    | 117   |
| 1600               | 46.1+j14.1                       | 0.150    | 97    |
| 1800               | 47.4+j5.0                        | 0.057    | 114   |
| 2000               | 42.0+j3.0                        | 0.093    | 157   |
| 2200               | 37.5+j6.8                        | 0.162    | 147   |
| 2400               | 34.8+j11.8                       | 0.224    | 134   |
| 2600               | 32.8+j16.1                       | 0.279    | 126   |

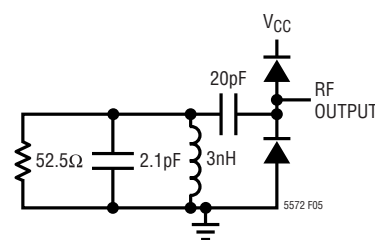
For EN = Low the  $S_{22}$  is given in Table 6.

**Table 6. RF Port Output Impedance vs Frequency for EN = Low**

| FREQUENCY<br>(MHz) | OUTPUT IMPEDANCE<br>( $\Omega$ ) | $S_{22}$ |       |
|--------------------|----------------------------------|----------|-------|
|                    |                                  | Mag      | Angle |
| 1000               | 20.3+j9.7                        | 0.440    | 154   |
| 1400               | 30.6+j20.2                       | 0.338    | 120   |
| 1600               | 41.8+j23.6                       | 0.264    | 95    |
| 1800               | 55.6+j18.5                       | 0.181    | 63    |
| 2000               | 58.3+j49.1                       | 0.089    | 28    |
| 2200               | 48.8-j0.1                        | 0.012    | -172  |
| 2400               | 40.4+j3.1                        | 0.112    | 160   |
| 2600               | 34.7+j8.3                        | 0.205    | 146   |

To improve  $S_{22}$  for lower frequencies, a shunt capacitor can be added to the RF output. At higher frequencies, a shunt inductor can improve the  $S_{22}$ . Figure 5 shows the equivalent circuit schematic of the RF output.

Note that an ESD diode is connected internally from the RF output to ground. For strong output RF signal levels (higher than  $3\text{dBm}$ ) this ESD diode can degrade the linearity performance if the  $50\Omega$  termination impedance is connected directly to ground. To prevent this, a coupling capacitor can be inserted in the RF output line. This is strongly recommended for  $1\text{dB}$  compression measurements.



**Figure 5. Equivalent Circuit Schematic of the RF Output**

### Enable Interface

Figure 6 shows a simplified schematic of the EN pin interface. The voltage necessary to turn on the LT5572 is  $1\text{V}$ . To disable (shut down) the chip, the enable voltage must be below  $0.5\text{V}$ . If the EN pin is not connected, the chip is disabled. This EN = Low condition is guaranteed by the  $75\text{k}\Omega$  on-chip pull-down resistor. It is important that the voltage at the EN pin does not exceed  $V_{CC}$  by more than  $0.5\text{V}$ . If this should occur, the full-chip supply

## APPLICATIONS INFORMATION

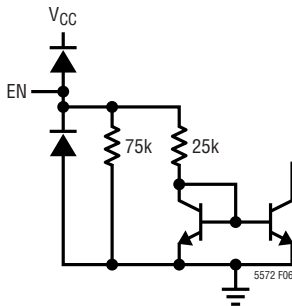


Figure 6. EN Pin Interface

current could be sourced through the EN pin ESD protection diodes, which are not designed for this purpose. Damage to the chip may result.

### Evaluation Board

Figure 7 shows the evaluation board schematic. A good ground connection is required for the Exposed Pad. If this is not done properly, the RF performance will degrade. Additionally, the Exposed Pad provides heat sinking for the part and minimizes the possibility of the chip overheating. R1 (optional) limits the EN pin current in the

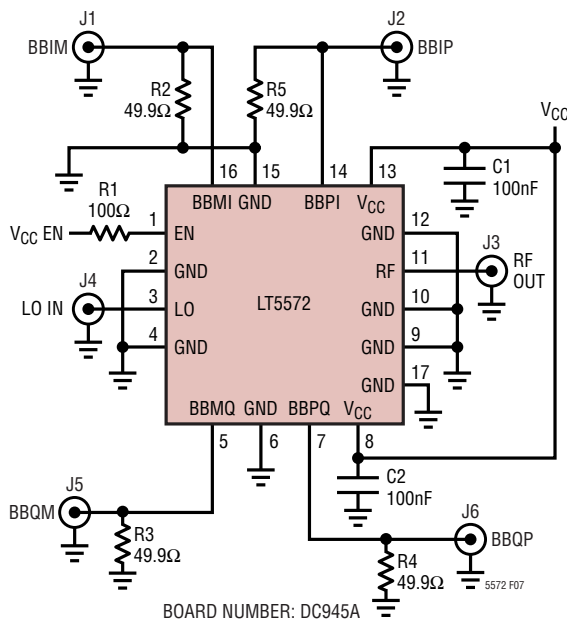


Figure 7. Evaluation Circuit Schematic

event that the EN pin is pulled high while the  $V_{CC}$  inputs are low. The application board PCB layouts are shown in Figures 8 and 9.

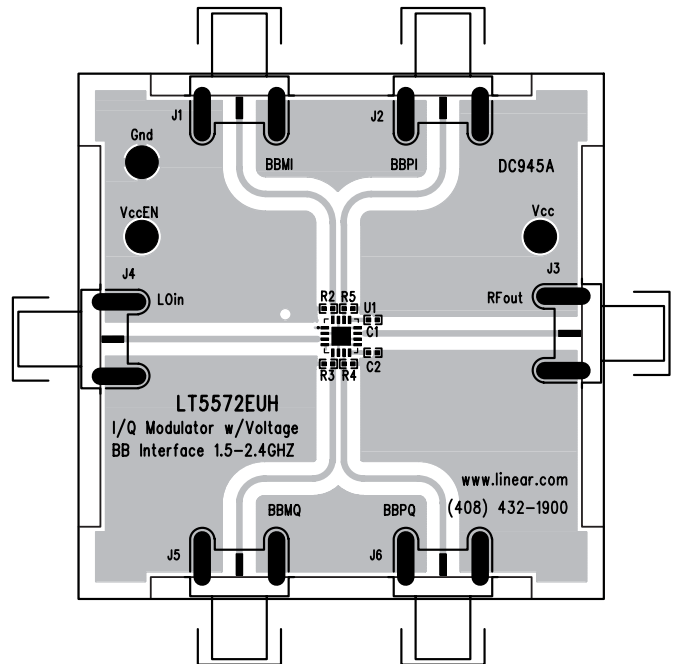


Figure 8. Component Side of Evaluation Board

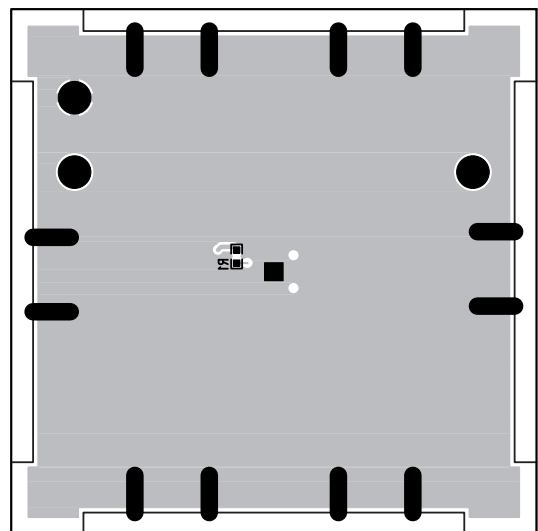


Figure 9. Bottom Side of Evaluation Board

# APPLICATIONS INFORMATION

## Application Measurements

The LT5572 is recommended for basestation applications using various modulation formats. Figure 10 shows a typical application. Figure 11 shows the ACPR performance for W-CDMA using 1-, 2- or 4-channel modulation. Figures 12, 13 and 14 illustrate the 1-, 2- and 4-channel W-CDMA

measurement. To calculate ACPR, a correction is made for the spectrum analyzer noise floor (Application Note 99).

If the output power is high, the ACPR will be limited by the linearity performance of the part. If the output power is low, the ACPR will be limited by the noise performance of the part. In the middle, an optimum ACPR is obtained.

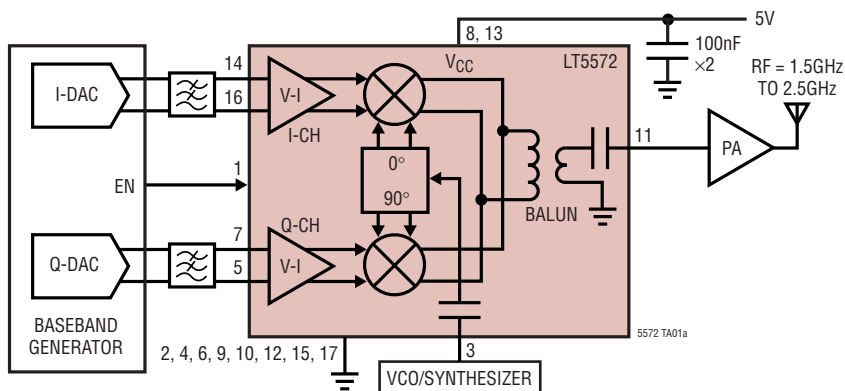


Figure 10. 1.5GHz to 2.4GHz Direct Conversion Transmitter Application

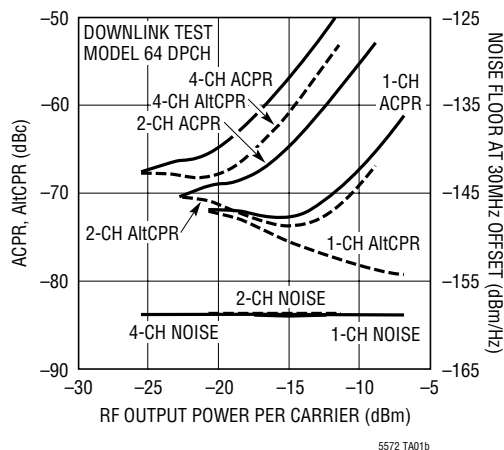


Figure 11. W-CDMA ACPR, ALTCP and Noise vs RF Output Power at 2140MHz for 1, 2 and 4 Channels

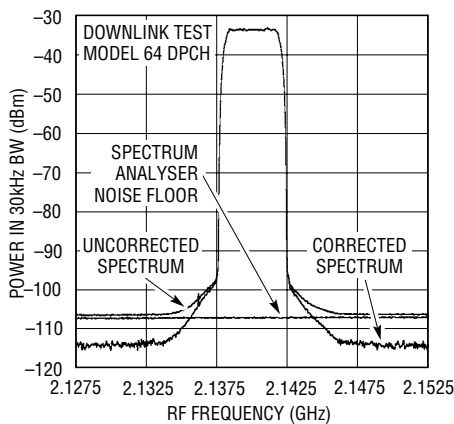


Figure 12. 1-Channel W-CDMA Spectrum

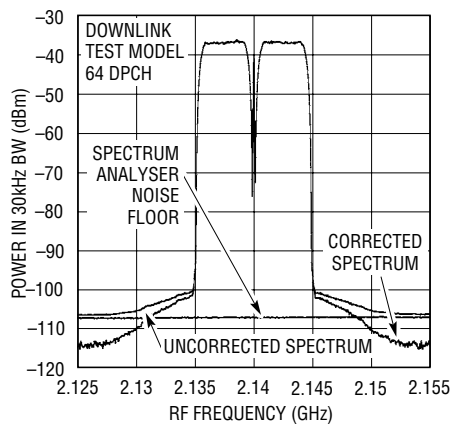


Figure 13. 2-Channel W-CDMA Spectrum

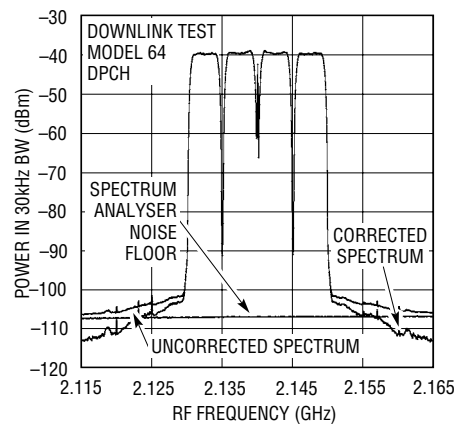


Figure 14. 4-Channel W-CDMA Spectrum

## APPLICATIONS INFORMATION

Because of the LT5572's very high dynamic range, the test equipment can limit the accuracy of the ACPR measurement. Consult the factory for advice on the ACPR measurement if needed.

The ACPR performance is sensitive to the amplitude match of the BBIP and BBIM (or BBQP and BBQM) input voltage. This is because a difference in AC voltage amplitude will give rise to a difference in amplitude between the even-order harmonic products generated in the internal V-I converter.

As a result, they will not cancel out entirely. Therefore, it is important to keep the amplitudes at the BBIP and BBIM (or BBQP and BBQM) inputs as equal as possible.

When the temperature is changed after calibration, the LO feedthrough and the image rejection performance will change. This is illustrated in Figure 15. The LO feedthrough and image rejection can also change as a function of the baseband drive level as depicted in Figure 16.

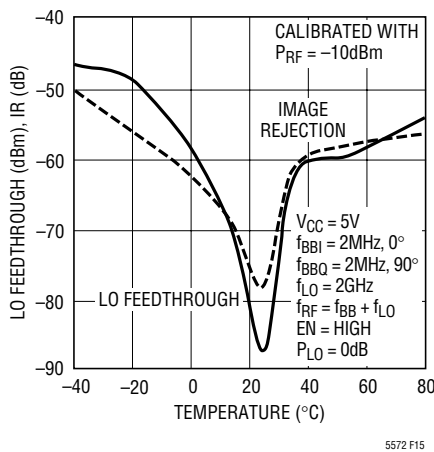


Figure 15. LO Feedthrough and Image Rejection vs Temperature After Calibration at 25°C

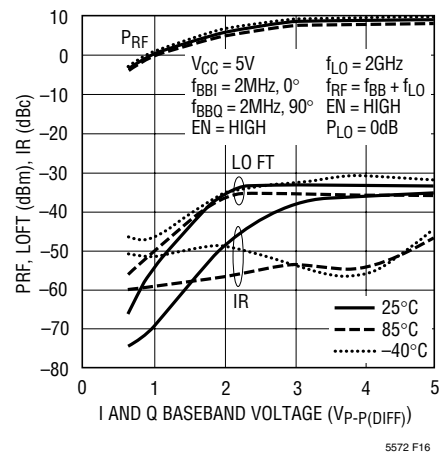
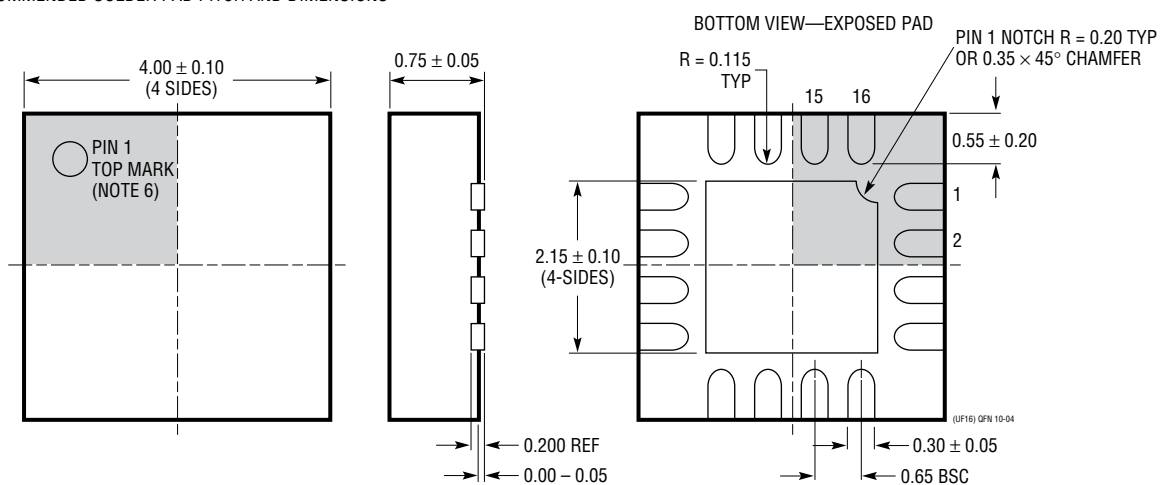
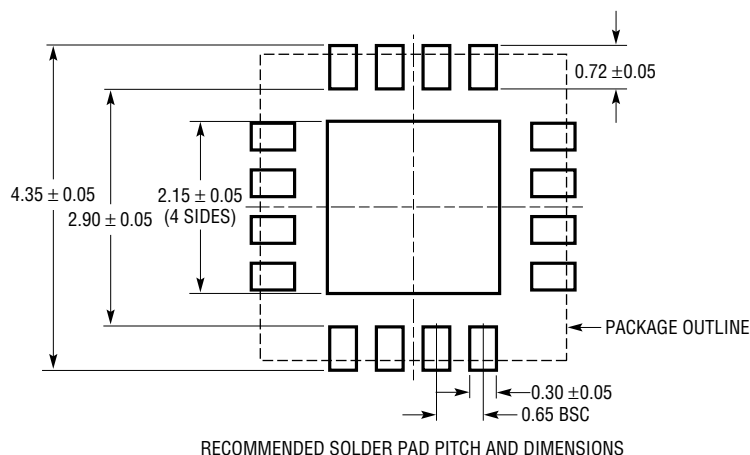


Figure 16. RF Output Power, Image Rejection and LO Feedthrough vs Baseband Drive Voltage After Calibration at 25°C

## PACKAGE DESCRIPTION

**UF Package**  
**16-Lead Plastic QFN (4mm × 4mm)**  
 (Reference LTC DWG # 05-08-1692)



**NOTE:**

1. DRAWING CONFORMS TO JEDEC PACKAGE OUTLINE MO-220 VARIATION (WGNC)
2. DRAWING NOT TO SCALE
3. ALL DIMENSIONS ARE IN MILLIMETERS
4. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
5. EXPOSED PAD SHALL BE SOLDER PLATED
6. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE

## RELATED PARTS

| PART NUMBER               | DESCRIPTION                                                                 | COMMENTS                                                                                                                                       |
|---------------------------|-----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Infrastructure</b>     |                                                                             |                                                                                                                                                |
| LT5511                    | High Linearity Upconverting Mixer                                           | RF Output to 3GHz, 17dBm IIP3, Integrated LO Buffer                                                                                            |
| LT5512                    | DC to 3GHz High Signal Level Downconverting Mixer                           | DC to 3GHz, 17dBm IIP3, Integrated LO Buffer                                                                                                   |
| LT5514                    | Ultralow Distortion, IF Amplifier/ADC Driver with Digitally Controlled Gain | 850MHz Bandwidth, 47dBm OIP3 at 100MHz, 10.5dB to 33dB Gain Control Range                                                                      |
| LT5515                    | 1.5GHz to 2.5GHz Direct Conversion Quadrature Demodulator                   | 20dBm IIP3, Integrated LO Quadrature Generator                                                                                                 |
| LT5516                    | 0.8GHz to 1.5GHz Direct Conversion Quadrature Demodulator                   | 21.5dBm IIP3, Integrated LO Quadrature Generator                                                                                               |
| LT5517                    | 40MHz to 900MHz Quadrature Demodulator                                      | 21dBm IIP3, Integrated LO Quadrature Generator                                                                                                 |
| LT5518                    | 1.5GHz to 2.4GHz High Linearity Direct Quadrature Modulator                 | 22.8dBm OIP3 at 2GHz, -158.2dBm/Hz Noise Floor, 50 $\Omega$ Single-Ended RF and LO Ports, 4-Channel W-CDMA ACPR = -64dBc at 2.14GHz            |
| LT5519                    | 0.7GHz to 1.4GHz High Linearity Upconverting Mixer                          | 17.1dBm IIP3 at 1GHz, Integrated RF Output Transformer with 50 $\Omega$ Matching, Single-Ended LO and RF Ports Operation                       |
| LT5520                    | 1.3GHz to 2.3GHz High Linearity Upconverting Mixer                          | 15.9dBm IIP3 at 1.9GHz, Integrated RF Output Transformer with 50 $\Omega$ Matching, Single-Ended LO and RF Ports Operation                     |
| LT5521                    | 10MHz to 3700MHz High Linearity Upconverting Mixer                          | 24.2dBm IIP3 at 1.95GHz, NF = 12.5dB, 3.15V to 5.25V Supply, Single-Ended LO Port Operation                                                    |
| LT5522                    | 600MHz to 2.7GHz High Signal Level Downconverting Mixer                     | 4.5V to 5.25V Supply, 25dBm IIP3 at 900MHz, NF = 12.5dB, 50 $\Omega$ Single-Ended RF and LO Ports                                              |
| LT5524                    | Low Power, Low Distortion ADC Driver with Digitally Programmable Gain       | 450MHz Bandwidth, 40dBm OIP3, 4.5dB to 27dB Gain Control                                                                                       |
| LT5525                    | High Linearity, Low Power Downconverting Mixer                              | Single-Ended 50 $\Omega$ RF and LO Ports, 17.6dBm IIP3 at 1900MHz, I <sub>CC</sub> = 28mA                                                      |
| LT5526                    | High Linearity, Low Power Downconverting Mixer                              | 3V to 5.3V Supply, 16.5dBm IIP3, 100kHz to 2GHz RF, NF = 11dB, I <sub>CC</sub> = 28mA, -65dBm LO-RF Leakage                                    |
| LT5527                    | 400MHz to 3.7GHz High Signal Level Downconverting Mixer                     | IIP3 = 23.5dBm and NF = 12.5dBm at 1900MHz, 4.5V to 5.25V Supply, I <sub>CC</sub> = 78mA                                                       |
| LT5528                    | 1.5GHz to 2.4GHz High Linearity Direct Quadrature Modulator                 | 21.8dBm OIP3 at 2GHz, -159.3dBm/Hz Noise Floor, 50 $\Omega$ , 0.5V <sub>DC</sub> Baseband Interface, 4-Channel W-CDMA ACPR = -66dBc at 2.14GHz |
| <b>RF Power Detectors</b> |                                                                             |                                                                                                                                                |
| LTC®5505                  | RF Power Detectors with >40dB Dynamic Range                                 | 300MHz to 3GHz, Temperature Compensated, 2.7V to 6V Supply                                                                                     |
| LTC5507                   | 100kHz to 1000MHz RF Power Detector                                         | 100kHz to 1GHz, Temperature Compensated, 2.7V to 6V Supply                                                                                     |
| LTC5508                   | 300MHz to 7GHz RF Power Detector                                            | 44dB Dynamic Range, Temperature Compensated, SC70 Package                                                                                      |
| LTC5509                   | 300MHz to 3GHz RF Power Detector                                            | 36dB Dynamic Range, Low Power Consumption, SC70 Package                                                                                        |
| LTC5530                   | 300MHz to 7GHz Precision RF Power Detector                                  | Precision V <sub>OUT</sub> Offset Control, Shutdown, Adjustable Gain                                                                           |
| LTC5531                   | 300MHz to 7GHz Precision RF Power Detector                                  | Precision V <sub>OUT</sub> Offset Control, Shutdown, Adjustable Offset                                                                         |
| LTC5532                   | 300MHz to 7GHz Precision RF Power Detector                                  | Precision V <sub>OUT</sub> Offset Control, Adjustable Gain and Offset                                                                          |
| LT5534                    | 50MHz to 3GHz Log RF Power Detector with 60dB Dynamic Range                 | ±1dB Output Variation over Temperature, 38ns Response Time, Log Linear Response                                                                |
| LTC5536                   | Precision 600MHz to 7GHz RF Power Detector with Fast Comparator Output      | 25ns Response Time, Comparator Reference Input, Latch Enable Input, -26dBm to +12dBm Input Range                                               |
| LT5537                    | Wide Dynamic Range Log RF/IF Detector                                       | Low Frequency to 1GHz, 83dB Dynamic Range, 2.7V to 5.25V Supply                                                                                |
| <b>High Speed ADCs</b>    |                                                                             |                                                                                                                                                |
| LTC2220-1                 | 12-Bit, 185Msps ADC                                                         | Single 3.3V Supply, 910mW Consumption, 67.5dB SNR, 80dB SFDR, 775MHz Full Power BW                                                             |
| LTC2249                   | 14-Bit, 80Msps ADC                                                          | Single 3V Supply, 222mW Consumption, 73dB SNR, 90dB SFDR                                                                                       |
| LTC2255                   | 14-Bit, 125Msps ADC                                                         | Single 3V Supply, 395mW Consumption, 72.4dB SNR, 88dB SFDR, 640MHz Full Power BW                                                               |