

## FEATURES

- Up or Downconverting Applications
- Noise Figure: 9.3dB Typical at 900MHz Output
- Conversion Gain: 2.4dB Typical
- IIP3: 9dBm Typical at  $I_{CC} = 10\text{mA}$
- Adjustable Supply Current: 4mA to 13.4mA
- Low LO Drive Level:  $-2\text{dBm}$
- Single-Ended or Differential LO
- High Port-to-Port Isolation
- Enable Control with Low Off-State Leakage Current
- Single 2.7V to 5V Supply
- Small 3mm × 3mm DFN Package

## APPLICATIONS

- Portable Wireless
- CATV/DBS Receivers
- WiMAX Radios
- PHS Basestations
- RF Instrumentation
- Microwave Data Links
- VHF/UHF 2-Way Radios

## DESCRIPTION

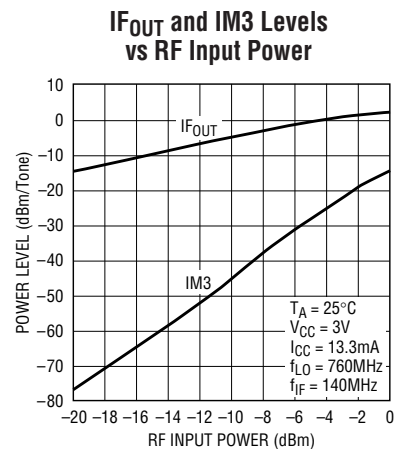
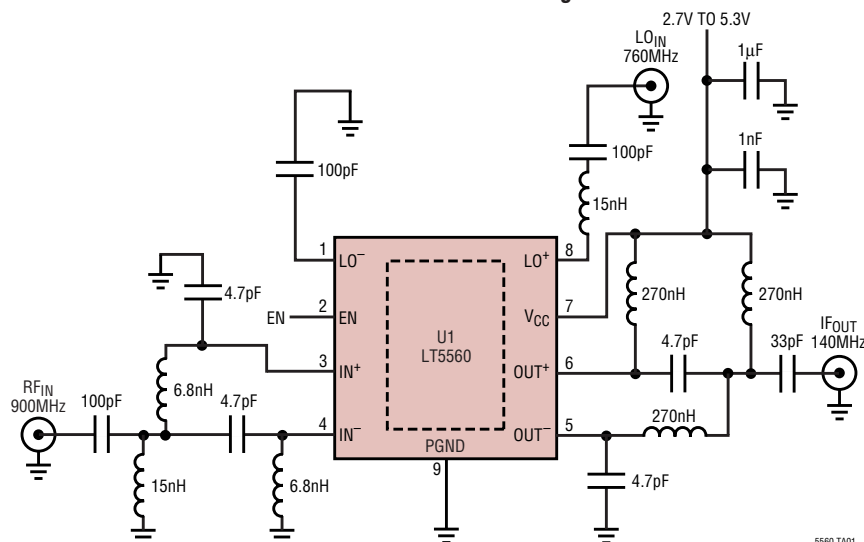
The LT<sup>®</sup>5560 is a low power, high performance broadband active mixer. This double-balanced mixer can be driven by a single-ended LO source and requires only  $-2\text{dBm}$  of LO power. The balanced design results in low LO leakage to the output, while the integrated input amplifier provides excellent LO to IN isolation. The signal ports can be impedance matched to a broad range of frequencies, which allows the LT5560 to be used as an up- or down-conversion mixer in a wide variety of applications.

The LT5560 is characterized with a supply current of 10mA; however, the DC current is adjustable, which allows the performance to be optimized for each application with a single resistor. For example, when biased at its maximum supply current (13.4mA), the typical upconverting mixer IIP3 is  $+10.8\text{dBm}$  for a 900MHz output.

LT, LT, LTC and LTM are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

## TYPICAL APPLICATION

Low Cost 900MHz Downconverting Mixer



5560 TA02

5560 TA01

## ABSOLUTE MAXIMUM RATINGS

(Note 1)

|   |                          |
|---|--------------------------|
| Supply Voltage .....                    | 5.5V                     |
| Enable Voltage .....                    | -0.3V to $V_{CC} + 0.3V$ |
| LO Input Power (Differential) .....     | +10dBm                   |
| Input Signal Power (Differential) ..... | +10dBm                   |
| $IN^+$ , $IN^-$ DC Currents .....       | 10mA                     |
| $OUT^+$ , $OUT^-$ DC Current .....      | 10mA                     |
| $T_{JMAX}$ .....                        | 125°C                    |
| Operating Temperature Range .....       | -40°C to 85°C            |
| Storage Temperature Range .....         | -65°C to 125°C           |

## PACKAGE/ORDER INFORMATION

|  |                 |
|--|-----------------|
| <p>TOP VIEW</p> <p>DD PACKAGE<br/>8-LEAD (3mm × 3mm) PLASTIC DFN<br/><math>T_{JMAX} = 125^{\circ}C</math>, <math>\theta_{JA} = 43^{\circ}C/W</math><br/>EXPOSED PAD (PIN 9) IS GND<br/>MUST BE SOLDERED TO PCB</p>       |                 |
| ORDER PART NUMBER  | DD PART MARKING |
| LT5560EDD  | LCBX            |
| <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

$V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^{\circ}C$ , unless otherwise noted. Test circuit shown in Figure 1. (Note 3)

| PARAMETER  | CONDITIONS                     | MIN | TYP       | MAX | UNITS              |
|--|--------------------------------|-----|-----------|-----|--------------------|
| <b>Power Supply Requirements (<math>V_{CC}</math>)</b> |                                |     |           |     |                    |
| Supply Voltage   |                                | 2.7 | 3         | 5.3 | V                  |
| Supply Current   | $V_{CC} = 3V$ , $R1 = 3\Omega$ |     | 10        | 12  | mA                 |
| Shutdown Current                                       | $EN = 0.3V$ , $V_{CC} = 3V$    |     | 0.1       | 10  | $\mu A$            |
| <b>Enable (EN) Low = Off, High = On</b>                |                                |     |           |     |                    |
| EN Input High Voltage (On)                             |                                | 2   |           |     | V                  |
| EN Input Low Voltage (Off)                             |                                |     |           | 0.3 | V                  |
| Enable Pin Input Current                               | $EN = 3V$<br>$EN = 0.3V$       |     | 25<br>0.1 |     | $\mu A$<br>$\mu A$ |
| Turn On Time   |                                |     | 2         |     | $\mu s$            |
| Turn Off Time  |                                |     | 5         |     | $\mu s$            |

## AC ELECTRICAL CHARACTERISTICS (Notes 2 and 3)

| PARAMETER                              | CONDITIONS                 | MIN | TYP    | MAX | UNITS |
|--|----------------------------|-----|--------|-----|-------|
| Signal Input Frequency Range (Note 4)  | Requires External Matching |     | < 4000 |     | MHz   |
| LO Input Frequency Range (Note 4)      | Requires External Matching |     | < 4000 |     | MHz   |
| Signal Output Frequency Range (Note 4) | Requires External Matching |     | < 4000 |     | MHz   |

5560f

## AC ELECTRICAL CHARACTERISTICS

$V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ ,  $P_{IN} = -20dBm$  ( $-20dBm/$ tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $P_{LO} = -2dBm$ , unless otherwise noted. Test circuits are shown in Figures 1, 2 and 3. (Notes 2 and 3)

| PARAMETER                 | CONDITIONS                      | MIN | TYP     | MAX | UNITS |
|---------------------------|---------------------------------|-----|---------|-----|-------|
| Signal Input Return Loss  | $Z = 50\Omega$ , External Match |     | 15      |     | dB    |
| LO Input Return Loss      | $Z = 50\Omega$ , External Match |     | 15      |     | dB    |
| Signal Output Return Loss | $Z = 50\Omega$ , External Match |     | 15      |     | dB    |
| LO Input Power            |                                 |     | -6 to 1 |     | dBm   |

**Upconverting Mixer Configuration:**  $V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ ,  $P_{IN} = -20dBm$  ( $-20dBm/$ tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $P_{LO} = -2dBm$ , unless otherwise noted. High side LO for 450MHz tests, low side LO for 900MHz and 1900MHz tests. Test circuits are shown in Figures 1 and 3. (Notes 2, 3 and 5)

| PARAMETER                            | CONDITIONS   | MIN | TYP    | MAX | UNITS          |
|--------------------------------------|--|-----|--------|-----|----------------|
| Conversion Gain                      | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | 2.7    |     | dB             |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | 2.4    |     | dB             |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | 1.2    |     | dB             |
| Conversion Gain vs Temperature       | $T_A = -40^\circ C$ to $85^\circ C$ , $f_{OUT} = 900MHz$ |     | -0.015 |     | dB/ $^\circ C$ |
| Input 3rd Order Intercept            | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | 9.6    |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | 9.0    |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | 8.0    |     | dBm            |
| Input 2nd Order Intercept            | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | 46     |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | 47     |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | 30     |     | dBm            |
| Single Sideband Noise Figure         | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | 8.8    |     | dB             |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | 9.3    |     | dB             |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | 10.3   |     | dB             |
| IN to LO Isolation (with LO Applied) | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | 69     |     | dB             |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | 64     |     | dB             |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | 64     |     | dB             |
| LO to IN Leakage                     | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | -63    |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | -54    |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | -36    |     | dBm            |
| LO to OUT Leakage                    | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | -44    |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | -41    |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | -36    |     | dBm            |
| Input 1dB Compression Point          | $f_{IN} = 70MHz$ , $f_{OUT} = 450MHz$                    |     | 0.4    |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 900MHz$                   |     | -2.8   |     | dBm            |
|                                      | $f_{IN} = 140MHz$ , $f_{OUT} = 1900MHz$                  |     | -0.8   |     | dBm            |

**Downconverting Mixer Configuration:**  $V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ ,  $P_{IN} = -20dBm$  ( $-20dBm/$ tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $P_{LO} = -2dBm$ , unless otherwise noted. High side LO for 450MHz tests, low side LO for 900MHz and 1900MHz tests. Test circuits are shown in Figures 2 and 3. (Notes 2, 3 and 5)

| PARAMETER                      | CONDITIONS  | MIN | TYP    | MAX | UNITS          |
|--------------------------------|---|-----|--------|-----|----------------|
| Conversion Gain                | $f_{IN} = 450MHz$ , $f_{OUT} = 70MHz$                   |     | 2.7    |     | dB             |
|                                | $f_{IN} = 900MHz$ , $f_{OUT} = 140MHz$                  |     | 2.6    |     | dB             |
|                                | $f_{IN} = 1900MHz$ , $f_{OUT} = 140MHz$                 |     | 2.3    |     | dB             |
| Conversion Gain vs Temperature | $T_A = -40^\circ C$ to $85^\circ C$ , $f_{IN} = 900MHz$ |     | -0.015 |     | dB/ $^\circ C$ |
| Input 3rd Order Intercept      | $f_{IN} = 450MHz$ , $f_{OUT} = 70MHz$                   |     | 10.1   |     | dBm            |
|                                | $f_{IN} = 900MHz$ , $f_{OUT} = 140MHz$                  |     | 9.7    |     | dBm            |
|                                | $f_{IN} = 1900MHz$ , $f_{OUT} = 140MHz$                 |     | 5.6    |     | dBm            |
| Single Sideband Noise Figure   | $f_{IN} = 450MHz$ , $f_{OUT} = 70MHz$                   |     | 10.5   |     | dB             |
|                                | $f_{IN} = 900MHz$ , $f_{OUT} = 140MHz$                  |     | 10.1   |     | dB             |
|                                | $f_{IN} = 1900MHz$ , $f_{OUT} = 140MHz$                 |     | 10.8   |     | dB             |

**AC ELECTRICAL CHARACTERISTICS**

Downconverting Mixer Configuration:  $V_{CC} = 3V$ ,  $EN = 3V$ ,  $T_A = 25^{\circ}C$ ,  $P_{IN} = -20dBm$  (-20dBm/tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $P_{LO} = -2dBm$ , unless otherwise noted. High side LO for 450MHz tests, low side LO for 900MHz and 1900MHz tests. Test circuits are shown in Figures 2 and 3. (Notes 2, 3 and 5)

| PARAMETER   | CONDITIONS  | MIN | TYP  | MAX | UNITS |
|---|---|-----|------|-----|-------|
| IN to LO Isolation (with LO Applied)  | $f_{IN} = 450MHz, f_{OUT} = 70MHz$                |     | 52   |     | dB    |
|   | $f_{IN} = 900MHz, f_{OUT} = 140MHz$               |     | 52   |     | dB    |
|   | $f_{IN} = 1900MHz, f_{OUT} = 140MHz$              |     | 25   |     | dB    |
| LO to IN Leakage  | $f_{IN} = 450MHz, f_{OUT} = 70MHz$                |     | -52  |     | dBm   |
|   | $f_{IN} = 900MHz, f_{OUT} = 140MHz$               |     | -57  |     | dBm   |
|   | $f_{IN} = 1900MHz, f_{OUT} = 140MHz$              |     | -37  |     | dBm   |
| LO to OUT Leakage   | $f_{IN} = 450MHz, f_{OUT} = 70MHz$                |     | -47  |     | dBm   |
|   | $f_{IN} = 900MHz, f_{OUT} = 140MHz$               |     | -63  |     | dBm   |
|   | $f_{IN} = 1900MHz, f_{OUT} = 140MHz$              |     | -24  |     | dBm   |
| 2RF – 2LO Output Spurious (Half IF) Product ( $f_{IN} = f_{LO} + f_{OUT}/2$ ) | 450MHz: $f_{IN} = 485MHz, f_{OUT} = 70MHz$        |     | -68  |     | dBc   |
|   | 900MHz: $f_{IN} = 830MHz, f_{OUT} = 140MHz$       |     | -69  |     | dBc   |
|   | 1900MHz: $f_{IN} = 1830MHz, f_{OUT} = 140MHz$     |     | -47  |     | dBc   |
| 3RF – 3LO Output Spurious (1/3 IF) Product ( $f_{IN} = f_{LO} + f_{OUT}/3$ )  | 450MHz: $f_{IN} = 496.7MHz, f_{OUT} = 69.9MHz$    |     | -79  |     | dBc   |
|   | 900MHz: $f_{IN} = 806.7MHz, f_{OUT} = 140.1MHz$   |     | -76  |     | dBc   |
|   | 1900MHz: $f_{IN} = 1806.7MHz, f_{OUT} = 140.1MHz$ |     | -62  |     | dBc   |
| Input 1dB Compression Point   | $f_{IN} = 450MHz, f_{OUT} = 70MHz$                |     | -0.8 |     | dBm   |
|   | $f_{IN} = 900MHz, f_{OUT} = 140MHz$               |     | 0    |     | dBm   |
|   | $f_{IN} = 1900MHz, f_{OUT} = 140MHz$              |     | -2.2 |     | dBm   |

**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

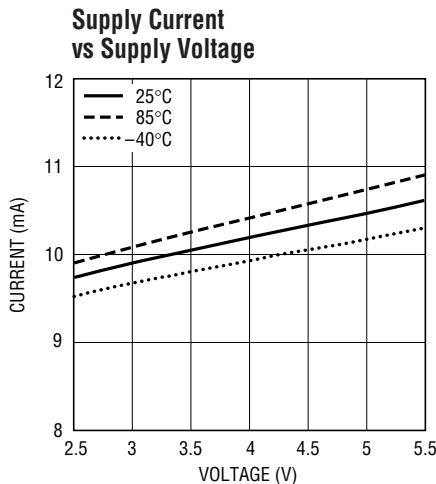
**Note 2:** Each set of frequency conditions requires an appropriate test board.

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

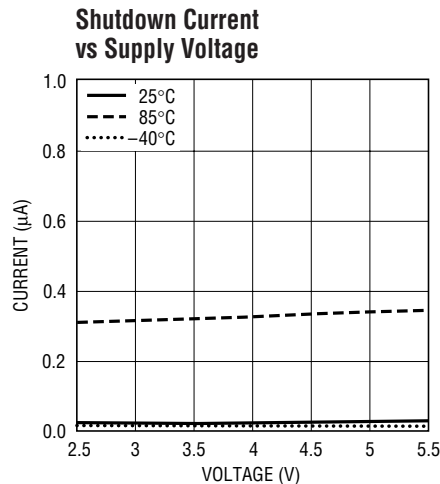
**Note 4:** Operation over a wider frequency range is possible with reduced performance. Consult the factory for information and assistance.

**Note 5:** SSB Noise Figure measurements are performed with a small-signal noise source and bandpass filter on the RF input (downmixer) or output (upmixer), and no other RF input signal applied.

**TYPICAL DC PERFORMANCE CHARACTERISTICS** (Test Circuit Shown in Figure 1)



5560 G01



5560 G02

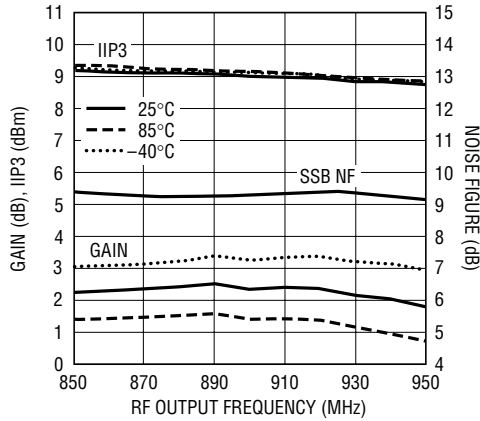
5560f

# TYPICAL AC PERFORMANCE CHARACTERISTICS

900MHz Upconverting Mixer Application:

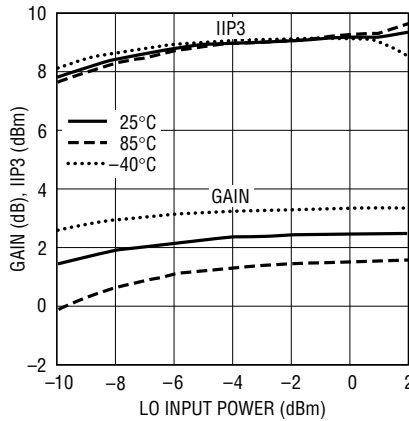
$V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ ,  $f_{IN} = 140MHz$ ,  $P_{IN} = -20dBm$  ( $-20dBm$ /tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $f_{LO} = 760MHz$ ,  $P_{LO} = -2dBm$ , output measured at 900MHz, unless otherwise noted. (Test circuit shown in Figure 1)

**Conversion Gain, IIP3 and SSB NF vs RF Output Frequency**



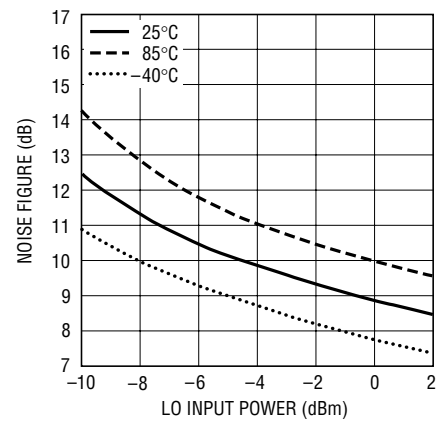
5560 G03

**Conversion Gain and IIP3 vs LO Input Power**



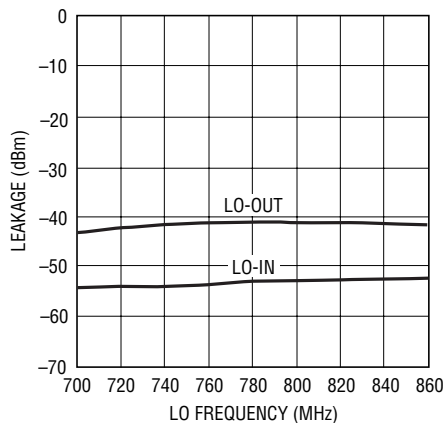
5560 G04

**SSB Noise Figure vs LO Input Power**



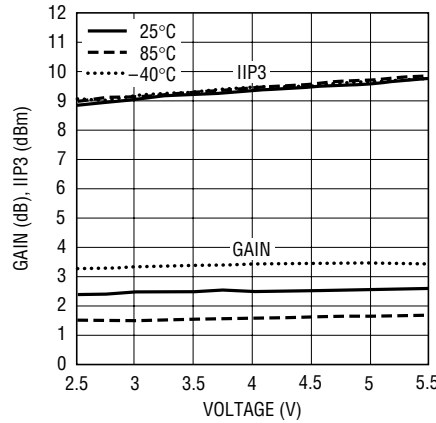
5560 G05

**LO-IN and LO-OUT Leakage vs LO Frequency**



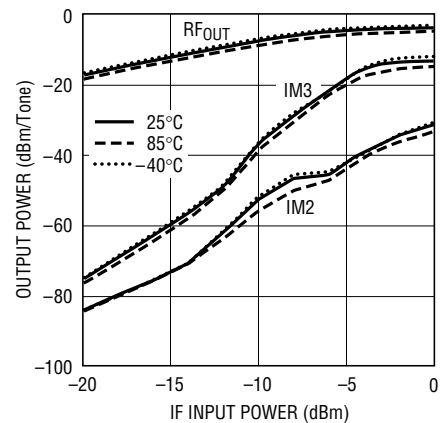
5560 G06

**Conversion Gain and IIP3 vs Supply Voltage**



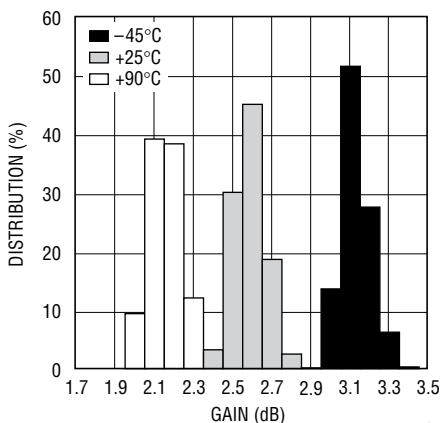
5560 G07

**RFOUT, IM3 and IM2 vs IF Input Power (Two Input Tones)**



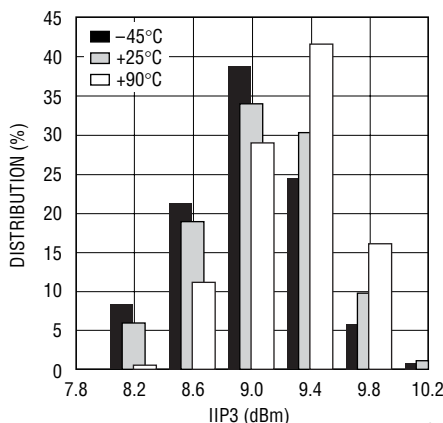
5560 G08

**Gain Distribution at 900MHz**



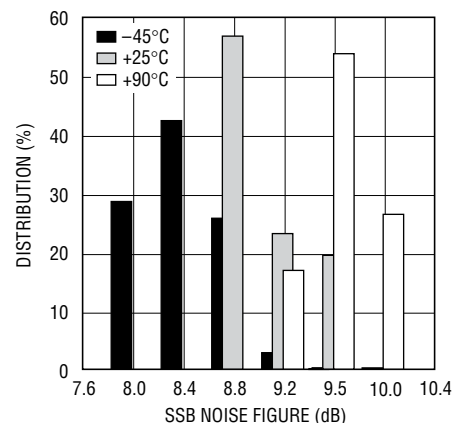
5560 G09

**IIP3 Distribution at 900MHz**



5560 G10

**SSB Noise Figure Distribution at 900MHz**



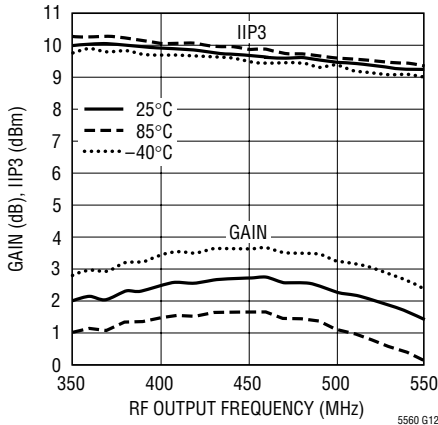
5560 G11

**TYPICAL AC PERFORMANCE CHARACTERISTICS**

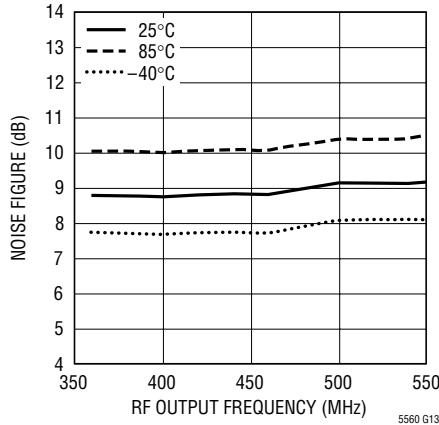
450MHz Upconverting Mixer Application:

$V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $EN = 3V$ ,  $T_A = 25^{\circ}C$ ,  $f_{IN} = 70MHz$ ,  $P_{IN} = -20dBm$  (-20dBm/tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $f_{LO} = 520MHz$ ,  $P_{LO} = -2dBm$ , output measured at 450MHz, unless otherwise noted. (Test circuit shown in Figure 3)

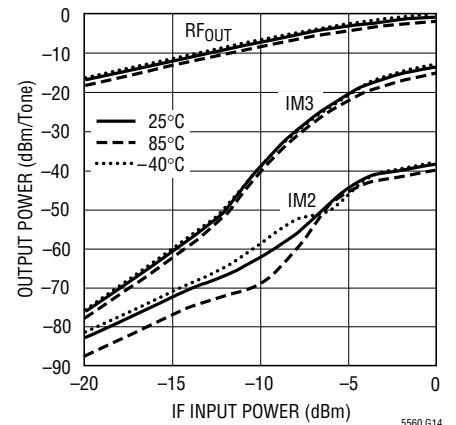
**Conversion Gain and IIP3 vs RF Output Frequency**



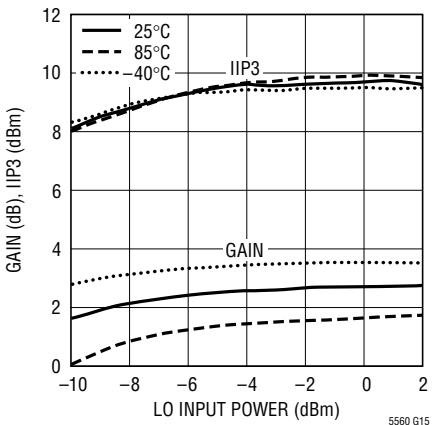
**SSB Noise Figure vs RF Output Frequency**



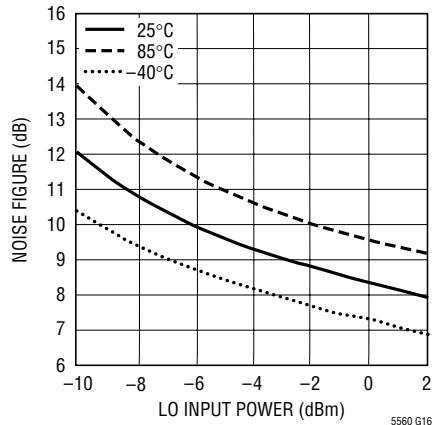
**RF<sub>OUT</sub>, IM3 and IM2 vs IF Input Power (Two Input Tones)**



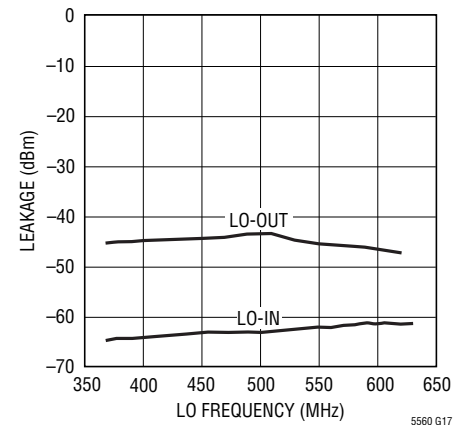
**Conversion Gain and IIP3 vs LO Input Power**



**SSB Noise Figure vs LO Input Power**

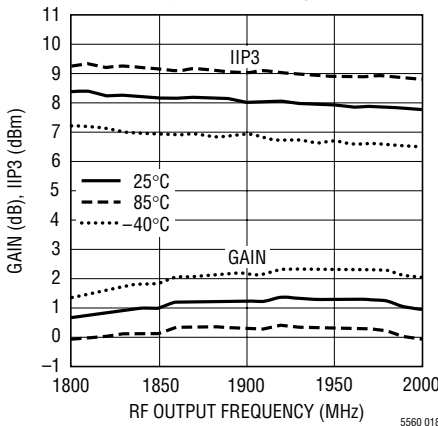


**LO-IN and LO-OUT Leakage vs LO Frequency**

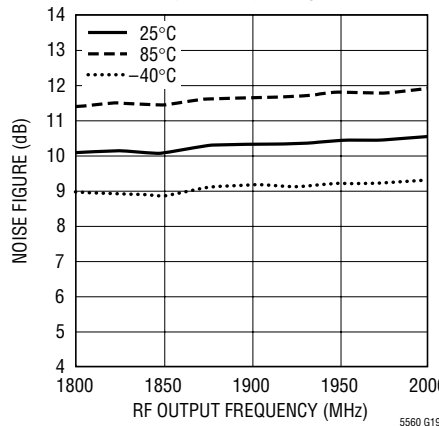


1900MHz Upconverting Mixer Application:  $V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $EN = 3V$ ,  $T_A = 25^{\circ}C$ ,  $f_{IN} = 140MHz$ ,  $P_{IN} = -20dBm$  (-20dBm/tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $f_{LO} = 1760MHz$ ,  $P_{LO} = -2dBm$ , output measured at 1900MHz, unless otherwise noted. (Test circuit shown in Figure 1)

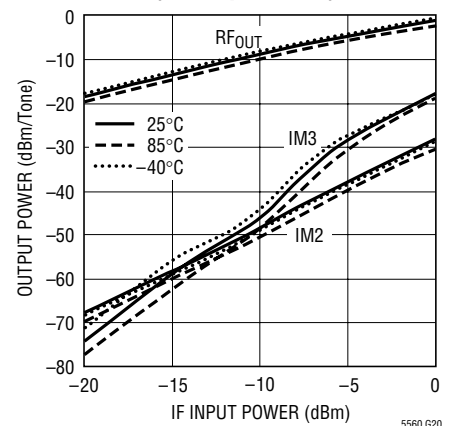
**Conversion Gain and IIP3 vs RF Output Frequency**



**SSB Noise Figure vs RF Output Frequency**



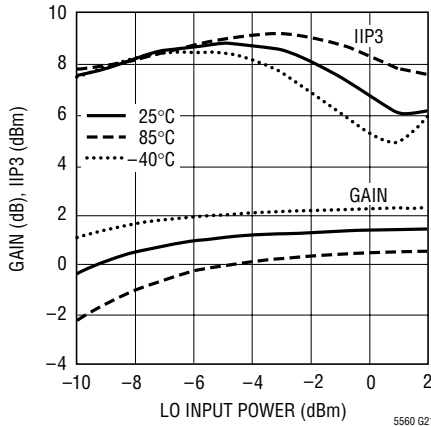
**RF<sub>OUT</sub>, IM3 and IM2 vs IF Input Power (Two Input Tones)**



# TYPICAL AC PERFORMANCE CHARACTERISTICS

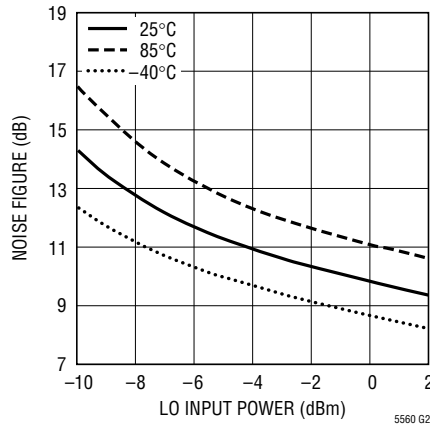
1900MHz Upconverting Mixer Application:  
 $V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $V_{EN} = 3V$ ,  $T_A = 25^\circ C$ ,  $f_{IN} = 140MHz$ ,  $P_{IN} = -20dBm$  ( $-20dBm$ /tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $f_{LO} = 1760MHz$ ,  $P_{LO} = -2dBm$ , output measured at 1900MHz, unless otherwise noted. (Test circuit shown in Figure 1)

**Conversion Gain and IIP3 vs LO Input Power**



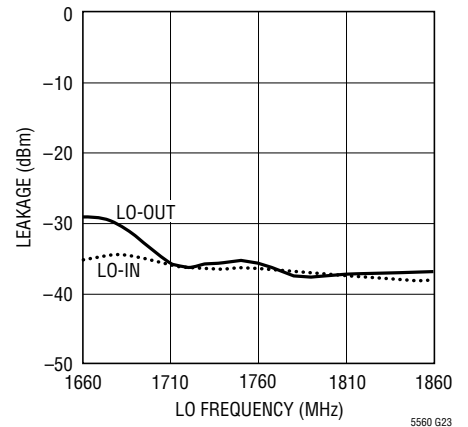
5560 G21

**SSB Noise Figure vs LO Input Power**



5560 G22

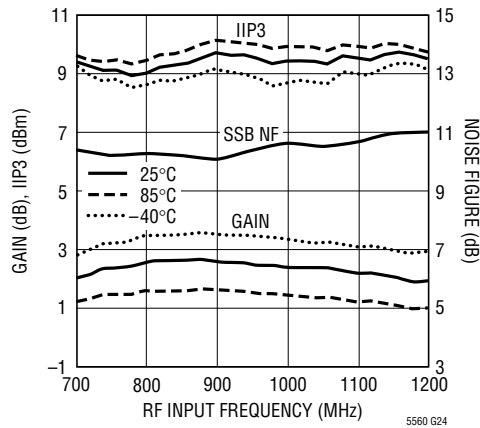
**LO-IN and LO-OUT Leakage vs LO Frequency**



5560 G23

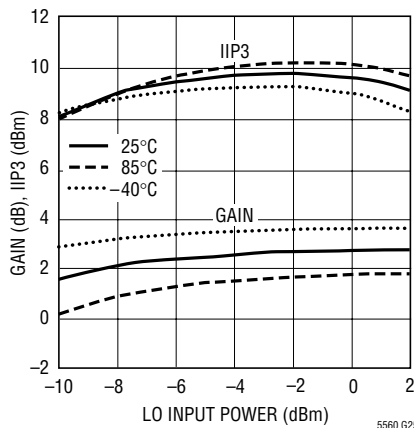
900MHz Downconverting Mixer Application:  $V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $V_{EN} = 3V$ ,  $T_A = 25^\circ C$ ,  $f_{IN} = 900MHz$ ,  $P_{IN} = -20dBm$  ( $-20dBm$ /tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $f_{LO} = 760MHz$ ,  $P_{LO} = -2dBm$ , output measured at 140MHz, unless otherwise noted. (Test circuit shown in Figure 2)

**Conversion Gain, IIP3 and SSB NF vs RF Input Frequency**



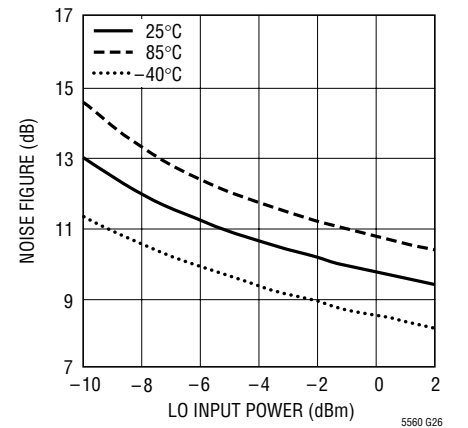
5560 G24

**Conversion Gain and IIP3 vs LO Input Power**



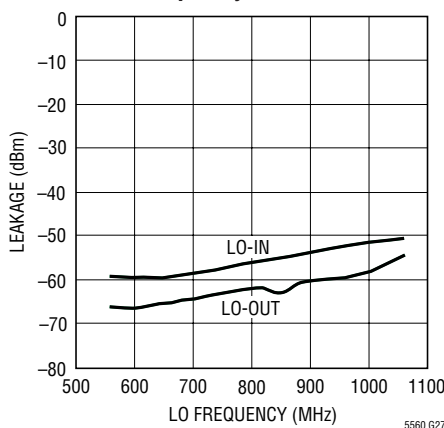
5560 G25

**SSB Noise Figure vs LO Input Power**



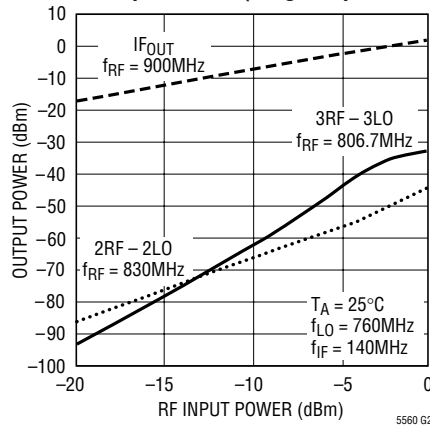
5560 G26

**LO-IN and LO-OUT Leakage vs LO Frequency**



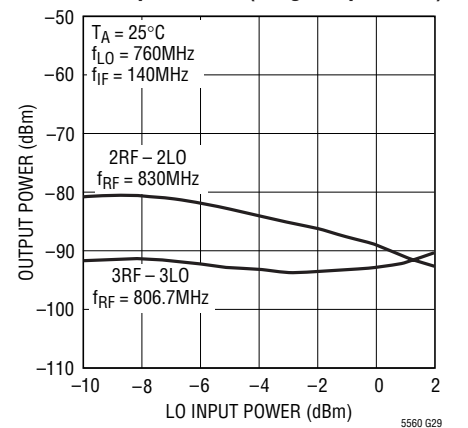
5560 G27

**I<sub>FOUT</sub>, 2 × 2 and 3 × 3 Spurs vs RF Input Power (Single Input Tone)**



5560 G28

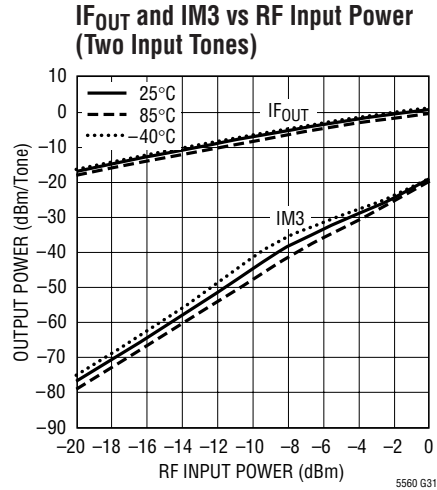
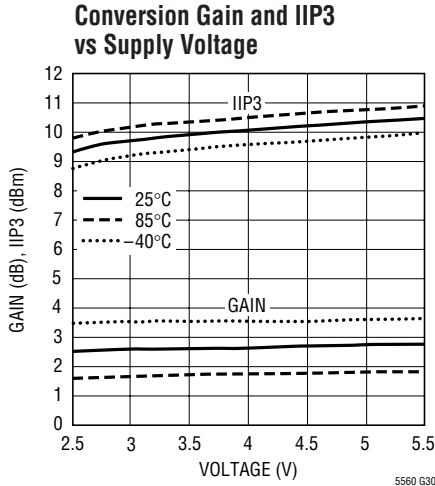
**2 × 2 and 3 × 3 Spurs vs LO Input Power (Single Input Tone)**



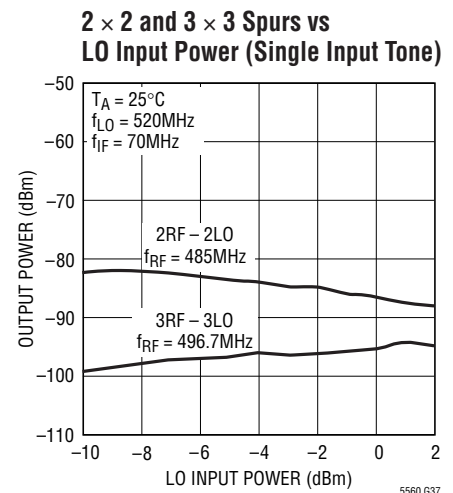
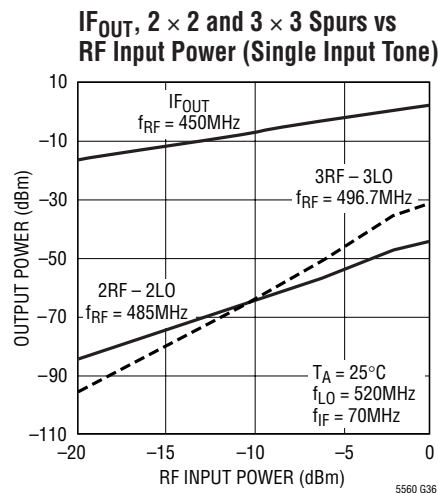
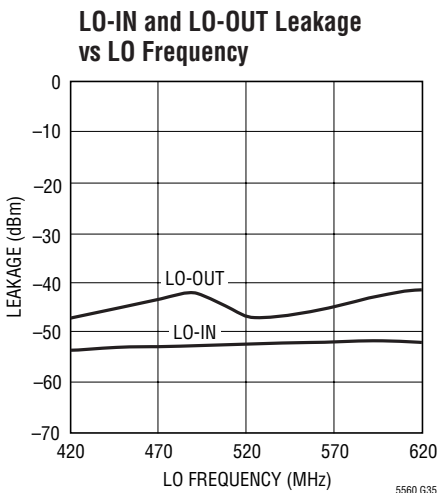
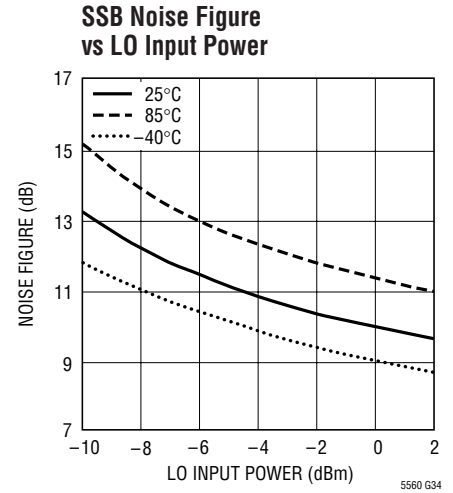
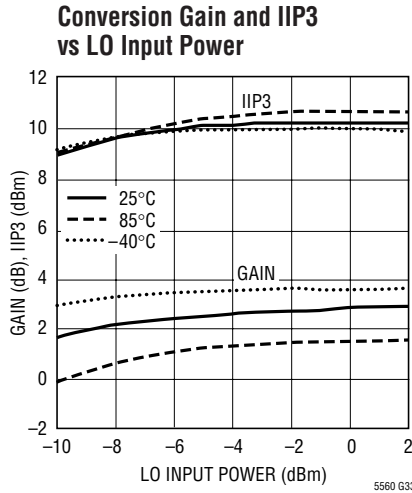
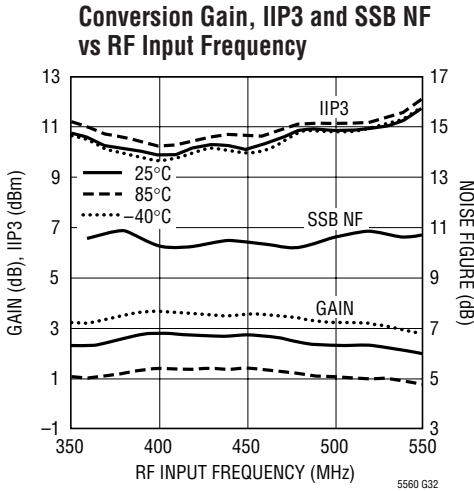
5560 G29

5560F

**TYPICAL AC PERFORMANCE CHARACTERISTICS** 900MHz Downconverting Mixer Application:  $V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ ,  $f_{IN} = 900MHz$ ,  $P_{IN} = -20dBm$  ( $-20dBm/$ tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $f_{LO} = 760MHz$ ,  $P_{LO} = -2dBm$ , output measured at 140MHz, unless otherwise noted. (Test circuit shown in Figure 2)

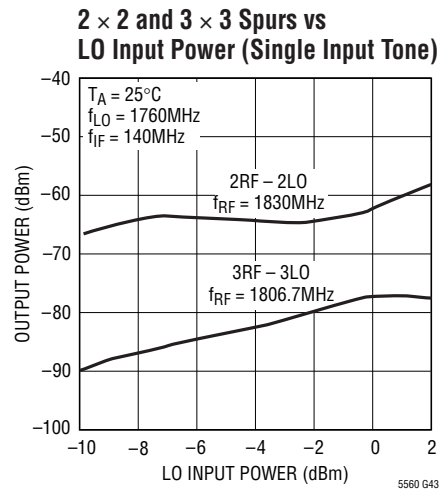
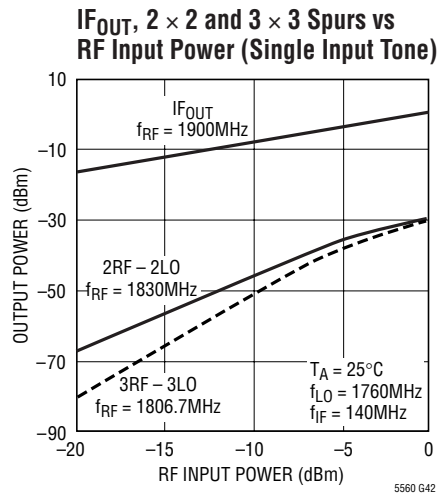
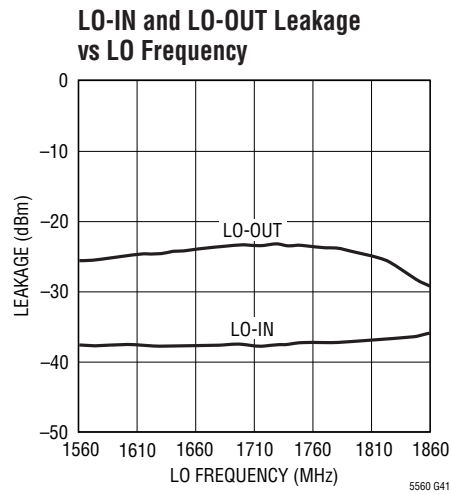
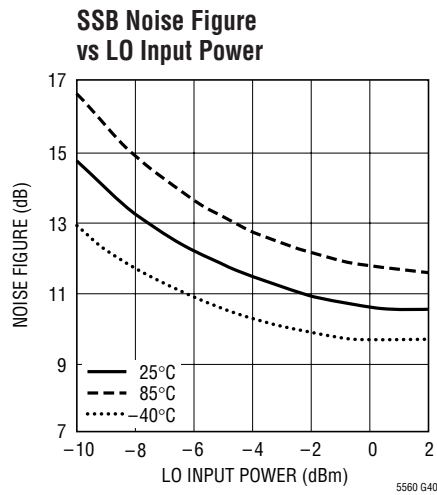
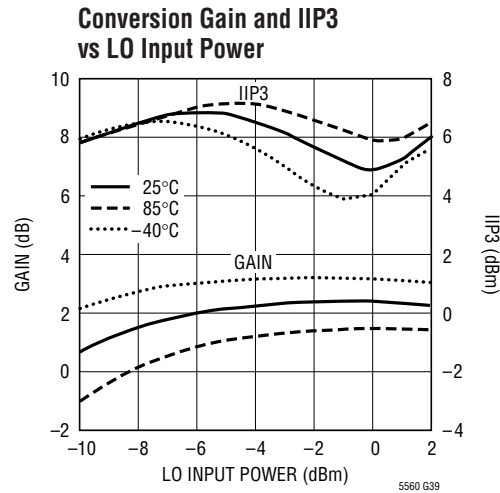
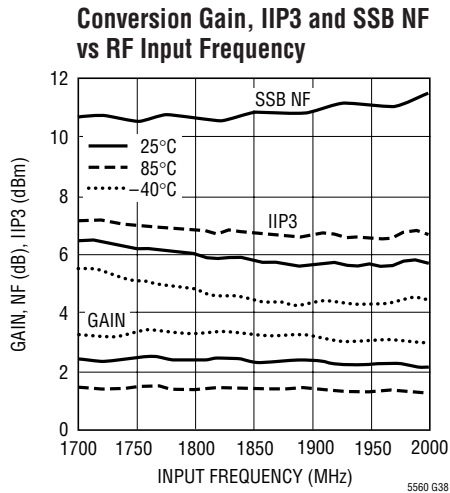


**450MHz Downconverting Mixer Application:  $V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ ,  $f_{IN} = 450MHz$ ,  $P_{IN} = -20dBm$  ( $-20dBm/$ tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  $f_{LO} = 520MHz$ ,  $P_{LO} = -2dBm$ , output measured at 70MHz, unless otherwise noted. (Test circuit shown in Figure 3)**





**TYPICAL AC PERFORMANCE CHARACTERISTICS** 1900MHz Downconverting Mixer Application:  
 $V_{CC} = 3V$ ,  $I_{CC} = 10mA$ ,  $EN = 3V$ ,  $T_A = 25^\circ C$ ,  $f_{IN} = 1900MHz$ ,  $P_{IN} = -20dBm$  (-20dBm/tone for 2-tone IIP3 tests,  $\Delta f = 1MHz$ ),  
 $f_{LO} = 1760MHz$ ,  $P_{LO} = -2dBm$ , output measured at 140MHz, unless otherwise noted. (Test circuit shown in Figure 2)



## PIN FUNCTIONS

**LO<sup>-</sup>, LO<sup>+</sup> (Pins 1, 8):** Differential Inputs for the Local Oscillator Signal. The LO input impedance is approximately  $180\Omega$ , thus external impedance matching is required. The LO pins are internally biased to approximately 1V below  $V_{CC}$ ; therefore, DC blocking capacitors are required. The LT5560 is characterized and production tested with a single-ended LO drive, though a differential LO drive can be used.

**EN (Pin 2):** Enable Pin. An applied voltage above 2V will activate the IC. For  $V_{EN}$  below 0.3V, the IC will be shut down. If the enable function is not required, then this pin should be connected to  $V_{CC}$ . The typical enable pin input current is  $25\mu\text{A}$  for  $EN = 3\text{V}$ . The enable pin should not be allowed to float because the mixer may not turn on reliably. Note that at no time should the EN pin voltage be allowed to exceed  $V_{CC}$  by more than 0.3V.

**IN<sup>+</sup>, IN<sup>-</sup> (Pins 3, 4):** Differential Inputs. These pins should be driven with a differential signal for optimum performance.

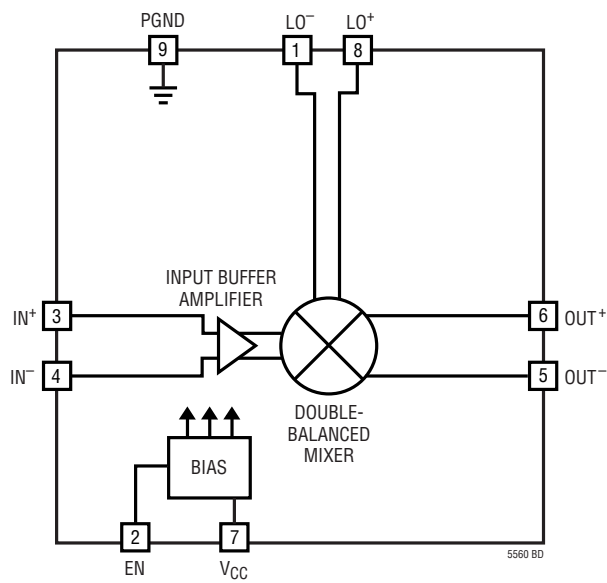
Each pin requires a DC current path to ground. Resistance to ground will cause a decrease in the mixer current. With  $0\Omega$  resistance, approximately 6mA of DC current flows out of each pin. For lowest LO leakage to the output, the DC resistance from each pin to ground should be equal. An impedance transformation is required to match the differential input to the desired source impedance.

**OUT<sup>-</sup>, OUT<sup>+</sup> (Pins 5, 6):** Differential Outputs. An impedance transformation may be required to match the outputs. These pins require a DC current path to  $V_{CC}$ .

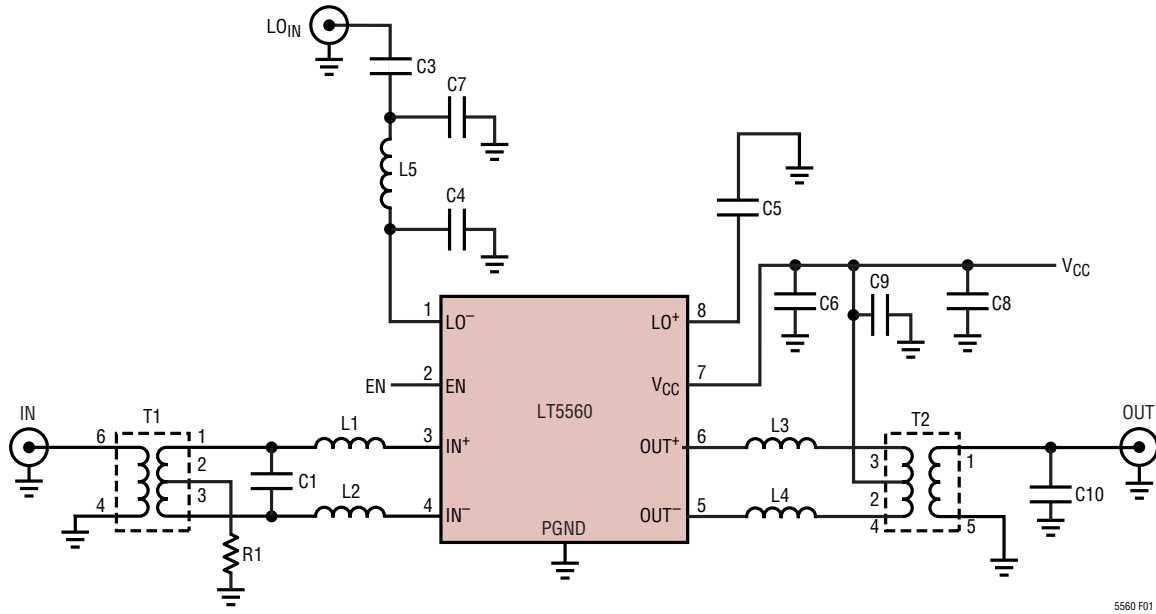
**V<sub>CC</sub> (Pin 7):** Power Supply Pin for the Bias Circuits. Typical current consumption is 1.5mA. This pin should be externally bypassed with a 1nF chip capacitor.

**Exposed Pad (Pin 9):** PGND. Circuit Ground Return for the Entire IC. This must be soldered to the printed circuit board ground plane.

**BLOCK DIAGRAM**



TEST CIRCUITS



Component Values for  $f_{OUT} = 900\text{MHz}$ ,  $f_{IN} = 140\text{MHz}$  and  $f_{LO} = 760\text{MHz}$

| REF DES | VALUE | SIZE | PART NUMBER               | REF DES | VALUE | SIZE | PART NUMBER        |
|---------|-------|------|---------------------------|---------|-------|------|--------------------|
| C1      | 22pF  | 0402 | AVX 04025A220JAT          | L1, L2  | 18nH  | 1005 | Toko LL1005-FH18NJ |
| C3, C5  | 100pF | 0402 | AVX 04025A101JAT          | L3, L4  | 27nH  | 1005 | Toko LL1005-FH27NJ |
| C4      | 1pF   | 0402 | AVX 04025A1R0BAT          | L5      | 12nH  | 1005 | Toko LL1005-FH12NJ |
| C6, C9  | 1nF   | 0402 | AVX 04023C102JAT          | R1      | 3Ω    | 0402 |                    |
| C8      | 1μF   | 0603 | Taiyo Yuden LMK107BJ105MA | T1      | 1:1   |      | Coilcraft WBC1-1TL |
| C10     | 2.2pF | 0402 | AVX 04025A2R2BAT          | T2      | 4:1   |      | TDK HHM1515B2      |

Note: C7 not used.

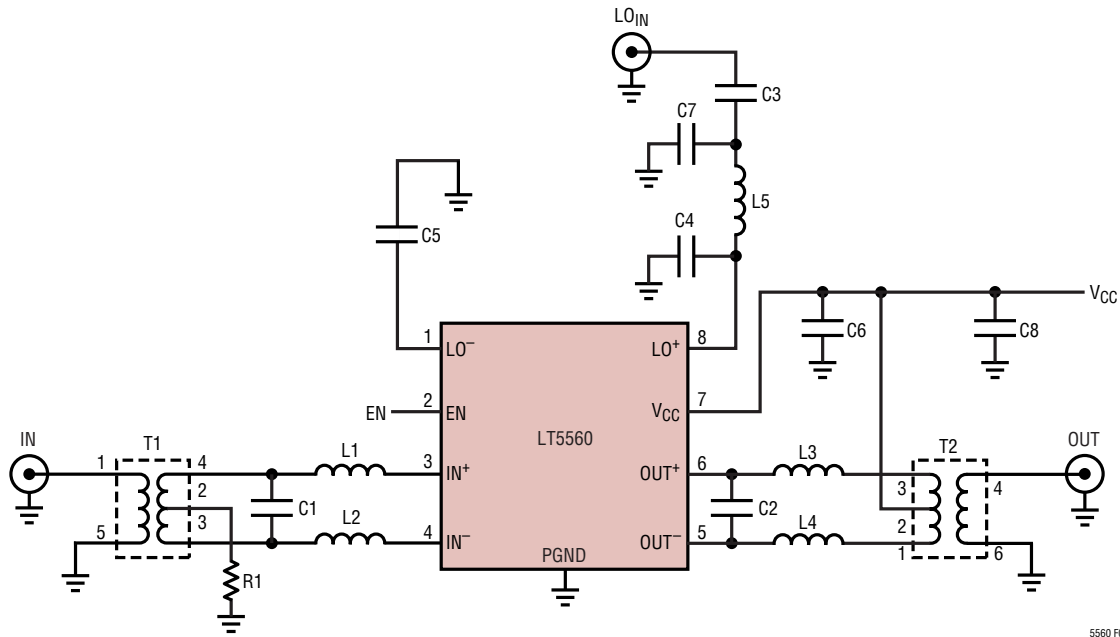
Component Values for  $f_{OUT} = 1900\text{MHz}$ ,  $f_{IN} = 140\text{MHz}$  and  $f_{LO} = 1760\text{MHz}$

| REF DES | VALUE | SIZE | PART NUMBER               | REF DES | VALUE | SIZE | PART NUMBER        |
|---------|-------|------|---------------------------|---------|-------|------|--------------------|
| C1      | 22pF  | 0402 | AVX 04025A220JAT          | L1, L2  | 18nH  | 1005 | Toko LL1005-FH18NJ |
| C3      | 100pF | 0402 | AVX 04025A101JAT          | L3, L4  | 3.9nH | 1005 | Toko LL1005-FH3N9S |
| C7      | 1.5pF | 0402 | AVX 04025A1R5BAT          | L5      | 5.6nH | 1005 | Toko LL1005-FH5N6S |
| C6, C9  | 1nF   | 0402 | AVX 04023C102JAT          | R1      | 3Ω    | 0402 |                    |
| C8      | 1μF   | 0603 | Taiyo Yuden LMK107BJ105MA | T1      | 1:1   |      | Coilcraft WBC1-1TL |
| C10     | 1pF   | 0402 | AVX 04025A1R0BAT          | T2      | 1:1   |      | TDK HHM1525        |

Note: C4 and C5 are not used.

Figure 1. Test Schematic for 900MHz and 1900MHz Upconverting Mixer Applications with 140MHz Input

TEST CIRCUITS



5560 F02

Component Values for  $f_{IN} = 900\text{MHz}$ ,  $f_{OUT} = 140\text{MHz}$  and  $f_{LO} = 760\text{MHz}$

| REF DES | VALUE | SIZE | PART NUMBER               | REF DES | VALUE | SIZE | PART NUMBER        |
|---------|-------|------|---------------------------|---------|-------|------|--------------------|
| C1      | 2.2pF | 0402 | AVX 04025A2R2BAT          | L1, L2  | 0Ω    | 1005 | 0Ω Resistor        |
| C2      | 1.2pF | 0402 | AVX 04025A1R2BAT          | L3, L4  | 220nH | 1608 | Toko LL1608-FSR22J |
| C3, C5  | 100pF | 0402 | AVX 04025A101JAT          | L5      | 12nH  | 0402 | Toko LL1005-FH12NJ |
| C4      | 1pF   | 0402 | AVX 04025A1R0BAT          | R1      | 3Ω    | 0402 |                    |
| C6      | 1nF   | 0402 | AVX 04023C102JAT          | T1      | 1:1   |      | TDK HHM1522B1      |
| C8      | 1μF   | 0603 | Taiyo Yuden LMK107BJ105MA | T2      | 4:1   |      | M/A-COM MABAES0061 |

Note: C7 not used.

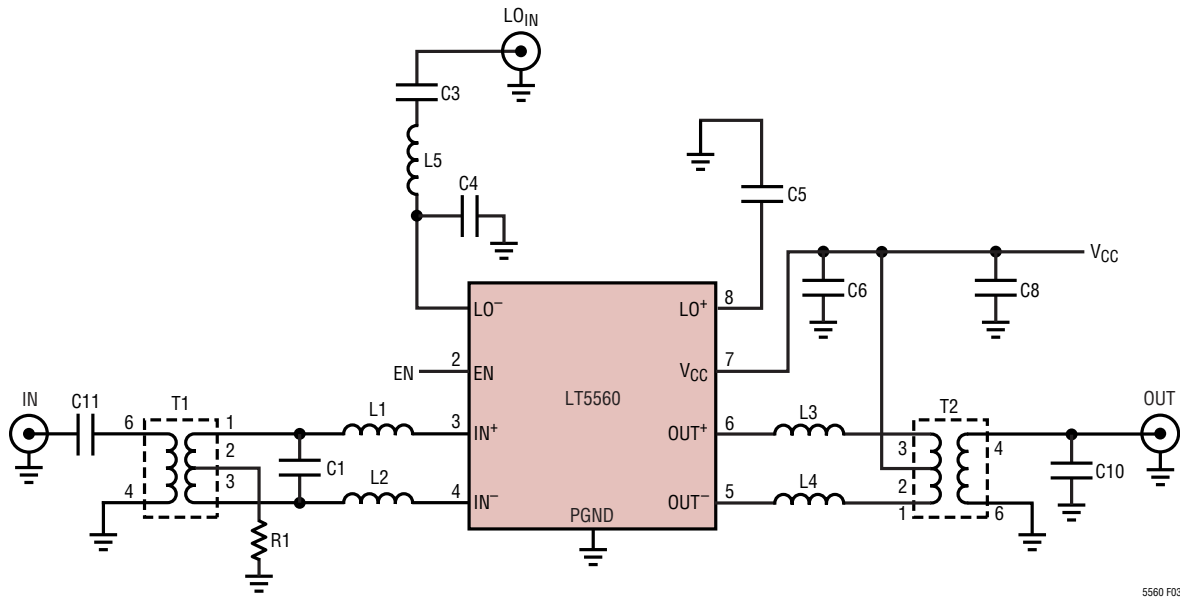
Component Values for  $f_{IN} = 1900\text{MHz}$ ,  $f_{OUT} = 140\text{MHz}$  and  $f_{LO} = 1760\text{MHz}$

| REF DES | VALUE | SIZE | PART NUMBER               | REF DES | VALUE | SIZE | PART NUMBER        |
|---------|-------|------|---------------------------|---------|-------|------|--------------------|
| C1      | 1.0pF | 0402 | AVX 04025A1R0BAT          | L1, L2  | 0Ω    | 1005 | 0Ω Resistor        |
| C2      | 1.2pF | 0402 | AVX 04025A1R2BAT          | L3, L4  | 220nH | 1608 | Toko LL1608-FSR22J |
| C3      | 100pF | 0402 | AVX 04025A101JAT          | L5      | 5.6nH | 1005 | Toko LL1005-FH5N6S |
| C7      | 1.5pF | 0402 | AVX 04025A1R5BAT          | R1      | 3Ω    | 0402 |                    |
| C6      | 1nF   | 0402 | AVX 04023C102JAT          | T1      | 2:1   |      | TDK HHM1526        |
| C8      | 1μF   | 0603 | Taiyo Yuden LMK107BJ105MA | T2      | 4:1   |      | M/A-COM MABAES0061 |

Note: C4 and C5 are not used.

Figure 2. Test Schematic for 900MHz and 1900MHz Downconverting Mixer Applications with 140MHz Input

TEST CIRCUITS



5560 F03

Upconverting Mixer Component Values for  $f_{IN} = 70\text{MHz}$ ,  $f_{OUT} = 450\text{MHz}$  and  $f_{LO} = 520\text{MHz}$

| REF DES    | VALUE     | SIZE | PART NUMBER               | REF DES | VALUE      | SIZE | PART NUMBER        |
|------------|-----------|------|---------------------------|---------|------------|------|--------------------|
| C1         | 39pF      | 0402 | AVX 04025390JAT           | L1, L2  | 33nH       | 1005 | Toko LL1005-FH33NJ |
| C3, C5, C6 | 1nF       | 0402 | AVX 04023C102JAT          | L3, L4  | 68nH       | 1608 | Toko LL1608-FS68NJ |
| C4         | 1.5pF     | 0402 | AVX 04025A1R5BAT          | L5      | 22nH       | 1005 | Toko LL1005-FH22NJ |
| C8         | 1 $\mu$ F | 0603 | Taiyo Yuden LMK107BJ105MA | R1      | 3 $\Omega$ | 0402 |                    |
| C10        | 1.5pF     | 0402 | AVX 04025A1R5BAT          | T1      | 1:1        |      | Coilcraft WBC1-1TL |
|            |           |      |                           | T2      | 4:1        |      | M/A-COM MABAES0061 |

Note: C11 is not used.

Downconverting Mixer Component Values for  $f_{IN} = 450\text{MHz}$ ,  $f_{OUT} = 70\text{MHz}$  and  $f_{LO} = 520\text{MHz}$

| REF DES    | VALUE      | SIZE | PART NUMBER               | REF DES | VALUE      | SIZE | PART NUMBER         |
|------------|------------|------|---------------------------|---------|------------|------|---------------------|
| C3, C5, C6 | 1nF        | 0402 | AVX 04023C102JAT          | L3, L4  | 0 $\Omega$ | 0402 | 0 $\Omega$ Resistor |
| C4         | 1.5pF      | 0402 | AVX 04025A1R5BAT          | L5      | 22nH       | 0402 | Toko LL1005-FH22NJ  |
| C8         | 1 $\mu$ F  | 0603 | Taiyo Yuden LMK107BJ105MA | R1      | 3 $\Omega$ | 0402 |                     |
| C11        | 5.6pF      | 0603 | AVX 06035A5R6BAT          | T1      | 1:1        |      | Coilcraft WBC1-1TL  |
| L1, L2     | 0 $\Omega$ | 0402 | 0 $\Omega$ Resistor       | T2      | 16:1       |      | Coilcraft WBC16-1TL |

Note: C1 and C10 not used.

Figure 3. Test Schematic for 450MHz Upconverting Mixer and Downconverting Mixer Applications

## APPLICATIONS INFORMATION

The LT5560 consists of a double-balanced mixer, a common-base input buffer amplifier, and bias/enable circuits. The IC has been designed for frequency conversion applications up to 4GHz, though operation over a wider frequency range may be possible with reduced performance. For best performance, the input and output should be connected differentially. The LO input can be driven by a single-ended source with either low side or high side LO operation. The LT5560 is characterized and production tested using a single-ended LO drive.

The quiescent DC current of the LT5560 can be adjusted from less than 4mA to approximately 13.5mA through the use of an external resistor. This functionality gives the user the ability to make application dependent trade-offs between IIP3 performance and DC current.

Three demo boards, as described in Table 1, are available depending on the desired application. The listed input and output frequency ranges are based on measured 12dB return loss bandwidths and the LO port frequency ranges are based on 10dB return loss bandwidths. The general circuit topologies are shown in Figures 1, 2 and 3 for DC963B, DC991A and DC1027A, respectively. The board layouts are shown in Figures 23, 24 and 25. The low frequency board, DC1027A, can be reconfigured for upconverting applications.

**Table 1. LT5560 Demo Board Descriptions**

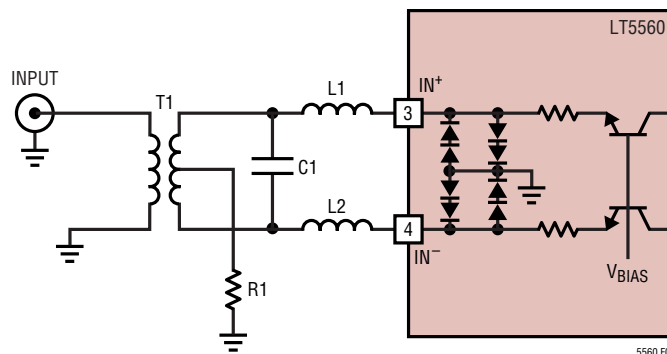
| MIXER DESCRIPTION            | DEMO BOARD NUMBER | INPUT FREQ. (MHz) | OUTPUT FREQ. (MHz) | LO FREQ. (MHz) |
|------------------------------|-------------------|-------------------|--------------------|----------------|
| Upconverting, Cellular Band  | DC963B            | 50-190            | 850-940            | 530-930        |
| Downconverting Cellular Band | DC991A            | 710-1300          | 110-170            | 530-930        |
| Downconverting, VHF Band     | DC1027A           | 115-295           | 3-60               | 180-310        |

Note: Consult factory for demo boards for UMTS, WLAN and other bands.

### Signal Input Port

Figure 4 shows a simplified schematic of the differential input signal port and an example topology for the external impedance matching circuit. Pins 3 and 4 each source up to 6mA of DC current. This current can be reduced by the addition of resistor R1 (adjustable mixer current is discussed in a later section). The DC ground path can be

provided through the center-tap of an input transformer, as shown, or through matching inductors or chokes connected from pins 3 and 4 to ground.



**Figure 4. Input Port with Lowpass External Matching Topology**

The lowpass impedance matching topology shown may be used to transform the differential input impedance at pins 3 and 4 to match that of the signal source. The differential input impedances for several frequencies are listed in Table 2.

**Table 2. Input Signal Port Differential Impedance**

| FREQUENCY (MHz) | INPUT IMPEDANCE ( $\Omega$ ) | REFLECTION COEFFICIENT ( $Z_0 = 50\Omega$ ) |              |
|-----------------|------------------------------|---|--------------|
|                 |                              | MAG   | ANGLE (DEG.) |
| 70              | 28.5 + j0.8                  | 0.274                                       | 177          |
| 140             | 28.5 + j1.6                  | 0.274                                       | 174          |
| 240             | 28.6 + j2.7                  | 0.275                                       | 171          |
| 360             | 28.6 + j4.0                  | 0.276                                       | 167          |
| 450             | 28.6 + j4.9                  | 0.278                                       | 163          |
| 750             | 28.8 + j8.2                  | 0.287                                       | 153          |
| 900             | 28.8 + j9.8                  | 0.294                                       | 148          |
| 1500            | 29.1 + j16.3                 | 0.328                                       | 138          |
| 1900            | 29.4 + j20.8                 | 0.357                                       | 120          |
| 2150            | 29.6 + j23.6                 | 0.376                                       | 114          |
| 2450            | 29.9 + j27.0                 | 0.399                                       | 107          |
| 3600            | 31.7 + j42.1                 | 0.499                                       | 86.2         |

## APPLICATIONS INFORMATION

The following example demonstrates the design of a lowpass impedance transformation network for a signal input at 900MHz.

The simplified input circuit is shown in Figure 5. For this example, the input transformer has a 1:1 impedance ratio, so  $R_S = 50\Omega$ . From Table 2, at 900MHz, the differential input impedance is:  $R_L + jX_{INT} = 28.8 + j9.8\Omega$ . The internal reactance will be used as part of the impedance matching network. The matching circuit consists of additional external series inductance (L1 and L2) and a capacitance (C1) in parallel with the  $50\Omega$  source impedance. The external capacitance and inductance are calculated below.

First, calculate the impedance transformation ratio ( $n$ ) and the network Q:

$$n = \frac{R_S}{R_L} = \frac{50}{28.8} = 1.74$$

$$Q = \sqrt{(n-1)} = 0.858$$

Next, the capacitance and inductance can be calculated as follows:

$$X_C = \frac{R_S}{Q} = 58.3\Omega$$

$$C1 = \frac{1}{\omega \cdot X_C} = 3.03\text{pF}$$

$$X_L = R_L \cdot Q = 24.7\Omega$$

$$X_{EXT} = X_L - X_{INT} = 14.9\Omega$$

$$L1 = L2 = \frac{L_{EXT}}{2} = \frac{X_{EXT}}{2\omega} = 1.32\text{nH}$$

The internal inductance has been accounted for by subtracting the internal reactance ( $X_{INT}$ ) from the total reactance ( $X_L$ ). Small inductance values may be realized using high-impedance printed transmission lines instead of lumped inductors. The equations above provide good starting values, though the values may need to be optimized to account for layout and component parasitics.

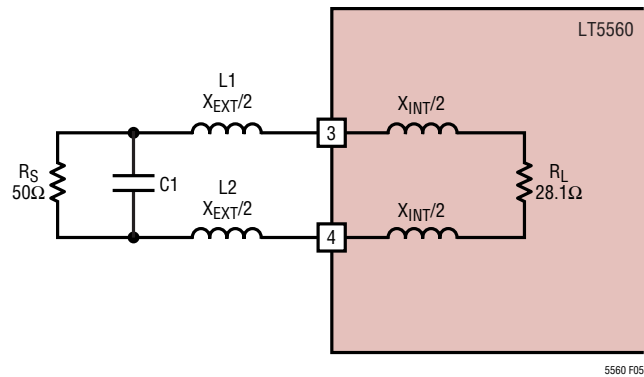


Figure 5. Small Signal Circuit for the Input Port

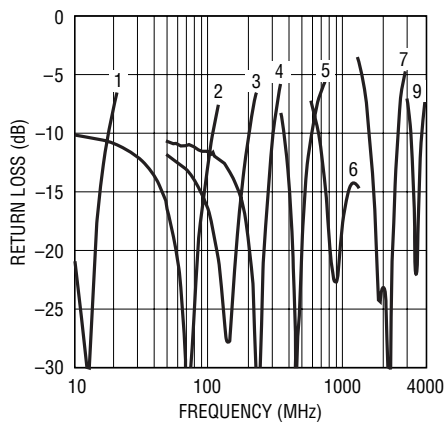


Table 3 lists actual component values used on the LT5560 evaluation boards for impedance matching at various frequencies. The measured Input Return Loss vs Frequency performance is plotted for several of the cases in Figure 6.

**Table 3. Component Values for Input Matching**

| CASE | FREQ. (MHz)      | T1            | C1 (pF) | L1, L2 (nH) | MATCH BW (@12dB RL) |
|------|------------------|---------------|---------|-------------|---------------------|
| 1    | 10               | WBC1-1TL 1:1  | 220     | 180         | 6-18                |
| 2    | 70               | WBC1-1TL 1:1  | 39      | 33          | 29-102              |
| 3    | 140              | WBC1-1TL 1:1  | 22      | 18          | 50-190              |
| 4    | 240              | WBC1-1TL 1:1  | 15      | 12          | 115-295             |
| 5    | 450 <sup>1</sup> | WBC1-1TL 1:1  | NA      | 0           | 390-560             |
| 6    | 900              | HHM1522B1 1:1 | 2.2     | 0           | 710-1630            |
| 7    | 1900             | HHM1526 2:1   | 1       | 0           | 1660-2500           |
| 8    | 2450             | HHM1520A2 2:1 | 1       | 0           | 1640-2580           |
| 9    | 3600             | HHM1583B1 2:1 | 0.5     | 0           | 3330-3840           |

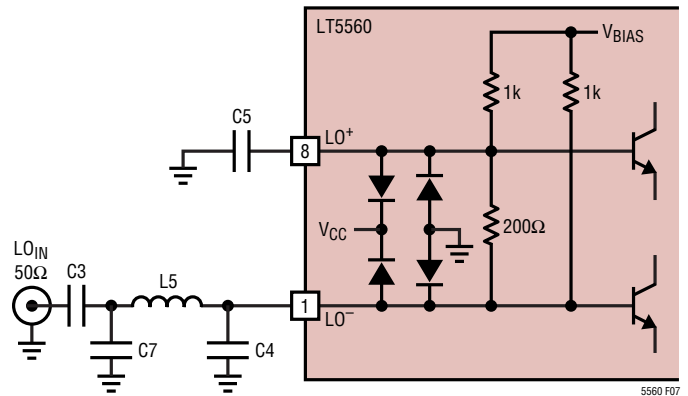
Note 1: Series 5.6pF capacitor is used at the input (see Figure 3).



**Figure 6. Input Return Loss vs Frequency for Different Matching Values**

### LO Input Port

Figure 7 shows a simplified schematic of the LO input. The LO input connections drive the bases of the mixer transistors, while a 200Ω resistor across the inputs provides the impedance termination. The internal 1kΩ bias resistors are in parallel with the input resistor resulting in a net input DC resistance of approximately 180Ω. The pins are biased by an internally generated voltage at approximately 1V below V<sub>CC</sub>; thus external DC blocking capacitors are required. If desired, the LO inputs can be driven differentially. The required LO drive at the IC is 240mV<sub>RMS</sub> (typ) which can come from a 50Ω source or a higher impedance such as PECL.



**Figure 7. LO Input Schematic**

## APPLICATIONS INFORMATION

Reactive matching from the LO source to the LO input is recommended to take advantage of the resulting voltage gain. To assist in matching, Table 4 lists the single-ended input impedances of the LO input port. Actual component values, for several LO frequencies, are listed in Table 5. Figure 8 shows the typical return loss response for each case.

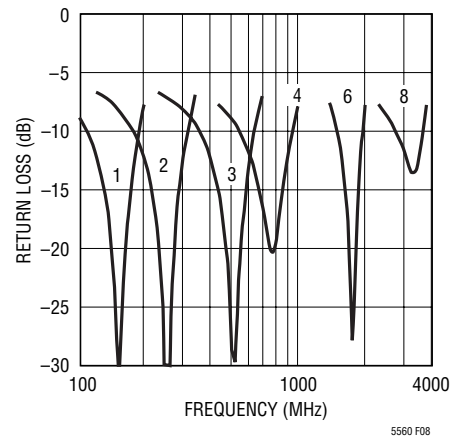
**Table 4. Single-Ended LO Input Impedance (Parallel Equivalent)**

| FREQUENCY (MHz) | INPUT IMPEDANCE ( $\Omega$ ) | REFLECTION COEFFICIENT ( $Z_0 = 50\Omega$ ) |              |
|-----------------|------------------------------|---|--------------|
|                 |                              | MAG   | ANGLE (DEG.) |
| 150             | 161    -j679                 | 0.529                                       | -9.3         |
| 520             | 142    -j275                 | 0.494                                       | -23.3        |
| 760             | 130    -j192                 | 0.475                                       | -33.5        |
| 1660            | 74    -j98                   | 0.347                                       | -74.5        |
| 1760            | 69    -j94                   | 0.330                                       | -80.1        |
| 2040            | 60    -j89                   | 0.308                                       | -90.1        |
| 2210            | 51    -j91                   | 0.266                                       | -104         |
| 3150            | 50    -j103                  | 0.235                                       | -104         |
| 3340            | 33    -j41                   | 0.472                                       | -138         |

**Table 5. Component Values for LO Input Matching**

| CASE | FREQ. (MHz) | C4 (pF) | L5 (nH) | C7 (pF) | C3, C5 (pF)      | MATCH BW (@12dB RL) |
|------|-------------|---------|---------|---------|------------------|---------------------|
| 1    | 150         | 8.2     | 68      | -       | 1000             | 120-180             |
| 2    | 250         | 4.7     | 47      | -       | 1000             | 195-300             |
| 3    | 520         | 1.5     | 22      | -       | 1000             | 390-605             |
| 4    | 760         | 1       | 12      | -       | 100              | 590-890             |
| 5    | 1200        | -       | 6.8     | -       | 100              | 850-1430            |
| 6    | 1760        | -       | 4.7     | 1       | 100 <sup>1</sup> | 1540-1890           |
| 7    | 2900        | -       | 1       | 1       | 10               | 2690-3120           |
| 8    | 3150        | -       | 0       | -       | 10               | 2990-3480           |

Note 1: C5 is not used at 1760MHz



**Figure 8. Typical LO Input Return Loss vs Frequency for Different Matching Values**

## APPLICATIONS INFORMATION

### Signal Output Port

A simplified schematic of the output circuit is shown in Figure 9. The output pins, OUT<sup>+</sup> and OUT<sup>-</sup>, are internally connected to the collectors of the mixer transistors. These pins must be biased at the supply voltage, which can be applied through a transformer center-tap, impedance matching inductors, RF chokes, or pull-up resistors. With external resistor R1 = 3Ω (Figures 1 to 3), each OUT pin draws about 4.5mA of supply current. For optimum performance, these differential outputs should be combined externally through a transformer or balun.

An equivalent small-signal model for the output is shown in Figure 10. The output impedance can be modeled as a 1.2kΩ resistor in parallel with a 0.7pF capacitor. For low frequency applications, the 0.7nH series bond-wire inductances can be ignored.

The external components, C2, L3 and L4, form a lowpass impedance transformation network to match the mixer output impedance to the input impedance of transformer T2. The values for these components can be estimated

using the impedance parameters listed in Table 6 along with similar equations as used for the input matching network. As an example, at an output frequency of 140MHz and R<sub>L</sub> = 200Ω (using a 4:1 transformer for T2),

$$n = \frac{R_S}{R_L} = \frac{1082}{200} = 5.41$$

$$Q = \sqrt{(n - 1)} = 2.10$$

$$X_C = \frac{R_S}{Q} = 515\Omega$$

$$C = \frac{1}{\omega \cdot X_C} = 2.21\text{pF}$$

$$C2 = C - C_{INT} = 1.51\text{pF}$$

$$X_L = R_L \cdot Q = 420\Omega$$

$$L3 = L4 = \frac{X_L}{2\omega} = 239\text{nH}$$

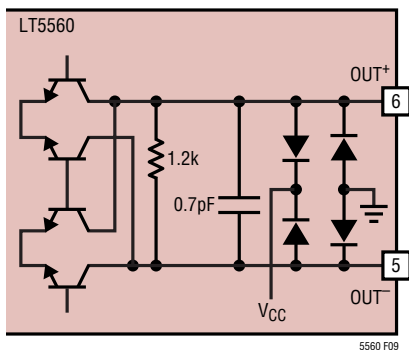


Figure 9. Output Port Schematic

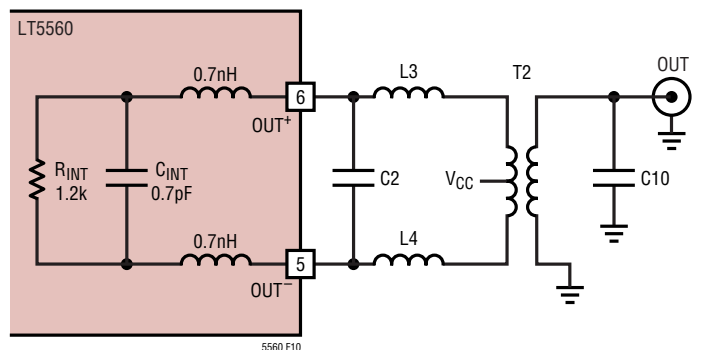


Figure 10. Output Port Small-Signal Model with External Matching

## APPLICATIONS INFORMATION

**Table 6. Output Port Differential Impedance (Parallel Equivalent)**

| FREQUENCY (MHz) | OUTPUT IMPEDANCE ( $\Omega$ ) | REFLECTION COEFFICIENT ( $Z_0 = 50\Omega$ ) |              |
|-----------------|-------------------------------|---|--------------|
|                 |                               | MAG   | ANGLE (DEG.) |
| 70              | 1098    -j3185                | 0.913                                       | -1.8         |
| 140             | 1082    -j1600                | 0.912                                       | -3.6         |
| 240             | 1082    -j974                 | 0.912                                       | -5.9         |
| 360             | 1093    -j646                 | 0.913                                       | -8.9         |
| 450             | 1083    -j522                 | 0.913                                       | -11.0        |
| 750             | 1037    -j320                 | 0.910                                       | -17.8        |
| 900             | 946    -j269                  | 0.903                                       | -21.1        |
| 1500            | 655    -j162                  | 0.870                                       | -34.5        |
| 1900            | 592    -j122                  | 0.865                                       | -44.6        |
| 2150            | 662    -j108                  | 0.883                                       | -50.0        |
| 2450            | 612    -j95.7                 | 0.879                                       | -55.4        |
| 3600            | 188    -j53.1                 | 0.756                                       | -88.7        |

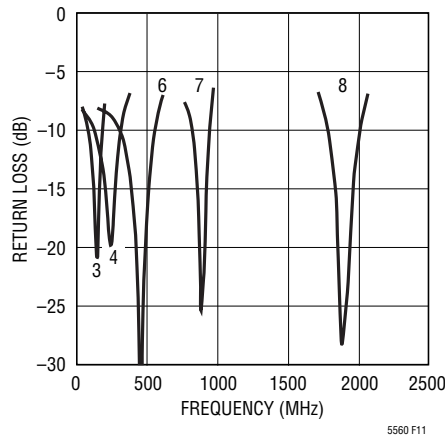
In cases where the calculated value of C2 is less than the internal output capacitance, capacitor C10 can be used to improve the impedance match.

Table 7 lists actual component values used on the LT5560 evaluation boards for impedance matching at several frequencies. The measured output return loss vs frequency performance is plotted for several of the cases in Figure 11.

**Table 7. Component Values for Output Matching**

| CASE | FREQ. (MHz) | T2             | C2 (pF) | L3, L4 (nH) | C10 (pF)       | MATCH BW (@12dB RL) |
|------|-------------|----------------|---------|-------------|----------------|---------------------|
| 1    | 10          | WBC16-1TL 16:1 | -       | 0           | -              | 3-60                |
| 2    | 70          | WBC16-1TL 16:1 | -       | 0           | - <sup>1</sup> | 3-60                |
| 3    | 140         | MABAES0061 4:1 | 1.5     | 220         | -              | 110-170             |
| 4    | 240         | MABAES0061 4:1 | 0.5     | 120         | -              | 175-300             |
| 5    | 380         | MABAES0061 4:1 | -       | 68          | -              | 290-490             |
| 6    | 450         | MABAES0061 4:1 | -       | 68          | 1.5            | 360-540             |
| 7    | 900         | HHM1515B2 4:1  | -       | 27          | 2.2            | 850-940             |
| 8    | 1900        | HHM1525 1:1    | -       | 3.9         | 1              | 1820-2000           |

Note 1: A better 70MHz match can be realized by adding a shunt 180nH inductor at the C10 location.



**Figure 11. Output Return Loss vs Frequency for Different Matching Values**

## APPLICATIONS INFORMATION

### Enable Interface

Figure 12 shows a simplified schematic of the EN pin interface. The voltage necessary to turn on the LT5560 is 2V. To disable the chip, the enable voltage must be less than 0.3V. If the EN pin is allowed to float, the chip will tend to remain in its last operating state, thus it is not recommended that the enable function be used in this manner. If the shutdown function is not required, then the EN pin should be connected directly to  $V_{CC}$ .

The voltage at the EN pin should never exceed the power supply voltage ( $V_{CC}$ ) by more than 0.3V. If this should occur, the supply current could be sourced through the EN pin ESD diode, potentially damaging the IC.

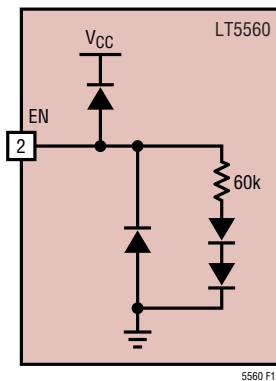


Figure 12. Enable Input Circuit

### Adjustable Supply Current

The LT5560 offers a direct trade-off between power supply current and linearity. This capability allows the user to optimize the performance and power dissipation of the mixer for a particular application. The supply current can be adjusted by changing the value of resistor R1 at the center-tap of the input balun. For downconversion applications, a bypass capacitor in parallel with R1 may be desired to minimize noise figure. The bypass capacitor has a greater effect on noise figure at larger values of R1. In upmixer configurations, adding a capacitor across R1 has little effect.

Figure 13 shows the supply current as a function of R1. Note that the current will also be affected by parasitic resistance in the matching components. Figure 14 illustrates the effect of supply current on Gain, IIP3 and NF of a 900MHz upconverting mixer. The performance

vs current of a 900MHz downconverting mixer is plotted in Figure 15. In this example, a 1nF capacitor has been placed in parallel to R1 for best noise figure.

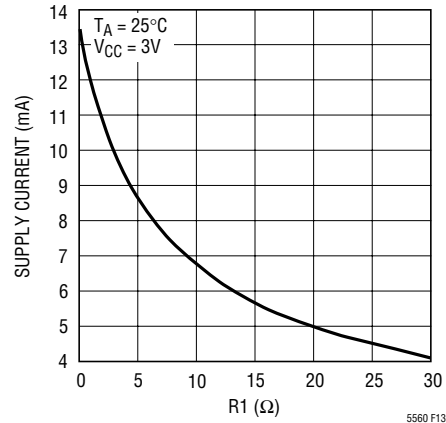


Figure 13. Typical Supply Current vs R1 Value

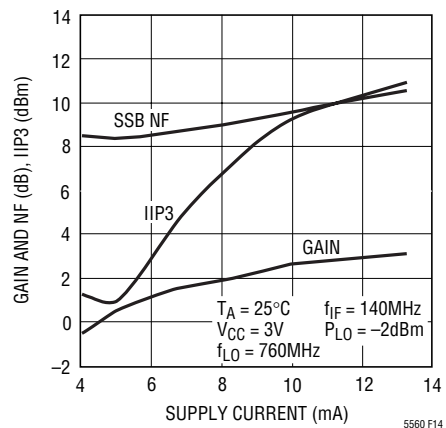


Figure 14. 900MHz Upconverting Mixer Gain, Noise Figure and IIP3 vs Supply Current

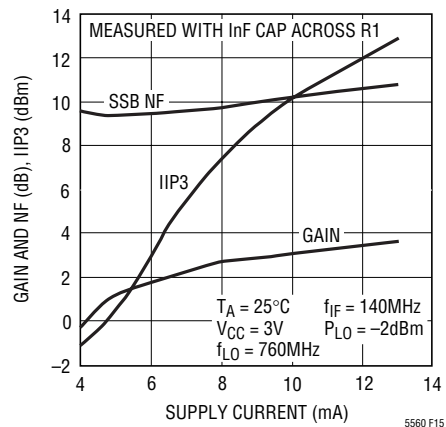


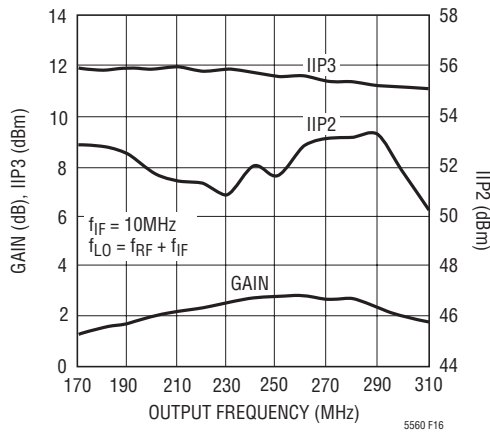
Figure 15. 900MHz Downconverting Mixer Gain, Noise Figure and IIP3 vs Supply Current

## APPLICATIONS INFORMATION

### Application Examples

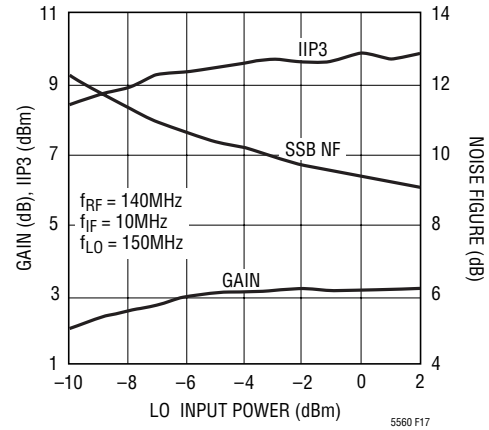
The LT5560 may be used as an upconverting or downconverting mixer in a wide variety of applications, in addition to those identified in the datasheet. The following examples illustrate the versatility of the LT5560. (The component values for each case can be found in Tables 3, 5 and 7).

Figure 16 demonstrates gain, IIP3 and IIP2 performance versus RF Output Frequency for the LT5560 when used as a 240MHz upconverting mixer. The input frequency is 10MHz, with an LO frequency of 250MHz. The circuit uses the topology shown in Figure 1.



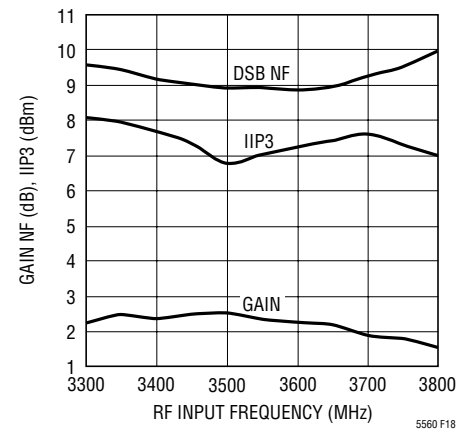
**Figure 16. LT5560 Performance in 240MHz Upconverting Mixer Application**

The performance in a 140MHz downconverting mixer application is plotted in Figure 17. In this case the gain, IIP3 and NF are shown as a function of LO power with an IF output frequency of 10MHz. The circuit topology for this case is shown in Figure 3.



**Figure 17. LT5560 Performance in 140MHz Downconverting Mixer Application**

The LT5560 operation at higher frequencies is demonstrated in Figure 18, where the performance of a 3600MHz downconverting mixer is shown. The conversion gain, IIP3 and DSB NF are plotted for an RF input frequency range of 3300 to 3800MHz and an IF frequency of 450MHz. The circuit is the same topology as shown in Figure 2.



**Figure 18. LT5560 Performance as a 3600MHz Downconverting Mixer**

## APPLICATIONS INFORMATION

### Lumped Element Matching

The applications described so far have employed external transformers or hybrid baluns to realize single-ended to differential conversions and, in some cases, impedance transformations. An alternate approach is to use lumped-element baluns to realize the input or output matching networks.

A lumped element balun topology is shown in Figure 19. The desired component values can be estimated using the equations below, where  $R_A$  and  $R_B$  are the terminating resistances on the unbalanced and balanced ports, respectively. Variable  $f_C$  is the desired center frequency. (The resistances of the LT5560 input and output can be found in Tables 2 and 6).

$$L_0 = \frac{\sqrt{R_A \cdot R_B}}{2 \cdot \pi \cdot f_C}$$

$$C_0 = \frac{1}{2 \cdot \pi \cdot f_C \cdot \sqrt{R_A \cdot R_B}}$$

The computed values are approximate, as they don't account for the effects of parasitics of the IC and external components.

Inductor  $L_{DC}$  is used to provide a DC path to ground or  $V_{CC}$  depending on whether the circuit is used at the input or output of the LT5560. In some cases, it is desirable to make the value of  $L_{DC}$  as large as practical to minimize loading on the circuit; however, the value can also be optimized to tune the impedance match. The shunt inductor,  $L_0$ , provides the DC path for the other balanced port.

Capacitor  $C_{DC}$  may be required for DC blocking but can often be omitted if DC decoupling is not required.

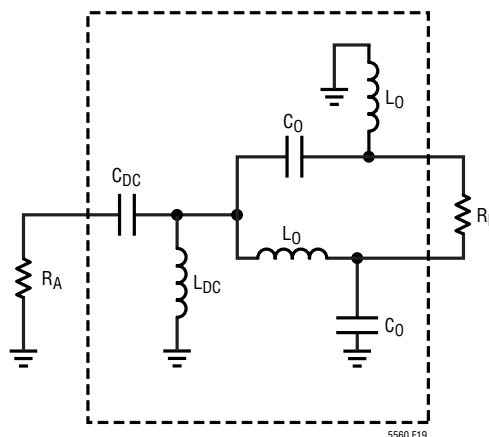


Figure 19. Lumped Element Balun

In some applications,  $C_{DC}$  is useful for optimizing the impedance match.

The circuit shown on page 1 illustrates the use of lumped element baluns. In this example, the LT5560 is used to convert a 900MHz input signal down to 140MHz using a 760MHz  $L_0$  signal.

For the 900MHz input,  $R_A = 50\Omega$  and  $R_B = 28\Omega$  (from Table 2). The actual values used for  $C_0$  and  $L_0$  are 4.7pF and 6.8nH, which agree very closely with the calculated values of 4.7pF and 6.6nH. The 15nH shunt inductor, in this case, has been used to optimize the impedance match, while the 100pF cap provides DC decoupling.

At the 140MHz output, the values used for  $R_A$  and  $R_B$  are 50 $\Omega$  and 1080 $\Omega$  (from Table 6), respectively, which result in calculated values of  $C_0 = 4.9\text{pF}$  and  $L_0 = 265\text{nH}$ . These values are very close to the actual values of 4.7pF and 270nH. A shunt inductor ( $L_{DC}$ ) of 270nH is used here and the 33pF blocking cap has been used to optimize the impedance.

## APPLICATIONS INFORMATION

Measured  $IF_{OUT}$  and IM3 levels vs RF input power for the mixer with lumped element baluns are shown on page 1. Additional performance parameters vs RF input frequency are plotted in Figure 20.

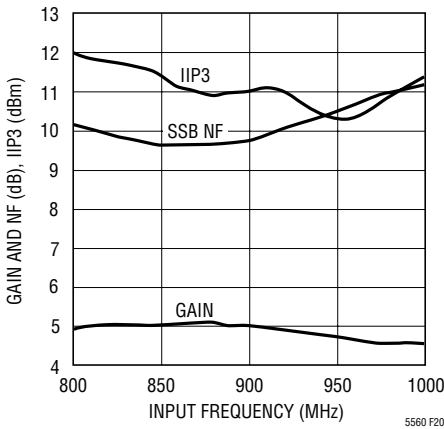


Figure 20. Performance of 900MHz Downconverting Mixer with Lumped Element Baluns

### Low Frequency Applications

At low IF frequencies, where transformers can be impractical due to their large size and cost, alternate methods can be used to achieve desired differential to single-ended conversions. The examples in Figures 21 and 22 use an

op-amp to demonstrate performance with an output frequency of 450KHz. Pull-up resistors R3 and R4 are used at the open-collector IF outputs instead of large inductors. The op-amp provides gain and converts the mixer differential outputs to single-ended. At low frequencies, the LO port can be easily matched with a shunt resistor and a DC blocking cap. This IF interface circuit can be used for signals up to 1MHz.

Figure 21 shows an input match that uses a transformer to present a differential signal to the mixer. A possible alternative, shown in Figure 22, is to use a single-ended drive on one input pin, with the other pin grounded. This approach is more cost effective than the transformer, however, some performance is sacrificed. Another option is to use a lumped-element balun, which requires only one more component than the single-ended impedance match, but could provide better performance. Measured data for the examples below are summarized in Table 8.

Table 8. Low-Frequency Performance

| $f_{IN}$ (MHz) | $f_{OUT}$ (MHz) | $G_C$ (dB) | IIP3 (dBm) | DSB NF (dB) | $I_{CC}$ (mA) |
|----------------|-----------------|------------|------------|-------------|---------------|
| 200            | 0.45            | 9          | 3.8        | 11.6        | 14            |
| 90             | 0.45            | 6.8        | 3.3        | 22          | 18            |

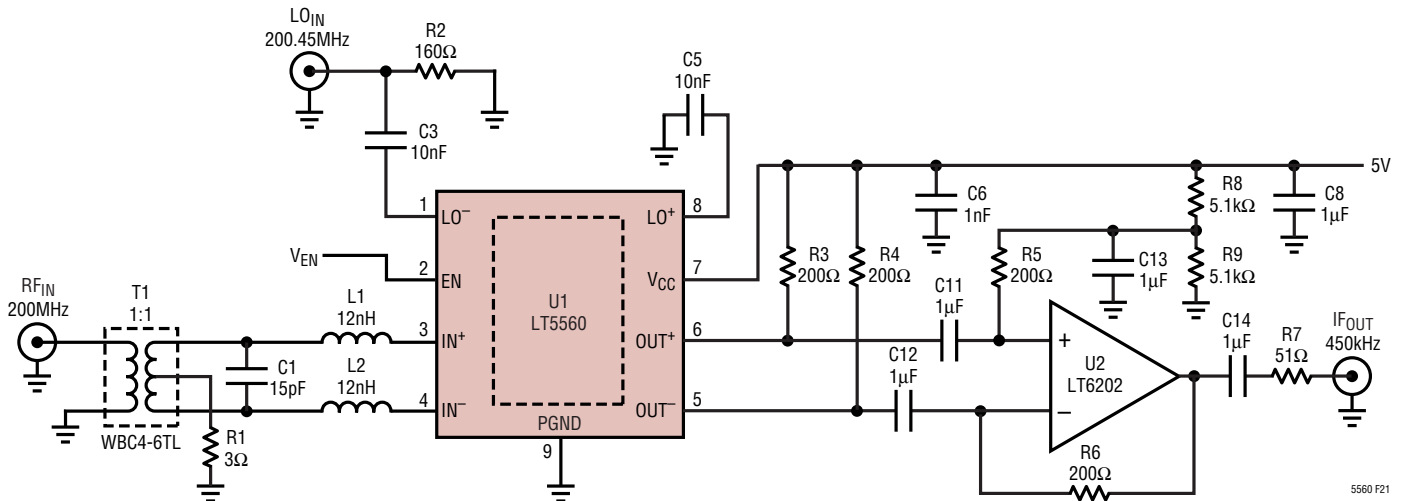


Figure 21. A 200MHz to 450KHz Downconverter with Active IF Interface



APPLICATIONS INFORMATION

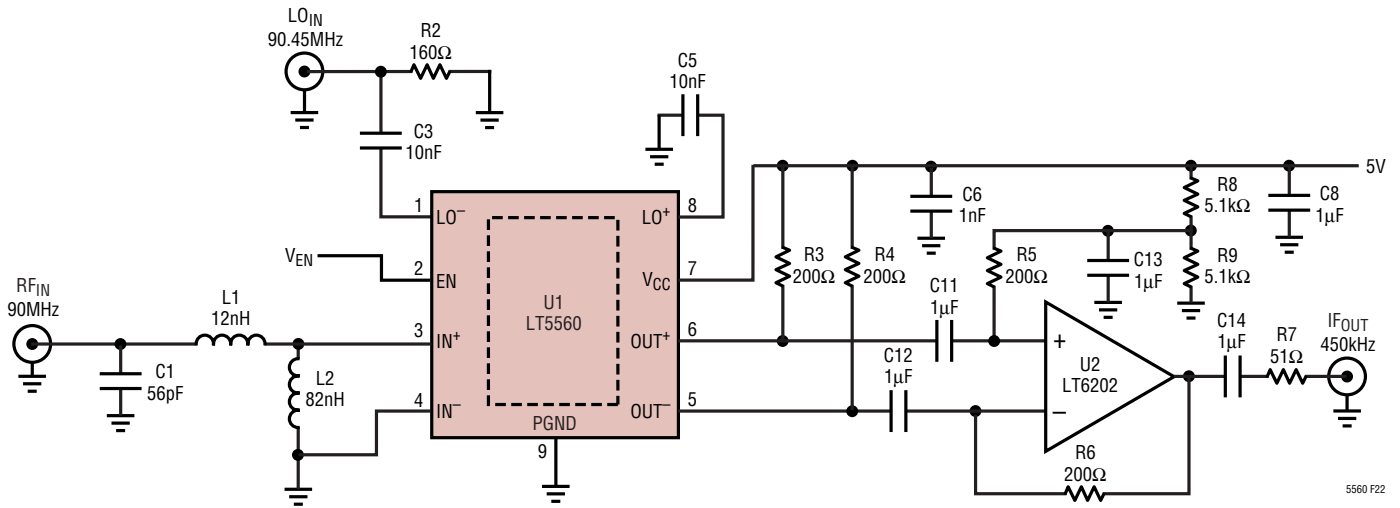


Figure 22. 90MHz Downconverter with a Low Cost Discrete Balun Input and a 450kHz Active IF Interface

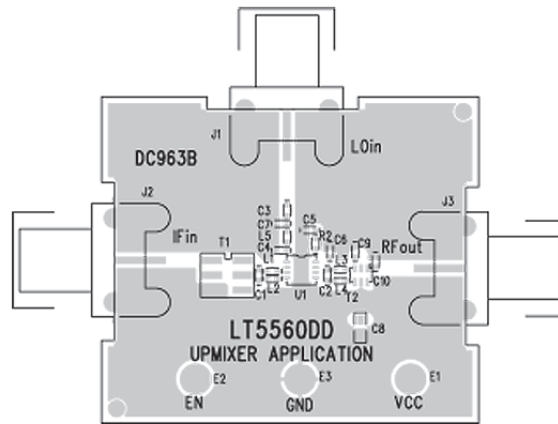


Figure 23. Upconverting Mixer Evaluation Board (DC963B)—See Table 1

**TYPICAL APPLICATIONS**

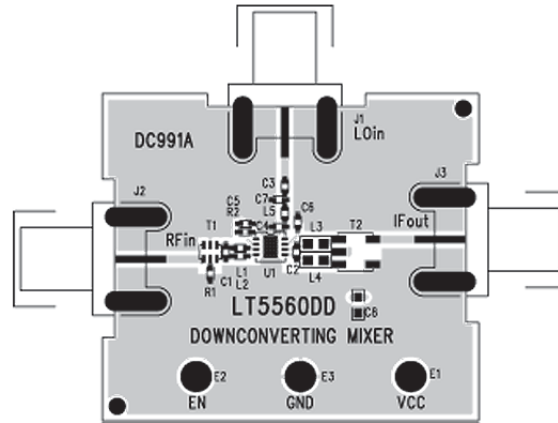


Figure 24. Downconverting Mixer Evaluation Board (DC991A)—See Table 1

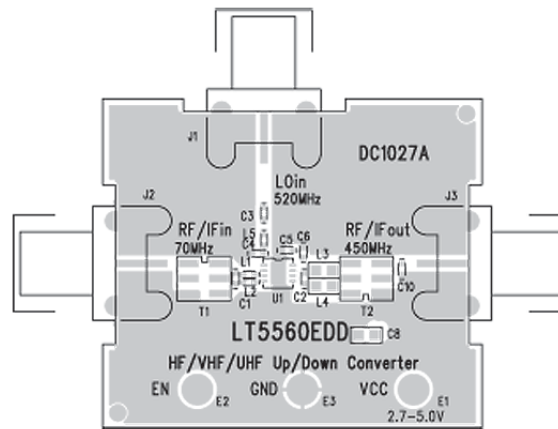
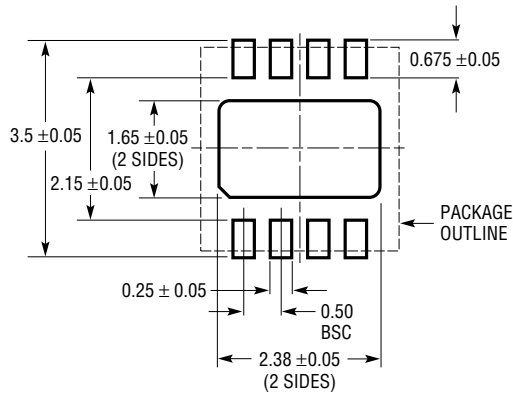


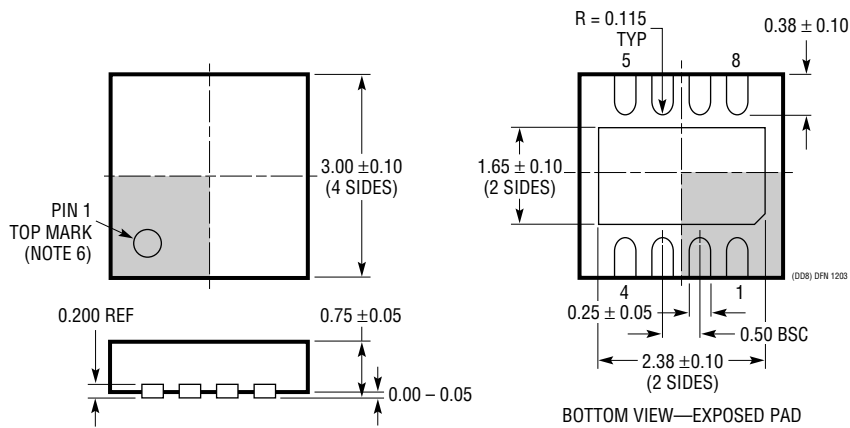
Figure 25. HF/VHF/UHF Upconverting or Downconverting Mixer Evaluation Board (DC1027A)—See Table 1

# PACKAGE DESCRIPTION

## DD8 Package 8-Lead Plastic DFN (3mm × 3mm) (Reference LTC DWG # 05-08-1698)



RECOMMENDED SOLDER PAD PITCH AND DIMENSIONS



- NOTE:
1. DRAWING TO BE MADE A JEDEC PACKAGE OUTLINE M0-229 VARIATION OF (WEED-1)
  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 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                    | 1KHz to 3GHz High Signal Level Downconverting Mixer                         | 20dBm IIP3, Integrated LO Buffer, HF/VHF/UHF Optimized   |
| 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, 50Ω Single-Ended LO and RF Ports, 4-Ch 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 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                              | 50Ω Single-Ended LO and RF Ports, 17.6 dBm IIP3 at 1900MHz, I <sub>CC</sub> = 28mA   |
| LT5526                    | High Linearity, Low Power Active 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 = 12.5dB at 1900MHz, 4.5V to 5.25V Supply, I <sub>CC</sub> = 78mA, Single-Ended LO and RF Ports            |
| LT5528                    | 1.5GHz to 2.4GHz High Linearity Direct Quadrature Modulator                 | 21.8dBm OIP3 at 2GHz, -159.3dBm/Hz Noise Floor, 50Ω, 0.5V <sub>DC</sub> Baseband Interface, 4-Ch W-CDMA ACPR = -66dBc at 2.14GHz |
| LT5568                    | 700MHz to 1050MHz High Linearity Direct Quadrature Modulator                | 22.9dBm OIP3, -160dBm/Hz Noise Floor, -46dBc Image Rejection, -43dBm LO Leakage  |
| <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 Linear Dynamic Range, Low Power Consumption, SC70 Package   |
| 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   |
| LTC5536                   | Precision 600MHz to 7GHz RF Detector with Fast Comparater                   | 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 800MHz, 83dB Dynamic Range, 2.7V to 5.25V Supply  |

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



## JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: [ocean@oceanchips.ru](mailto:ocean@oceanchips.ru)

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А