

## FEATURES

- Broadband RF, LO and IF Operation
- High Input IP3: >20dBm from 30MHz to 900MHz  
+17dBm at 1900MHz
- Typical Conversion Gain: 1dB
- SSB Noise Figure: 11dB at 900MHz  
14dB at 1900MHz
- Integrated LO Buffer: Insensitive to LO Drive Level
- Single-Ended or Differential LO Drive
- High LO-RF Isolation
- Enable Function
- 4.5V to 5.25V Supply Voltage Range
- 4mm × 4mm QFN Package

## APPLICATIONS

- HF/VHF/UHF Mixer
- Cellular/PCS/UMTS Infrastructure
- High Linearity Mixer Applications
- ISM Band Receivers
- Wireless Medical Telemetry System (WMTS)

## DESCRIPTION

The LT<sup>®</sup>5512 is an active double-balanced mixer IC, optimized for high linearity HF, VHF and UHF applications. The IC includes an integrated LO buffer amplifier to drive the mixer and an RF buffer amplifier for improved LO-RF isolation. Internal bias circuits eliminate the need for precision external resistors and allow the device to be powered-down using the enable control (EN) pin.

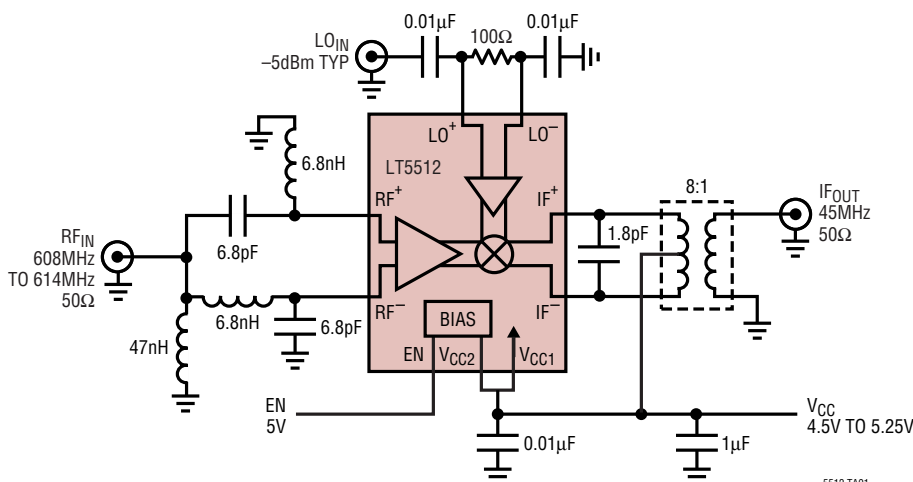
The externally matched RF and IF ports allow the mixer to be used at very low frequencies, below 1MHz or up to 3GHz. The differential LO input is designed for single-ended or a differential input drive.

The LT5512 is a high-linearity alternative to passive diode mixers. Unlike passive mixers, which have conversion loss and require high LO drive levels, the LT5512 delivers conversion gain and requires significantly lower LO drive levels.

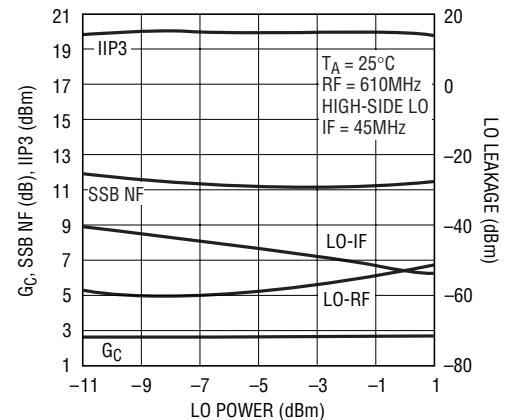
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## TYPICAL APPLICATION

High Signal-Level Downmixer for 600MHz Wireless Medical Telemetry System



Conv Gain, IIP3, NF and  
LO Leakage vs LO Power



5512 TA01a

5512 TA01

5512fa

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|                                                                 |                          |
|-----------------------------------------------------------------|--------------------------|
| Supply Voltage ( $V_{CC1}$ , $V_{CC2}$ , $IF^+$ , $IF^-$ )..... | 5.5V                     |
| Enable Voltage .....                                            | -0.3V to $V_{CC} + 0.3V$ |
| $LO^+$ to $LO^-$ Differential Voltage .....                     | $\pm 1.5V$               |
| ..... (+6dBm equivalent)                                        |                          |
| $RF^+$ to $RF^-$ Differential Voltage .....                     | $\pm 0.7V$               |
| ..... (+11dBm equivalent)                                       |                          |
| Operating Temperature Range .....                               | -40°C to 85°C            |
| Storage Temperature Range.....                                  | -65°C to 125°C           |
| Junction Temperature ( $T_J$ ) .....                            | 125°C                    |

## PACKAGE/ORDER INFORMATION

|                                                                                                                                                                                                                          |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| <p>TOP VIEW</p> <p>UF PACKAGE<br/>16-LEAD (4mm × 4mm) PLASTIC QFN<br/><math>T_{JMAX} = 125^\circ C</math>, <math>\theta_{JA} = 37^\circ C/W</math><br/>EXPOSED PAD IS GROUND (PIN 17)<br/>(MUST BE SOLDERED TO PCB)</p>  |              |
| ORDER PART NUMBER                                                                                                                                                                                                        | PART MARKING |
| LT5512EUF                                                                                                                                                                                                                | 5512         |
| <p><b>Order Options</b> Tape and Reel: Add #TR<br/>Lead Free: Add #PBF Lead Free Tape and Reel: Add #TRPBF<br/>Lead Free Part Marking: <a href="http://www.linear.com/leadfree/">http://www.linear.com/leadfree/</a></p> |              |

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

## DC ELECTRICAL CHARACTERISTICS

(Test Circuit Shown in Figure 2)  $V_{CC} = 5V$ ,  $EN = High$ ,

$T_A = 25^\circ C$  (Note 3), unless otherwise noted.

| PARAMETER                                              | CONDITIONS        | MIN | TYP | MAX  | UNITS   |
|--------------------------------------------------------|-------------------|-----|-----|------|---------|
| <b>Enable (EN) Low = Off, High = On</b>                |                   |     |     |      |         |
| Turn On Time                                           |                   |     | 3   |      | $\mu s$ |
| Turn Off Time                                          |                   |     | 13  |      | $\mu s$ |
| Input Current                                          | $V_{ENABLE} = 5V$ |     | 50  |      | $\mu A$ |
| Enable = High (On)                                     |                   | 3   |     |      | V       |
| Enable = Low (Off)                                     |                   |     |     | 0.3  | V       |
| <b>Power Supply Requirements (<math>V_{CC}</math>)</b> |                   |     |     |      |         |
| Supply Voltage                                         |                   | 4.5 |     | 5.25 | V       |
| Supply Current                                         |                   |     | 56  | 74   | mA      |
| Shutdown Current                                       | $EN = Low$        |     |     | 100  | $\mu A$ |

## AC ELECTRICAL CHARACTERISTICS

| PARAMETER                 | CONDITIONS                                                               | MIN        | TYP           | MAX     | UNITS      |
|---------------------------|--------------------------------------------------------------------------|------------|---------------|---------|------------|
| RF Input Frequency Range  | Requires Appropriate Matching                                            |            | 0.001 to 3000 |         | MHz        |
| LO Input Frequency Range  | Requires Appropriate Matching                                            |            | 0.001 to 3000 |         | MHz        |
| IF Output Frequency Range | Requires Appropriate Matching                                            |            | 0.001 to 2000 |         | MHz        |
| LO Input Power            | 1kHz to 1700MHz (Resistive Match)<br>1200MHz to 3000MHz (Reactive Match) | -11<br>-18 | -5<br>-10     | 1<br>-2 | dBm<br>dBm |

**AC ELECTRICAL CHARACTERISTICS**

Downmixer Applications: (Test Circuits Shown in Figures 1 and 2)

$V_{CC} = 5V$ ,  $EN = \text{High}$ ,  $T_A = 25^\circ\text{C}$ ,  $P_{RF} = -10\text{dBm}$  ( $-10\text{dBm}/\text{tone}$  for two-tone IIP3 tests,  $\Delta f = 200\text{kHz}$ ), High-Side LO at  $-5\text{dBm}$  for 45MHz, 140MHz and 450MHz tests, Low-Side LO at  $-10\text{dBm}$  for 900MHz, 1900MHz and 2450MHz tests, unless otherwise noted.

(Note 2, 3 and 4)

| PARAMETER                                                           | CONDITIONS                                                                          | MIN | TYP        | MAX | UNITS                |
|---------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----|------------|-----|----------------------|
| Conversion Gain                                                     | RF = 45MHz, IF = 2MHz                                                               |     | 1          |     | dB                   |
|                                                                     | RF = 140MHz, IF = 10MHz                                                             |     | 2          |     | dB                   |
|                                                                     | RF = 450MHz, IF = 70MHz                                                             |     | 1.1        |     | dB                   |
|                                                                     | RF = 900MHz, IF = 170MHz                                                            |     | 0          |     | dB                   |
|                                                                     | RF = 1900MHz, IF = 170MHz                                                           | -1  | 1          |     | dB                   |
|                                                                     | RF = 2450MHz, IF = 240MHz                                                           |     | 2          |     | dB                   |
| Conversion Gain vs Temperature                                      | $T_A = -40^\circ\text{C}$ to $85^\circ\text{C}$ , RF = 900MHz                       |     | -0.011     |     | dB/ $^\circ\text{C}$ |
| Input 3rd Order Intercept                                           | RF = 45MHz, IF = 2MHz                                                               |     | 20.4       |     | dBm                  |
|                                                                     | RF = 140MHz, IF = 10MHz                                                             |     | 20.7       |     | dBm                  |
|                                                                     | RF = 450MHz, IF = 70MHz                                                             |     | 21.3       |     | dBm                  |
|                                                                     | RF = 900MHz, IF = 170MHz                                                            |     | 21         |     | dBm                  |
|                                                                     | RF = 1900MHz, IF = 170MHz                                                           |     | 17         |     | dBm                  |
|                                                                     | RF = 2450MHz, IF = 240MHz                                                           |     | 13         |     | dBm                  |
| Single-Sideband Noise Figure                                        | RF = 140MHz, IF = 10MHz                                                             |     | 10.3       |     | dB                   |
|                                                                     | RF = 450MHz, IF = 70MHz                                                             |     | 10.3       |     | dB                   |
|                                                                     | RF = 900MHz, IF = 170MHz                                                            |     | 11         |     | dB                   |
|                                                                     | RF = 1900MHz, IF = 170MHz                                                           |     | 14         |     | dB                   |
|                                                                     | RF = 2450MHz, IF = 240MHz                                                           |     | 13.4       |     | dB                   |
| LO to RF Leakage                                                    | $f_{LO} = 250\text{kHz}$ to $700\text{MHz}$ (Figure 1)                              |     | $\leq -63$ |     | dBm                  |
|                                                                     | $f_{LO} = 700\text{MHz}$ to $2500\text{MHz}$ (Figure 2)                             |     | $\leq -50$ |     | dBm                  |
| LO to IF Leakage                                                    | $f_{LO} = 250\text{kHz}$ to $500\text{MHz}$ (Figure 1)                              |     | $\leq -35$ |     | dBm                  |
|                                                                     | $f_{LO} = 500\text{MHz}$ to $1250\text{MHz}$ (Figure 1)                             |     | $\leq -40$ |     | dBm                  |
|                                                                     | $f_{LO} = 700\text{MHz}$ to $1500\text{MHz}$ (Figure 2)                             |     | $\leq -45$ |     | dBm                  |
|                                                                     | $f_{LO} = 1500\text{MHz}$ to $1950\text{MHz}$ (Figure 2)                            |     | $\leq -40$ |     | dBm                  |
|                                                                     | $f_{LO} = 1950\text{MHz}$ to $2500\text{MHz}$ (Figure 2)                            |     | $\leq -32$ |     | dBm                  |
| RF to LO Isolation                                                  | $f_{RF} = 250\text{kHz}$ to $800\text{MHz}$ (Figure 1)                              |     | $> 61$     |     | dB                   |
|                                                                     | $f_{RF} = 700\text{MHz}$ to $1200\text{MHz}$ (Figure 2)                             |     | $> 49$     |     | dB                   |
|                                                                     | $f_{RF} = 1200\text{MHz}$ to $1700\text{MHz}$ (Figure 2)                            |     | $> 46$     |     | dB                   |
|                                                                     | $f_{RF} = 1700\text{MHz}$ to $2500\text{MHz}$ (Figure 2)                            |     | $> 43$     |     | dB                   |
| 2RF-2LO Output Spurious Product<br>( $f_{RF} = f_{LO} + f_{IF}/2$ ) | 900MHz: $f_{RF} = 815\text{MHz}$ at $-12\text{dBm}$ , $f_{IF} = 170\text{MHz}$      |     | -66        |     | dBc                  |
|                                                                     | 1900MHz: $f_{RF} = 1815\text{MHz}$ at $-12\text{dBm}$ , $f_{IF} = 170\text{MHz}$    |     | -59        |     | dBc                  |
| 3RF-3LO Output Spurious Product<br>( $f_{RF} = f_{LO} + f_{IF}/3$ ) | 900MHz: $f_{RF} = 786.67\text{MHz}$ at $-12\text{dBm}$ , $f_{IF} = 170\text{MHz}$   |     | -83        |     | dBc                  |
|                                                                     | 1900MHz: $f_{RF} = 1786.67\text{MHz}$ at $-12\text{dBm}$ , $f_{IF} = 170\text{MHz}$ |     | -58        |     | dBc                  |
| Input 1dB Compression                                               | RF = 10MHz to 500MHz (Figure 1)                                                     |     | 10.5       |     | dBm                  |
|                                                                     | RF = 900MHz (Figure 2)                                                              |     | 10.1       |     | dBm                  |
|                                                                     | RF = 1900MHz (Figure 2)                                                             |     | 6.2        |     | dBm                  |

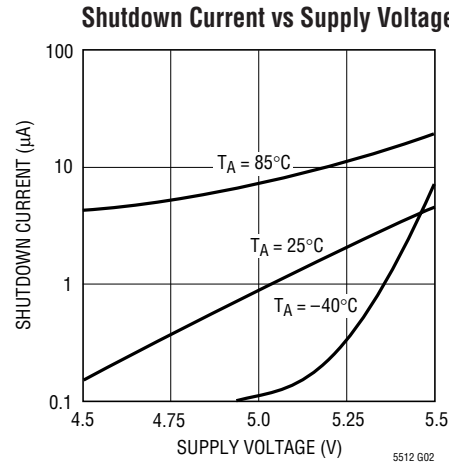
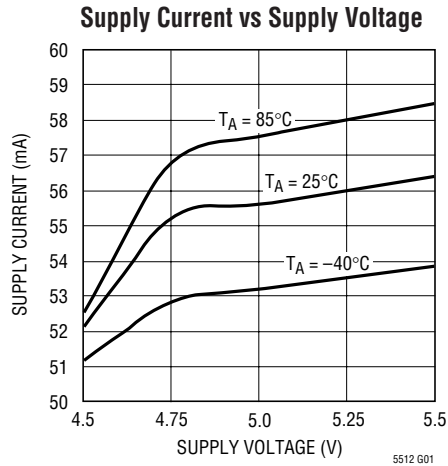
**Note 1:** Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

**Note 2:** 45MHz, 140MHz and 450MHz performance measured on the test circuit shown in Figure 1. 900MHz, 1900MHz and 2450MHz performance measured on the test circuit shown in Figure 2.

**Note 3:** Specifications over the  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  temperature range are assured by design, characterization and correlation with statistical process control.

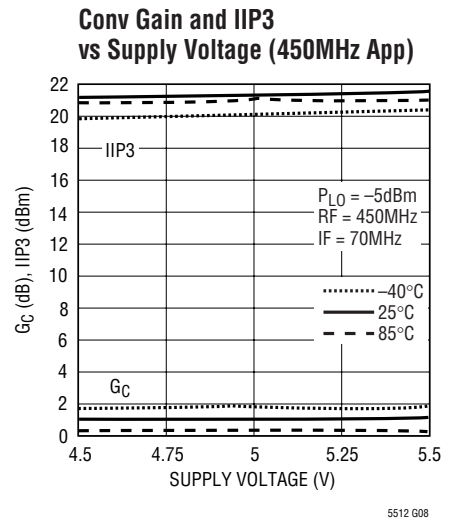
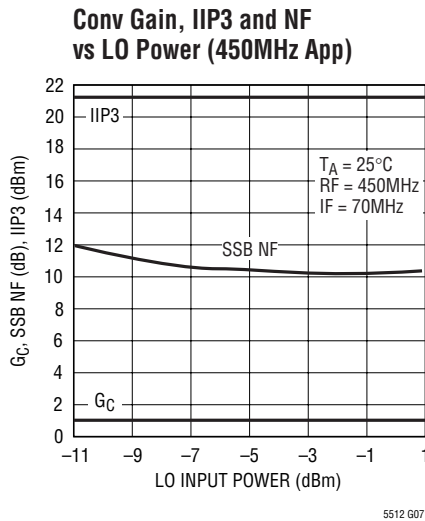
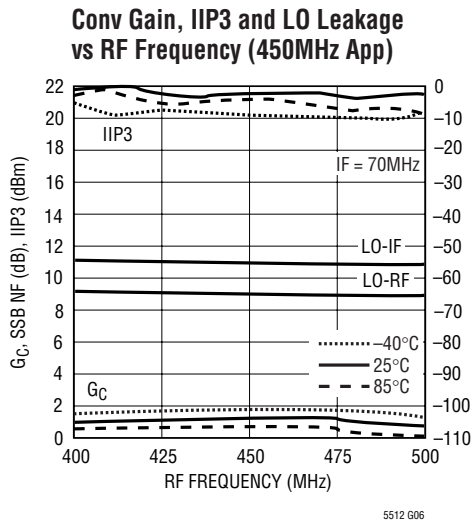
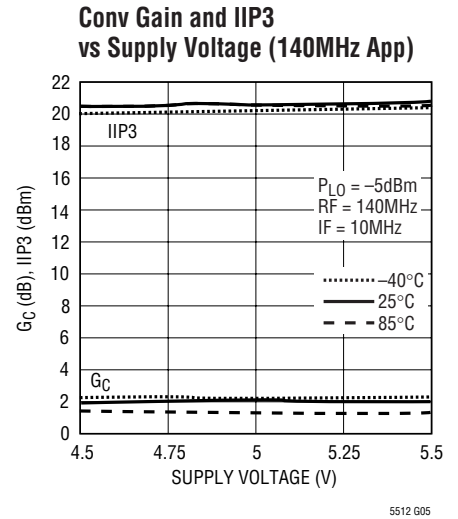
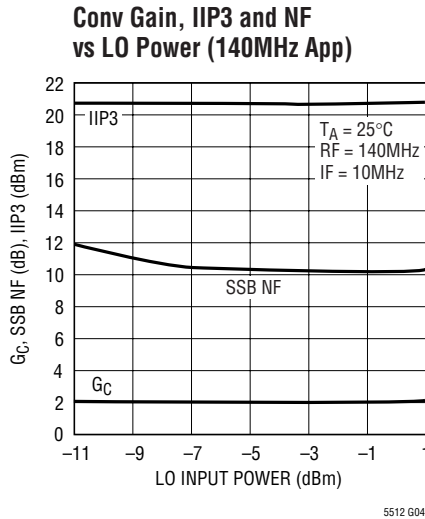
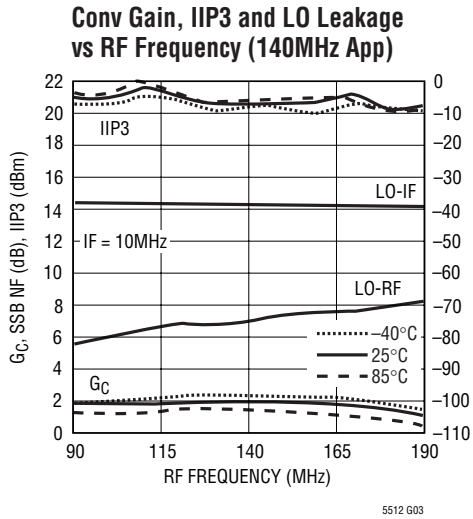
**Note 4:** SSB Noise Figure measurements performed with a small-signal noise source and bandpass filter on RF input and no other RF signal applied.

# TYPICAL DC PERFORMANCE CHARACTERISTICS (Test Circuit Shown Figure 2)



# TYPICAL AC PERFORMANCE CHARACTERISTICS HF/VHF/UHF Downmixer Application

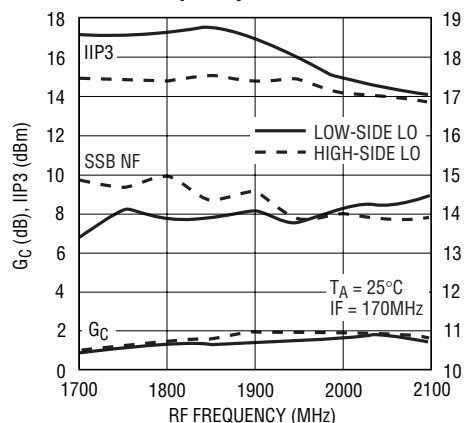
$V_{CC} = 5V$ ,  $EN = High$ ,  $P_{RF} = -10dBm$  ( $-10dBm/tone$  for 2-tone IIP3 tests,  $\Delta f = 200kHz$ ), High-Side LO,  $P_{LO} = -5dBm$ , unless otherwise noted. Test Circuit Shown in Figure 1.



# TYPICAL PERFORMANCE CHARACTERISTICS (1900MHz Downmixer Application)

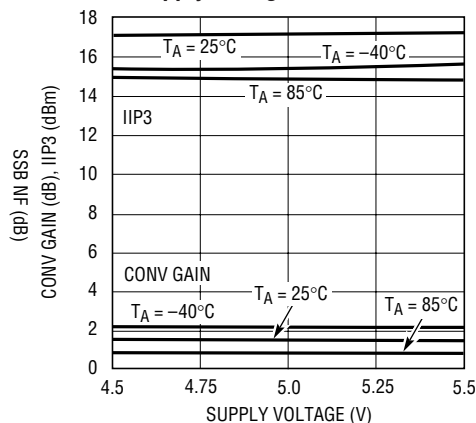
$V_{CC} = 5V$ ,  $EN = High$ ,  $T_A = 25^\circ C$ , 1900MHz RF input matching,  $P_{RF} = -10dBm$  (-10dBm/tone for 2-tone IIP3 tests,  $\Delta f = 200kHz$ ), Low-Side LO,  $P_{LO} = -10dBm$ , IF output measured at 170MHz, unless otherwise noted. Test circuit shown in Figure 2.

**Conv Gain, IIP3 and NF vs RF Frequency**



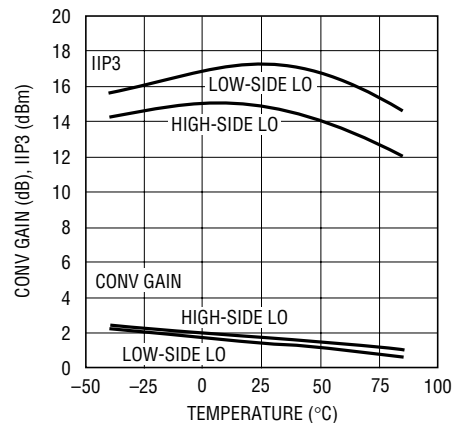
5512 G09

**Conv Gain and IIP3 vs Supply Voltage**



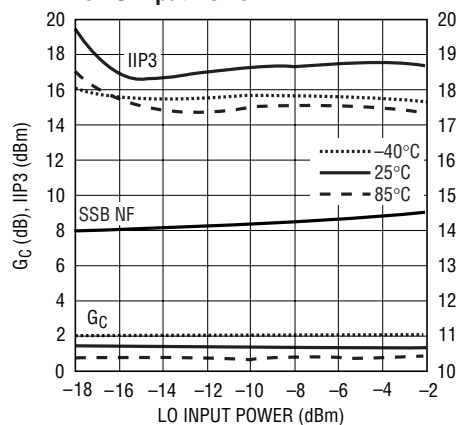
5512 G10

**Conv Gain and IIP3 vs Temperature**  
RF = 1900MHz, IF = 170MHz



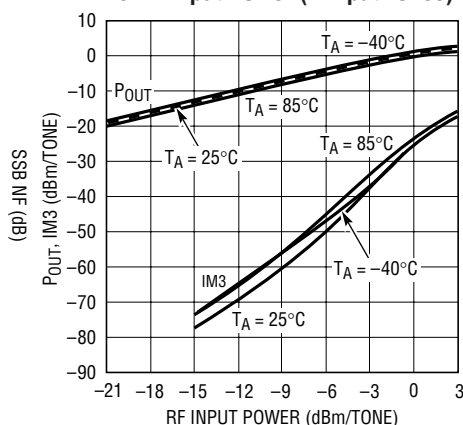
5512 G11

**Conv Gain, IIP3 and NF vs LO Input Power**



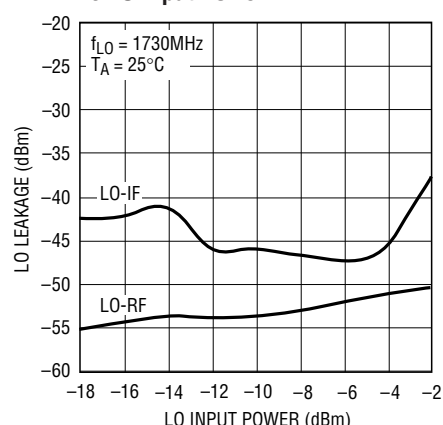
5512 G12

**Output IF Power and Output IM3 vs RF Input Power (2 Input Tones)**



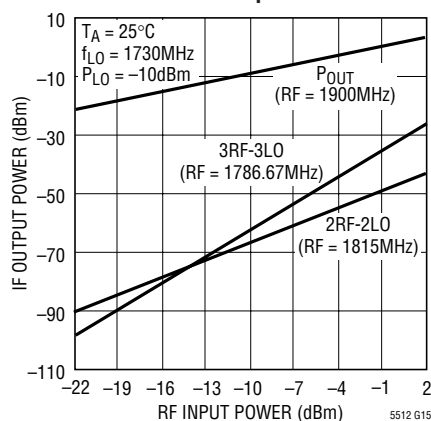
5512 G13

**LO-IF and LO-RF Leakage vs LO Input Power**



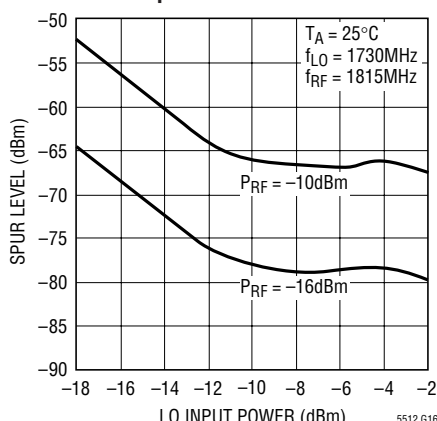
5512 G14

**IF Output Power, 2RF-2LO and 3RF-3LO vs RF Input Power**



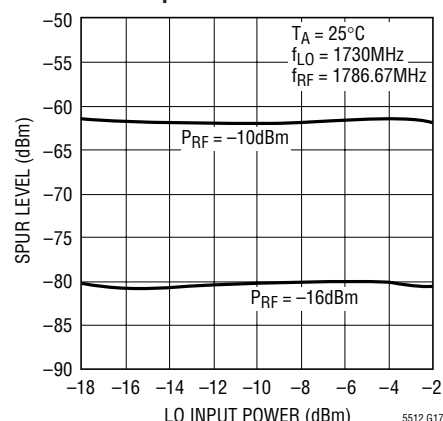
5512 G15

**2RF-2LO (Half-IF) Spur Level vs LO Input Power**



5512 G16

**3RF-3LO Spur Level vs LO Input Power**



5512 G17

## PIN FUNCTIONS

**NC (Pins 1, 4, 8, 13, 16):** Not connected internally. These pins should be grounded on the circuit board for improved LO to RF and LO to IF isolation.

**RF<sup>+</sup>, RF<sup>-</sup> (Pins 2, 3):** Differential Inputs for the RF Signal. These pins must be driven with a differential signal. Each pin must be connected to a DC ground capable of sinking 15mA (30mA total). This DC bias return can be accomplished through the center-tap of a balun, or with shunt inductors. An impedance transformation is required to match the RF input to 50Ω (or 75Ω).

**EN (Pin 5):** Enable Pin. When the input voltage is higher than 3V, the mixer circuits supplied through Pins 6, 7, 10, and 11 are enabled. When the input voltage is less than 0.3V, all circuits are disabled. Typical enable pin input current is 50μA for EN = 5V and 0μA when EN = 0V.

**V<sub>CC1</sub> (Pin 6):** Power Supply Pin for the LO Buffer Circuits. Typical current consumption is 22mA. This pin should be externally connected to the other V<sub>CC</sub> pins, and decoupled with 0.01μF and 1μF capacitors.

**V<sub>CC2</sub> (Pin 7):** Power Supply Pin for the Bias Circuits. Typical current consumption is 4mA. This pin should be

externally connected to the other V<sub>CC</sub> pins, and decoupled with 0.01μF and 1μF capacitors.

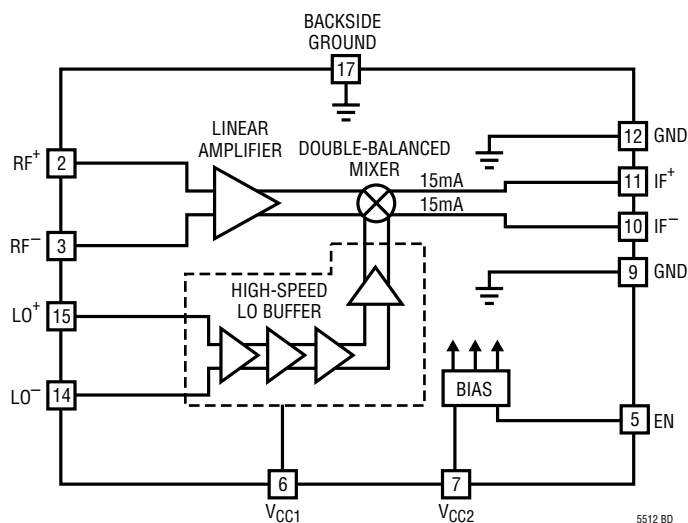
**GND (Pins 9 and 12):** Ground. These pins are internally connected to the backside ground for better isolation. They should be connected to RF ground on the circuit board, although they are not intended to replace the primary grounding through the backside contact of the package.

**IF<sup>-</sup>, IF<sup>+</sup> (Pins 10, 11):** Differential Outputs for the IF Signal. An impedance transformation may be required to match the outputs. These pins must be connected to V<sub>CC</sub> through impedance matching inductors, RF chokes or a transformer center-tap.

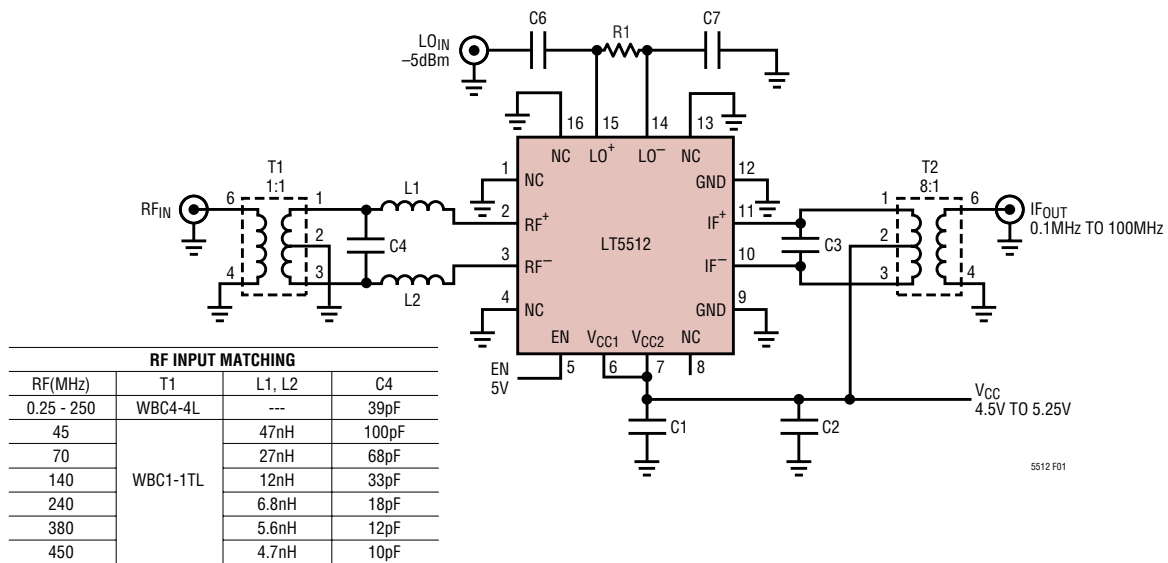
**LO<sup>-</sup>, LO<sup>+</sup> (Pins 14, 15):** Differential Inputs for the Local Oscillator Signal. They can also be driven single-ended by connecting one to an RF ground through a DC blocking capacitor. These pins are internally biased to 2V; thus, DC blocking capacitors are required. An impedance transformation or matching resistor is required to match the LO input to 50Ω (or 75Ω).

**GROUND (Pin 17):** (Backside Contact): Circuit Ground Return for the Entire IC. This must be soldered to the printed circuit board ground plane.

## BLOCK DIAGRAM

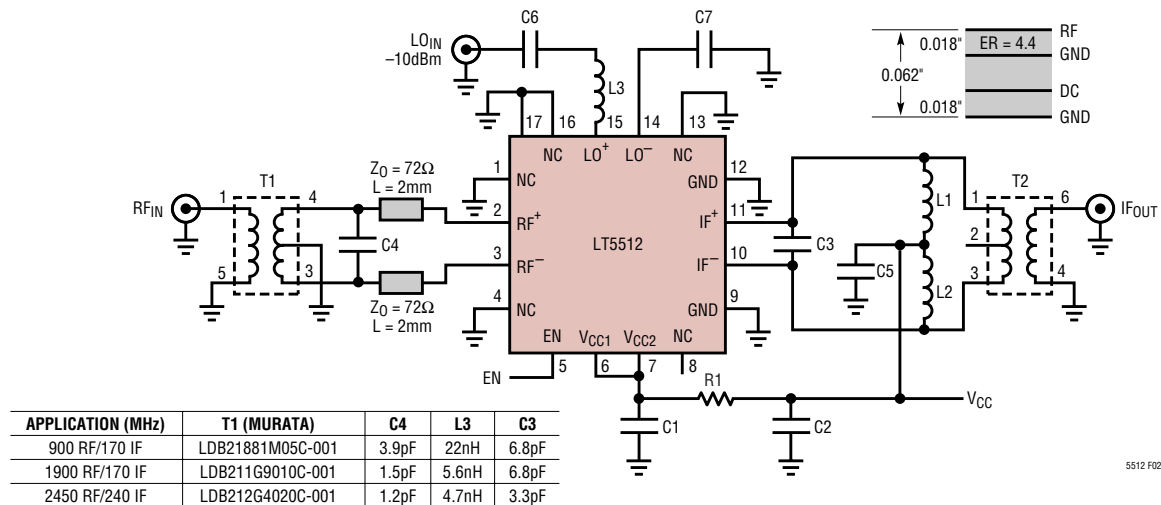


## TEST CIRCUITS



| REF DES    | VALUE  | SIZE | PART NUMBER      | REF DES | VALUE     | SIZE | PART NUMBER         |
|------------|--------|------|------------------|---------|-----------|------|---------------------|
| R1         | 100Ω   | 0402 | AAC CR05-101J    | C4      | See Table | 0402 | AVX 0402            |
| C1, C6, C7 | 0.01μF | 0402 | AVX 04023C103JAT | L1, L2  | See Table | 0402 | Toko LL1005-FH      |
| C2         | 1μF    | 0603 | AVX 0603ZD105KAT | T1      | 1:1       |      | Coilcraft WBC1-1TL  |
| C3         | 1.8pF  | 0402 | AVX 04025A1R8BAT | T2      | 8:1       |      | Mini-Circuits TC8-1 |

Figure 1. Test Schematic for HF/VHF/UHF Downmixer Applications



| REF DES    | VALUE     | SIZE | PART NUMBER              | REF DES | VALUE     | SIZE | PART NUMBER           |
|------------|-----------|------|--------------------------|---------|-----------|------|-----------------------|
| C5, C6, C7 | 100pF     | 0402 | Murata GRP1555C1H101J    | L1, L2  | 47nH      | 0402 | Coilcraft 0402CS-47NX |
| C1         | 0.01μF    | 0402 | Murata GRP155R71C103K    | L3      | See Table | 0402 | Toko LL1005-FH        |
| C2         | 1.0μF     | 0603 | Taiyo Yuden LMK107F105ZA | R1      | 10        | 0402 |                       |
| C4         | See Table | 0402 | Murata GRP1555C          | T1      | See Table |      | Murata LDB21 Series   |
| C3         | See Table | 0402 | Murata GRP1555C          | T2      | 8:1       |      | Mini-Circuits TC8-1   |

Figure 2. Test Schematic for 900MHz to 2.5GHz Downmixer Applications

5512fa

# APPLICATIONS INFORMATION

The LT5512 consists of a double-balanced mixer, RF buffer amplifier, high-speed limiting LO buffer and bias/enable circuits. The differential RF, LO and IF ports require simple external matching which allows the mixer to be used at very low frequencies, below 1MHz, or up to 3GHz. Low side or high side LO injection can be used.

Two evaluation circuits are available. The HF/VHF/UHF evaluation circuit is shown in Figure 1 and the 900MHz to 2.5GHz evaluation circuit is shown in Figure 2. The corresponding demo board layouts are shown in Figures 10 and 11, respectively.

## RF Input Port

A simplified schematic of the differential RF input is shown in Figure 3, with the associated external impedance matching elements for a 450MHz application. Each RF input requires a low resistance DC return to ground

capable of sinking 15mA. This can be accomplished with the center-tap of a balun as shown in Figure 3, or with bias chokes connected from Pins 2 and 3 to ground, if a differential RF input signal is available. The value of the bias chokes should be high enough to avoid reducing the input impedance at the frequency of interest.

Table 1 lists the differential input impedance and differential reflection coefficient between Pins 2 and 3 for several common RF frequencies. As shown in Figures 3 and 4, low-pass impedance matching is used to transform the differential input impedance up to the desired value for the balun input. The following example shows how to design the low-pass impedance transformation network for the RF input.

From Table 1, the differential input impedance at 450MHz is  $18.1 + j5.2$ . As shown in Figure 4, the  $5.2\Omega$  reactance is split, with one half on each side of the  $18.1\Omega$  load resistor. The matching network will consist of additional inductance in series with the internal inductance and a capacitor in parallel with the desired  $50\Omega$  source impedance. The capacitance (C4) and inductance are calculated as follows.

$$Q = \sqrt{(R_S / R_L) - 1} = \sqrt{(50 / 18.1) - 1} = 1.328$$

$$C4 = \frac{Q}{\omega R_S} = \frac{1.328}{2\pi \cdot 450\text{MHz} \cdot 50} = 9.4\text{pF (use 10pF)}$$

$$L1, L2 = \frac{R_L \cdot Q}{2\omega} = \frac{18.1 \cdot 1.328}{2 \cdot 2\pi \cdot 450\text{MHz}} = 4.2\text{nH (use 4.7nH)}$$

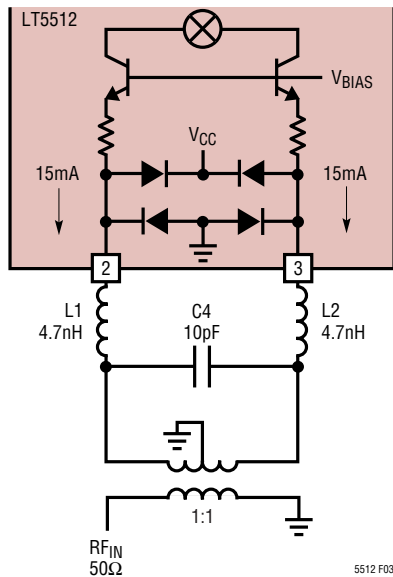


Figure 3. RF Input with External Matching for a 450MHz Application

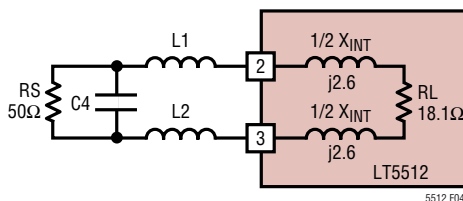


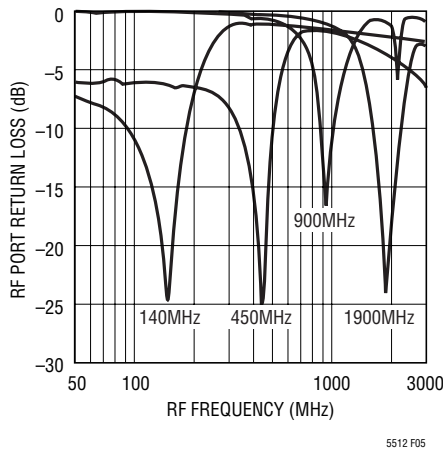
Figure 4. 450MHz RF Input Matching

Table 1. RF Input Differential Impedance

| Frequency (MHz) | Differential Input Impedance | Differential S11 |       |
|-----------------|------------------------------|------------------|-------|
|                 |                              | Mag              | Angle |
| 10              | $18.2 + j0.14$               | 0.467            | 179.6 |
| 44              | $18 + j0.26$                 | 0.470            | 178.6 |
| 240             | $18.1 + j2.8$                | 0.471            | 172.6 |
| 450             | $18.1 + j5.2$                | 0.473            | 166.3 |
| 950             | $18.7 + j11.3$               | 0.479            | 150.8 |
| 1900            | $20.6 + j22.8$               | 0.503            | 124.3 |
| 2150            | $21.4 + j26.5$               | 0.512            | 116.9 |
| 2450            | $22.5 + j30.5$               | 0.522            | 109.2 |
| 2700            | $24.1 + j34.7$               | 0.530            | 101.7 |

5512fa

# APPLICATIONS INFORMATION



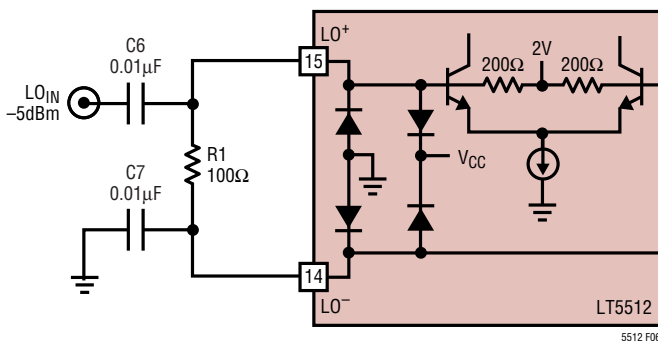
**Figure 5. RF Input Return Loss  
(140MHz, 450MHz, 900MHz and 1900MHz Matching)**

At high frequencies (greater than 900MHz), this same matching technique is used, but it is important to consider the IC's input reactance when calculating the external inductance. As shown in Figure 2, the high-frequency evaluation board uses short (2mm) 72Ω microstrip lines to realize the required inductance, instead of chip inductors.

External matching values for several frequencies, ranging from 45MHz to 2.45GHz are shown in Figures 1 and 2. Measured RF input return losses are plotted in Figure 5.

## LO Input Port

The LO buffer amplifier consists of high-speed limiting differential amplifiers, designed to drive the mixer quad for high linearity. The LO<sup>+</sup> and LO<sup>-</sup> pins are designed for differential or single-ended drive. Both LO pins are internally biased to 2V<sub>DC</sub>.



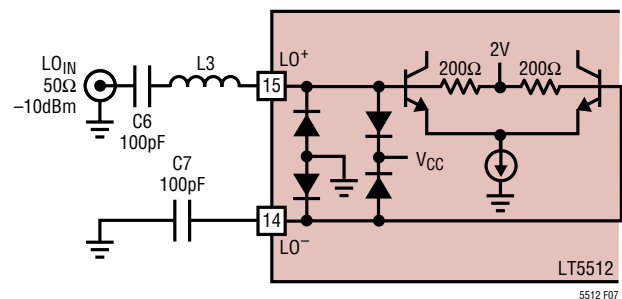
**Figure 6. LO Input with Resistive Matching**

**Table 2. LO Input Differential Impedance**

| Frequency (MHz) | Differential Input Impedance | Differential S11 |       |
|-----------------|------------------------------|------------------|-------|
|                 |                              | Mag              | Angle |
| 750             | 263 + j172                   | 0.766            | -10.2 |
| 1000            | 213 + j178                   | 0.760            | -13.4 |
| 1250            | 175 + j173                   | 0.752            | -16.6 |
| 1500            | 146 + j164                   | 0.743            | -19.8 |
| 1750            | 125 + j153                   | 0.733            | -22.8 |
| 2000            | 108 + j142                   | 0.722            | -25.8 |
| 2250            | 95 + j131                    | 0.709            | -28.9 |
| 2500            | 86 + j122                    | 0.695            | -31.8 |
| 2750            | 78 + j133                    | 0.68             | -34.6 |

A simplified schematic of the LO input is shown in Figure 6 with simple resistive matching and DC blocking capacitors. This is the preferred matching for LO frequencies below 1.5GHz. The internal (DC) resistance is 400Ω. The required LO drive at the IC is 150mV<sub>RMS</sub> (typical) which can come from a 50Ω source, or a higher impedance source such as PECL. The external matching resistor is required only to reduce the amplitude of the LO signal at the IC, although the input stage will tolerate 10dB of overdrive without significant performance degradation. Resistive LO port matching is used on the low-frequency evaluation board (see Figure 1).

Above 1.5GHz, the internal capacitance becomes significant and reactive matching to 50Ω with a single series inductor and DC blocking capacitors is preferred. A schematic is shown in Figure 7. Table 2 lists the differential input



**Figure 7. LO Input with Reactive Matching**

APPLICATIONS INFORMATION

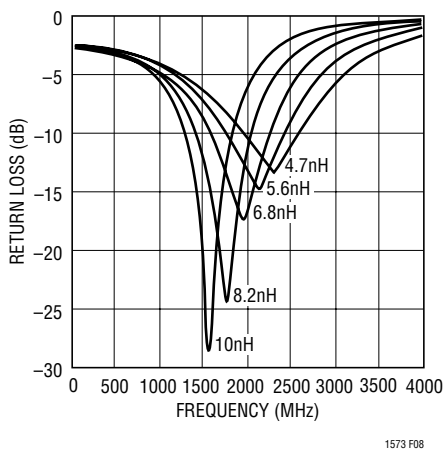


Figure 8. Single-Ended LO Port Return Loss vs Frequency for Various Values of L3

impedance and differential reflection coefficient between the LO<sup>+</sup> and LO<sup>-</sup> pins. This information can be used to compute the value of the series matching inductor, L3. Alternatively, Figure 8 shows measured LO input return loss versus frequency for various values of L3. Reactive LO port matching is used on the high-frequency evaluation board (see Figure 2).

IF Output Port

The differential IF outputs, IF<sup>+</sup> and IF<sup>-</sup>, are internally connected to the collectors of the mixer switching transistors as shown in Figure 9. These outputs should be combined externally through an RF balun or 180° hybrid to achieve optimum performance. Both pins must be biased at the supply voltage, which can be applied through matching inductors (see Figure 2), or through the center-tap of an output transformer (see Figure 1). These pins are protected with ESD diodes; the diodes allow peak AC signal swing up to 1.3V above V<sub>CC</sub>.

As shown in Table 3, the IF output differential impedance is approximately 390Ω in parallel with 0.44pF. A simple band-pass IF matching network suitable for wireless applications is shown in Figure 9. Here, L1, L2 and C3 set the desired IF output frequency. The 390Ω differential output can then be applied directly to a differential filter, or an 8:1 balun for impedance transformation down to 50Ω. To achieve maximum linearity, C3 should be located as

close as possible to the IF<sup>+</sup>/IF<sup>-</sup> pins. Even small amounts of inductance in series with C3 (such as through a via) can significantly degrade IIP3. The value of C3 should be reduced by the value of internal capacitance (see Table 3). This matching network is simple and offers good selectivity for narrow band IF applications.

For IF frequencies below 100MHz, the simplest IF matching technique is an 8:1 transformer connected across the IF pins as shown in Figure 1. DC bias to the IF<sup>+</sup> and IF<sup>-</sup> pins is provided through the transformer's center-tap. A small value IF capacitor (C3) improves the LO-IF leakage and attenuates the undesired image frequency. No inductors are required.

| Frequency (MHz) | Differential Output Impedance | Differential S11 |       |
|-----------------|-------------------------------|------------------|-------|
|                 |                               | Mag              | Angle |
| 10              | 396 II - j10k                 | 0.766            | 0     |
| 70              | 394 II - j5445                | 0.775            | -1.1  |
| 170             | 393 II - j2112                | 0.774            | -2.8  |
| 240             | 392 II - j1507                | 0.773            | -3.9  |
| 450             | 387 II - j798                 | 0.772            | -7.3  |
| 750             | 377 II - j478                 | 0.768            | -12.2 |
| 860             | 371 II - j416                 | 0.766            | -14.0 |
| 1000            | 363 II - j359                 | 0.762            | -16.2 |
| 1250            | 363 II - j295                 | 0.764            | -19.6 |
| 1500            | 346 II - j244                 | 0.756            | -23.6 |
| 1900            | 317 II - j192                 | 0.743            | -29.9 |

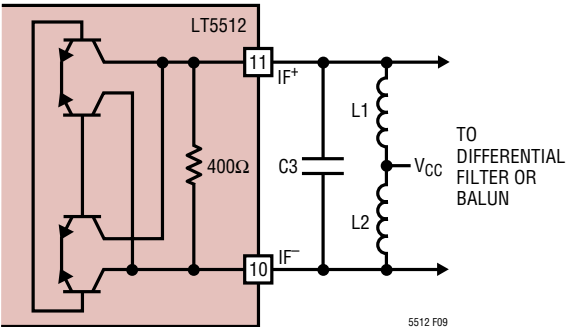
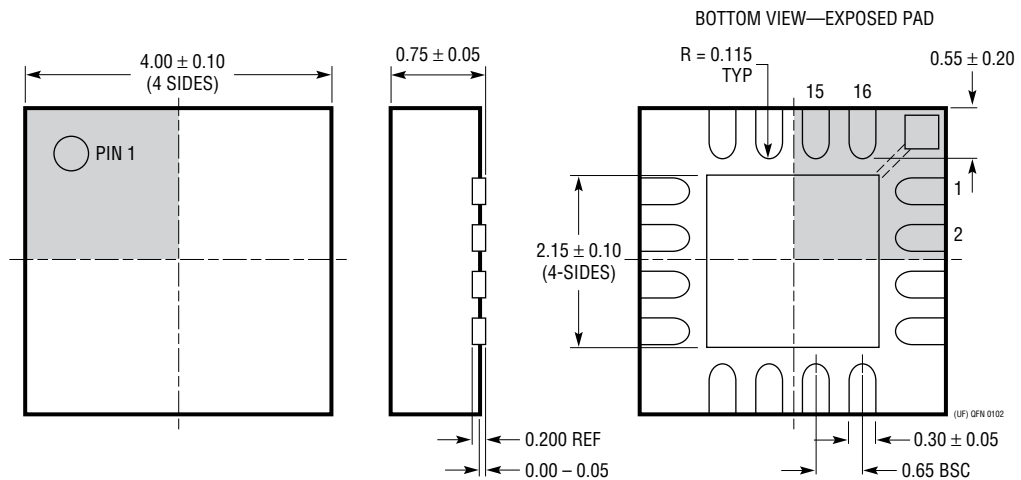
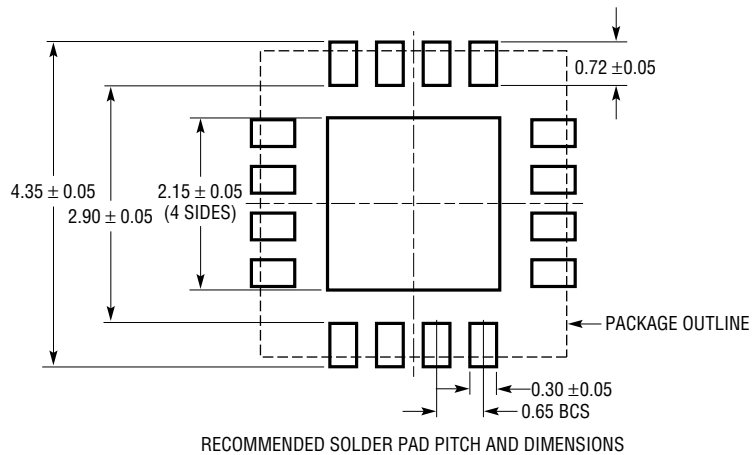


Figure 9. IF Output Equivalent Circuit with Band-Pass Matching Elements

# 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 (WGGC)
  2. ALL DIMENSIONS ARE IN MILLIMETERS
  3. 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
  4. EXPOSED PAD SHALL BE SOLDER PLATED

## APPLICATIONS INFORMATION

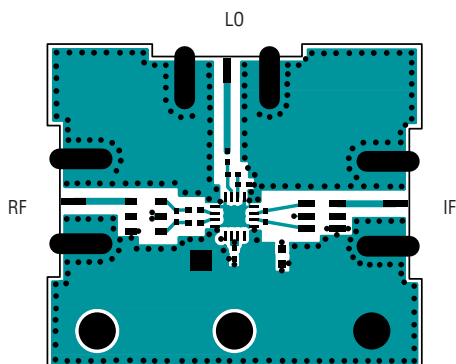


Figure 10. HF/VHF/UHF Evaluation Board Layout (DC933A)

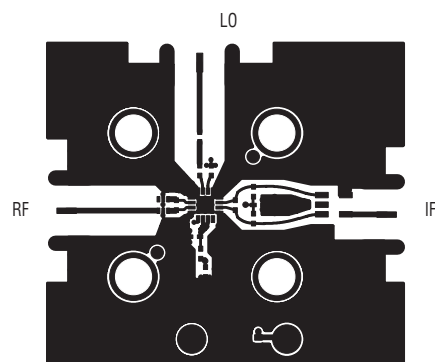


Figure 11. High-Frequency Evaluation Board Layout (DC478B)

## RELATED PARTS

| PART NUMBER    | DESCRIPTION                                                                 | COMMENTS                                                                                                           |
|----------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Infrastructure |                                                                             |                                                                                                                    |
| LT5511         | High Linearity Upconverting Mixer                                           | RF Output 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                                                                     |
| LT5519         | 0.7GHz to 1.4GHz High Linearity Upconverting Mixer                          | 17.1dBm IIP3 at 1GHz, Integrated RF Output Transformer with 50Ω 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 50Ω 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         | 400MHz to 2.7GHz High Signal Level Downconverting Mixer                     | 4.5V to 5.25V Supply, 25dBm IIP3 at 900MHz, NF = 12.5dB, 50Ω 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 50Ω 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                     | Single-Ended 50Ω RF and LO Ports, 23.5dBm IIP3 at 1.9GHz                                                           |
| LT5528         | 1.5GHz to 2.4GHz High Linearity Direct I/Q Modulator                        | 21.8dBm OIP3 at 2GHz, -159dBm/Hz Noise Floor, 50Ω Interface at all Ports                                           |