# LF–7GHz Wideband Low Power Active Mixer

## FEATURES

- **Wideband Frequency Range to 7GHz**
- **Low Power: 2.7V to 3.6V, 40mA Supply**
- **Supply Current Adjustable Down to 15mA**
- **Up or Downconversion**
- **OIP3: +20dBm at 3.6GHz Out**
- **Conversion Gain: +1dB**
- **Low LO Drive: –4dBm to +2dBm**
- LO Impedance Match Maintained During Shutdown
- Enable Control, 10µA Shutdown Current
- 2kV ESD (HBM and CDM)
- –40°C to 105°C Operation
- Small 2mm × 2mm 10-Lead QFN Package

## APPLICATIONS

- Portable Radios
- Portable Test Instruments
- Wireless Infrastructure
- Fixed Wireless Access Equipment
- VHF & UHF Mixer
- Wireless Repeaters

## DESCRIPTION

The LTC®5562 is a versatile low power mixer optimized for applications requiring wide input bandwidth, low distortion and low LO leakage. This mixer can be used for either upconverting or downconverting applications, and provides a nominal conversion gain of 1dB. The differential input is optimized for use with a 1:1 transmission-line balun, the input is 50Ω broadband matched from 30MHz to 7GHz.

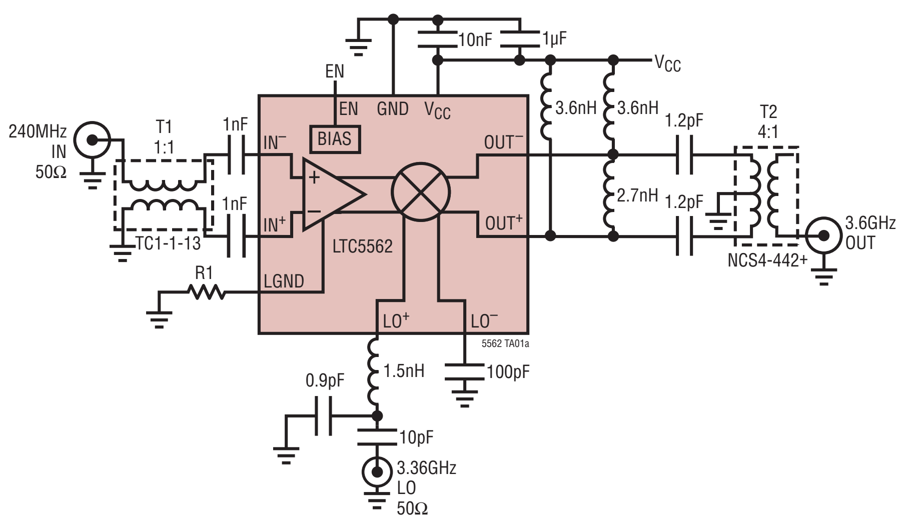
The LO can be differential or single-ended and requires only –1dBm of LO power to achieve excellent distortion and noise performance. The impedance match at the LO input is maintained during shutdown. This mixer offers low LO leakage, greatly reducing the need for output filtering to meet LO suppression requirements.

The LTC5562 uses a 3.3V supply for low power consumption and the enable control allows the part to be shut down for further power savings. The total mixer current is adjustable, by simply adding a resistor in series with the LGND pin, for applications requiring even lower power.

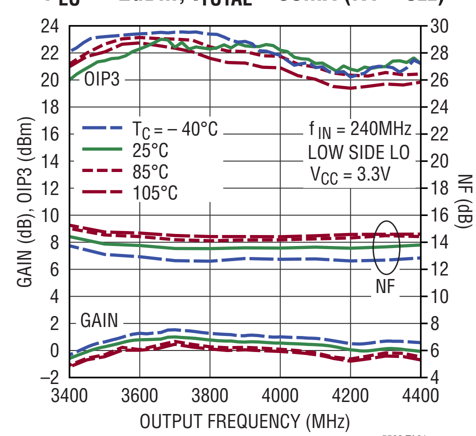


## TYPICAL APPLICATION

**3.6GHz Upconverting Mixer**




**Conversion Gain, OIP3 and NF vs $f_{OUT}$ $P_{LO}$ = –2dBm, $I_{TOTAL}$ = 35mA (R1 = 5Ω)**



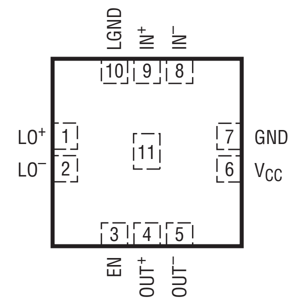
## ABSOLUTE MAXIMUM RATINGS

**(Note 1)**

Supply Voltage ($V_{CC}$, OUT⁺, OUT⁻) .......................... 4.0V
EN Voltage ....................................... –0.3V to $V_{CC}$+0.3V
LO⁺, LO⁻ Input Power ....................................... +10dBm
IN⁺, IN⁻ Input Power ......................................... +15dBm
Operating Temperature Range ($T_C$) ........ –40°C to 105°C
Junction Temperature ($T_J$) .................................... 150°C
Storage Temperature Range .................. –65°C to 150°C

## PIN CONFIGURATION

TOP VIEW




UC PACKAGE
10-LEAD (2mm × 2mm) PLASTIC QFN

$T_{JMAX}$ = 150°C, $\theta_{JC}$ = 25°C/W
EXPOSED PAD (PIN 11) IS GND, MUST BE SOLDERED TO PCB

## ORDER INFORMATION http://www.linear.com/product/LTC5562#orderinfo

| LEAD FREE FINISH | TAPE AND REEL | PART MARKING | PACKAGE DESCRIPTION | TEMPERATURE RANGE |
|---|---|---|---|---|
| LTC5562IUC#PBF | LTC5562IUC#TRPBF | LGZQ | 10-Lead (2mm × 2mm) Plastic QFN | –40°C to 105°C |

Consult ADI Marketing for parts specified with wider operating temperature ranges.
Consult ADI Marketing for information on lead based finish parts.

For more information on lead free part marking, go to: http://www.linear.com/leadfree/
For more information on tape and reel specifications, go to: http://www.linear.com/tapeandreel/. Some packages are available in 500 unit reels through designated sales channels with #TRMPBF suffix.

## DC ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $V_{CC}$ = 3.3V, $T_C$ = 25°C. Test circuits shown in Figures 1 and 2. (Note 2)**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Supply Voltage ($V_{CC}$) | | ● | 2.7 | 3.3 | 3.6 | V |
| Supply Current, EN = High | R1 = 0Ω<br>R1 = 10Ω<br>R1 = 20Ω<br>R1 = 60Ω | | | 40<br>30<br>25<br>15 | 46 | mA |
| Supply Current, EN = Low | Shutdown | | | 10 | | µA |
| **Enable Logic Input (EN)** | | | | | | |
| EN Input High Voltage (On) | | ● | 1.8 | | | V |
| EN Input Low Voltage (Off) | | ● | | | 0.5 | V |
| EN Input Current | –0.3V to $V_{CC}$ + 0.3V | ● | –15 | | 25 | µA |
| Turn-On Time | | | | 0.1 | | µs |
| Turn-Off Time | | | | 0.5 | | µs |

## AC ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $V_{CC}$ = 3.3V, EN = High, $T_C$ = 25°C, $P_{LO}$ = –1dBm, R1 = 0Ω. Test circuits shown in Figures 1 and 2. (Notes 2, 3, 4)**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| LO Input Frequency Range | External Matching Required | ● | | LF-9 | | GHz |
| Input Frequency Range | External Matching Required | ● | | LF-7 | | GHz |
| Output Frequency Range | External Matching Required | ● | | DC-7 | | GHz |
| Input Return Loss | $Z_0$ = 50Ω, External Matching Required Below 30MHz | | | >12 | | dB |
| LO Input Return Loss | $Z_0$ = 50Ω, External Matching Required | | | >10 | | dB |
| Output Impedance | Differential at 900MHz<br>Differential at 3.5GHz<br>Differential at 5.8GHz | | | 650Ω \|\| 0.3pF<br>350Ω \|\| 0.3pF<br>120Ω \|\| 0.3pF | | R \|\| C<br>R \|\| C<br>R \|\| C |
| LO Input Power | Single-Ended or Differential | | –4 | –1 | 2 | dBm |
| LO to IN Leakage | $f_{LO}$ = 1MHz to 1.8GHz<br>$f_{LO}$ = 1.8GHz to 4.5GHz<br>$f_{LO}$ > 4.5GHz | | | < –45<br>< –35<br>< –30 | | dBm<br>dBm<br>dBm |
| LO to OUT Leakage | $f_{LO}$ = 1MHz to 1.8GHz<br>$f_{LO}$ = 1.8GHz to 4.4GHz<br>$f_{LO}$ > 4.4GHz | | | < –37<br>< –35<br>< –30 | | dBm<br>dBm<br>dBm |

## AC ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_C$ = 25°C. $V_{CC}$ = 3.3V, EN = High, $P_{IN}$ = –12dBm (–12dBm/Tone for 2-tone tests), $P_{LO}$ = –1dBm, R1 = 0Ω, unless otherwise noted. Test circuit shown in Figure 1. (Notes 2, 3, 4)**

**Upconverting Applications**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Conversion Gain | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | 0.3 | 1.5<br>1<br>2 | | dB<br>dB<br>dB |
| Conversion Gain vs Temperature | $T_C$ = –40°C to 105°C, $f_{OUT}$ = 3.6GHz | ● | | –0.01 | | dB/°C |
| Two-Tone Output 3rd Order Intercept (Δf = 2MHz) | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | 18 | 21<br>19<br>17 | | dBm<br>dBm<br>dBm |
| Two-Tone Output 2nd Order Intercept | $\Delta f_{IN}$ = 141MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$\Delta f_{IN}$ = 241MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$\Delta f_{IN}$ = 901MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | | 36<br>36<br>31 | | dBm<br>dBm<br>dBm |
| SSB Noise Figure | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | | 13.5<br>14.6<br>15.9 | | dB<br>dB<br>dB |
| Output Noise Floor at $P_{IN}$ = 0dBm | $f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO | | | –157 | | dBm/Hz |
| Input 1dB Compression | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | | 6<br>5<br>4.5 | | dBm<br>dBm<br>dBm |
| LO-OUT Leakage | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | | –37<br>–35<br>–30 | | dBm<br>dBm<br>dBm |
| LO-IN Leakage | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | | –50<br>–39<br>–30 | | dBm<br>dBm<br>dBm |
| IN to OUT Isolation | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | | 65<br>68<br>68 | | dB<br>dB<br>dB |
| IN-LO Isolation | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz, High Side LO<br>$f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz, Low Side LO<br>$f_{IN}$ = 900MHz, $f_{OUT}$ = 5.8GHz, Low Side LO | | | 60<br>56<br>62 | | dB<br>dB<br>dB |

## AC ELECTRICAL CHARACTERISTICS

**The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_C$ = 25°C. $V_{CC}$ = 3.3V, EN = High, $P_{RF}$ = –12dBm (–12dBm/Tone for 2-tone tests), $P_{LO}$ = –1dBm, R1 = 0Ω. Test circuit shown in Figure 2. (Notes 2, 3, 4)**

**Downconverting Applications**

| PARAMETER | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Conversion Gain | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | 1.9<br>2<br>2 | | dB<br>dB<br>dB |
| Conversion Gain vs Temperature | $T_C$ = –40°C to 105°C, $f_{OUT}$ = 3.6 GHz | ● | | –0.01 | | dB/°C |
| Two-Tone Input 3rd Order Intercept (Δf = 2MHz) | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | 19<br>16<br>14 | | dBm<br>dBm<br>dBm |
| SSB Noise Figure | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | 13.9<br>14.2<br>14.6 | | dB<br>dB<br>dB |
| Output Noise Floor at $P_{IN}$ = 0dBm | $f_{IN}$ = 3.6GHz, $f_{OUT}$ = 350MHz, Low Side LO | | | –158 | | dBm/Hz |
| Input 1dB Compression | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | 7<br>6<br>5.5 | | dBm<br>dBm<br>dBm |
| LO-OUT Leakage | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | –45<br>–55<br>–45 | | dBm<br>dBm<br>dBm |
| LO-IN Leakage | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | –55<br>–38<br>–39 | | dBm<br>dBm<br>dBm |
| IN to OUT Isolation | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | 50<br>60<br>44 | | dB<br>dB<br>dB |
| IN-LO Isolation | $f_{IN}$ = 900MHz, $f_{OUT}$ = 140MHz, High Side LO<br>$f_{IN}$ = 3.6GHz, $f_{OUT}$ = 456MHz, High Side LO<br>$f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz, Low Side LO | | | 42<br>39<br>58 | | dB<br>dB<br>dB |
| 1/2 IF Output Spurious Product | $f_{IN}$ = 5400MHz, $f_{LO}$ = 5000MHz, $f_{SPUR}$ = 800MHz | | | –62 | | dBc |
| 1/3 IF Output Spurious Product | $f_{IN}$ = 5249.67Hz, $f_{LO}$ = 4983MHz, $f_{SPUR}$ = 800MHz | | | –82 | | dBc |

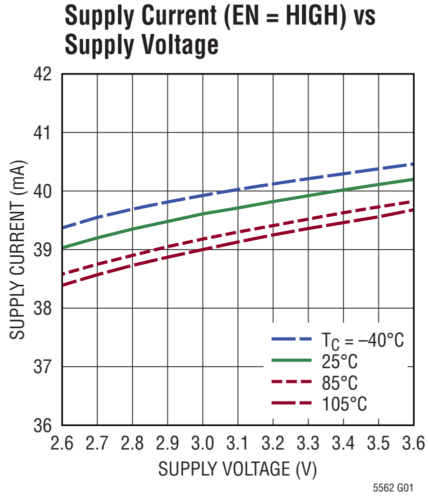
**Note 1:** Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.

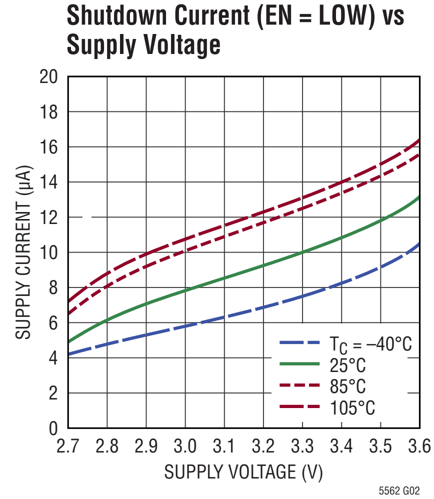
**Note 2:** The LTC5562 is guaranteed functional over the –40°C to 105°C case temperature range.

**Note 3:** SSB Noise Figure measured with a small-signal noise source, bandpass filter and 3dB matching pad on IN port, and bandpass filter on the LO input.

**Note 4:** Specified performance includes all external components and evaluation PCB losses.

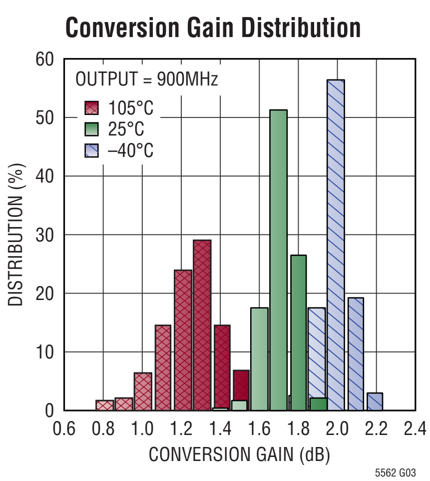
## TYPICAL DC PERFORMANCE CHARACTERISTICS (Test Circuit Shown in Figure 1)

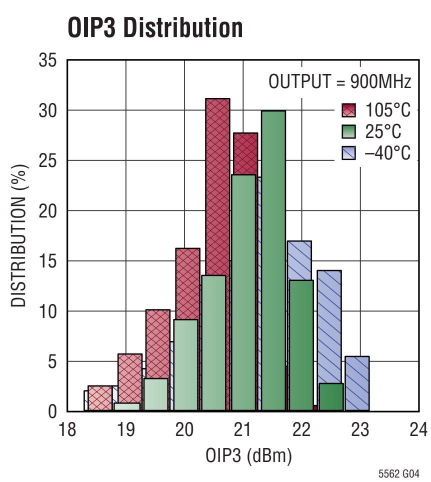


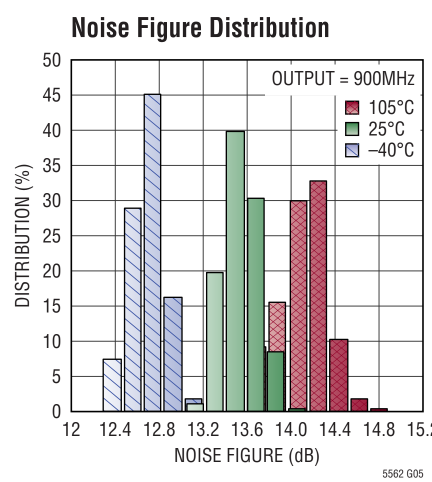




## TYPICAL PERFORMANCE CHARACTERISTICS 900MHz Upconverting Application:

$V_{CC}$ = 3.3VDC , $T_C$ = 25°C, $f_{IN}$ = 140MHz, $P_{IN}$ = –12dBm (–12dBm/tone for 2-tone OIP3 tests, Δf = 2MHz). $P_{LO}$ = 0dBm, $f_{LO}$ = $f_{IN}$ + $f_{OUT}$, High Side LO, Output Measured at 900MHz, R1 = 0Ω, unless otherwise noted.



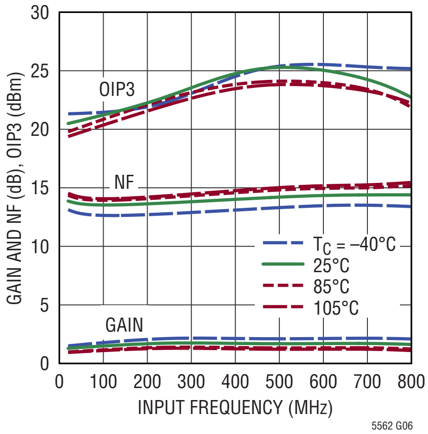



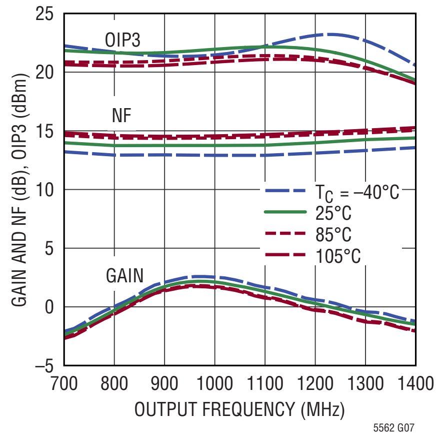
## TYPICAL PERFORMANCE CHARACTERISTICS

**900MHz Upconverting Application:** **$V_{CC}$ = 3.3VDC , $T_C$ = 25°C, $f_{IN}$ = 140MHz, $P_{IN}$ = –12dBm (–12dBm/tone for 2-tone OIP3 tests, Δf = 2MHz). $P_{LO}$ = –1dBm, $f_{LO}$ = $f_{OUT}$ + $f_{IN}$, High Side LO, Output Measured at 900MHz, R1 = 0Ω, unless otherwise noted. Test Circuit Shown in Figure 1.**

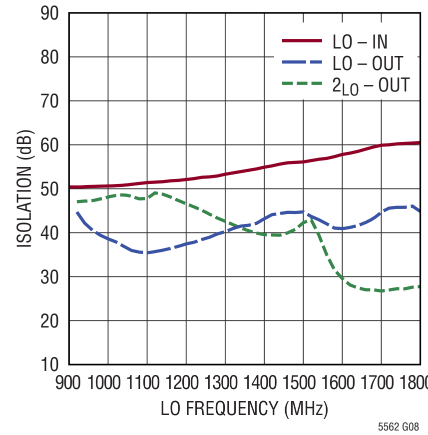
**Conversion Gain, OIP3 and NF vs Input Frequency, $f_{OUT}$ = 900MHz**



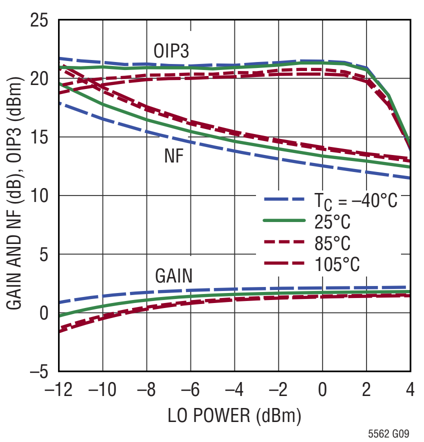

**Conversion Gain, OIP3 and NF vs Output Frequency, $f_{IN}$ = 140MHz**



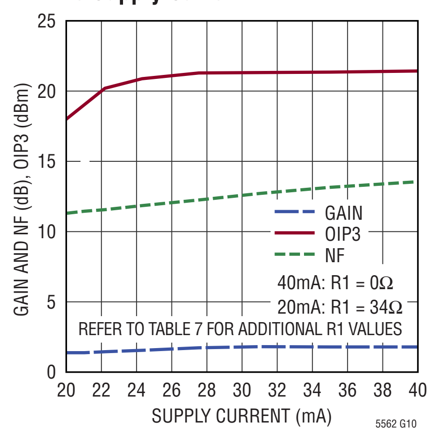

**LO Isolation vs LO Frequency**



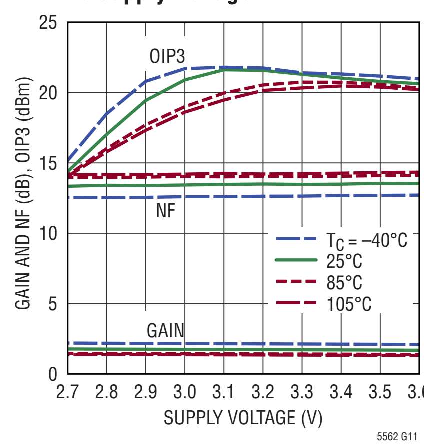

**Conversion Gain, OIP3 and NF vs LO Power**



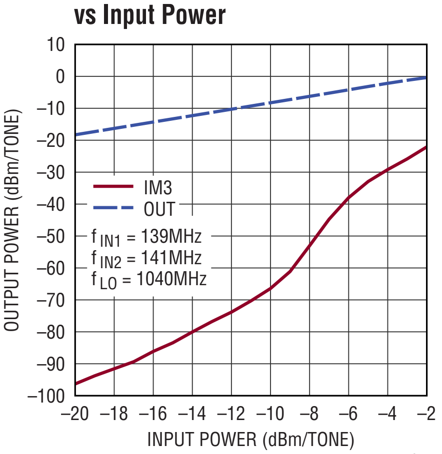

**Conversion Gain, OIP3 and NF vs Supply Current**



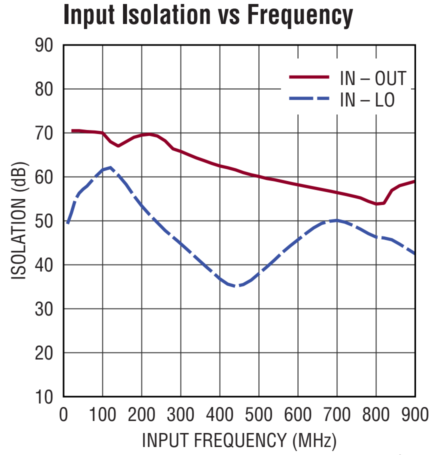

**Conversion Gain, OIP3 and NF vs Supply Voltage**



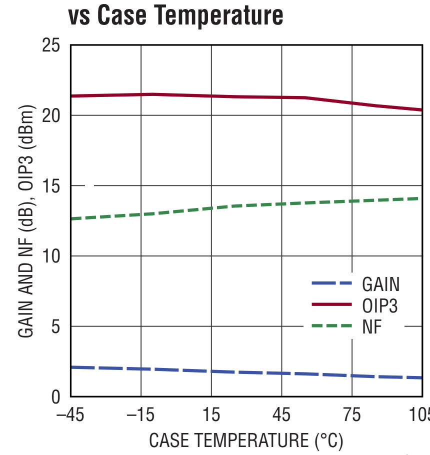

**2-Tone Output and IM3 Power vs Input Power**




**Input Isolation vs Frequency**



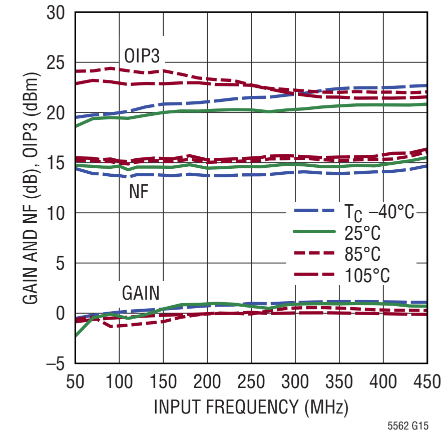

**Conversion Gain, OIP3 and NF vs Case Temperature**



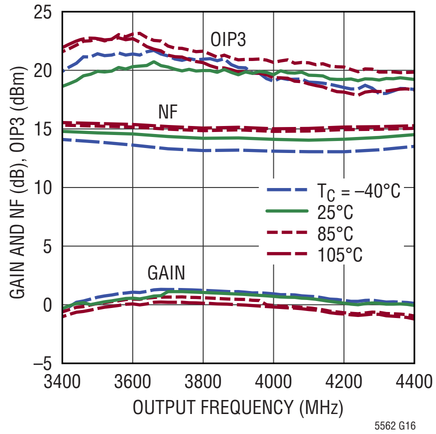
## TYPICAL PERFORMANCE CHARACTERISTICS 3.6GHz Upconverting Application:

$V_{CC}$ = 3.3VDC, $T_C$ = 25°C, $f_{IN}$ = 240MHz, $P_{IN}$ = –12dBm (–12dBm/tone for 2-tone OIP3 tests, Δf = 2MHz). $P_{LO}$ = –1dBm, $f_{LO} = f_{OUT} – f_{IN}$, Low Side LO, Output Measured at 3.6GHz, R1 = 0Ω, unless otherwise noted. Test Circuit Shown in Figure 1.

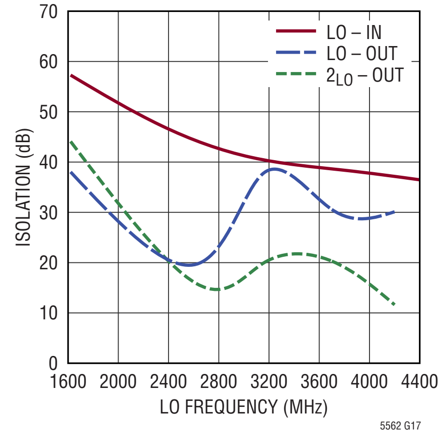
**Conversion Gain, OIP3 and NF vs Input Frequency, $f_{OUT}$ = 3.6GHz**



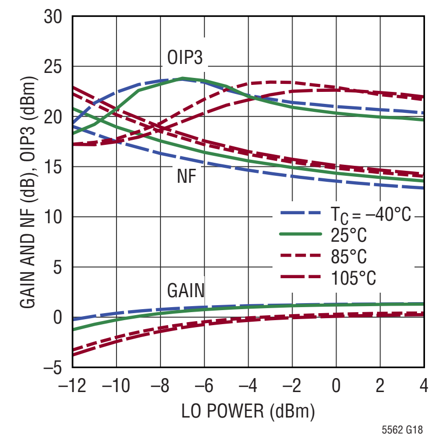

**Conversion Gain, OIP3 and NF vs Output Frequency, $f_{IN}$ = 240MHz**



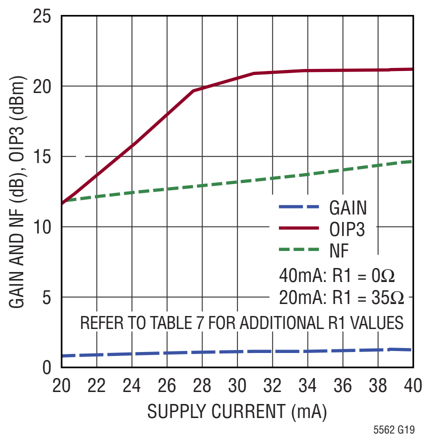

**LO Isolation vs LO Frequency**



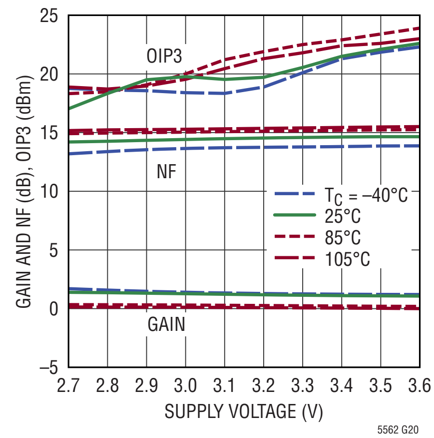

**Conversion Gain, OIP3 and NF vs LO Power**



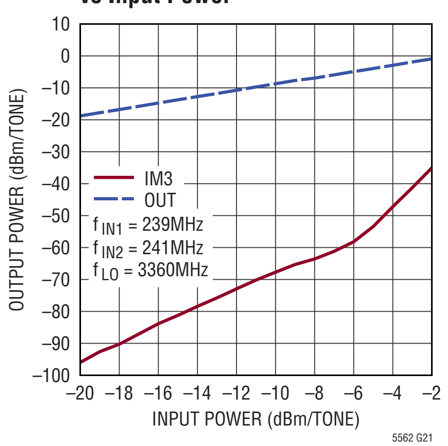

**Conversion Gain, OIP3 and NF vs Supply Current**



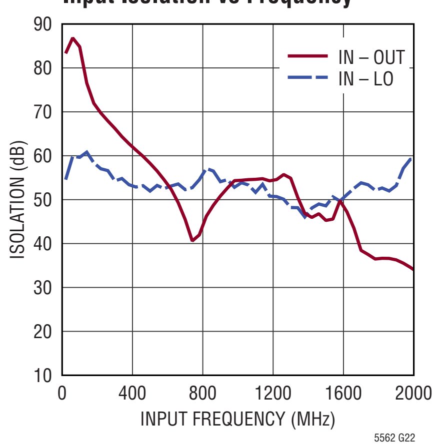

**Conversion Gain, OIP3 and NF vs Supply Voltage**



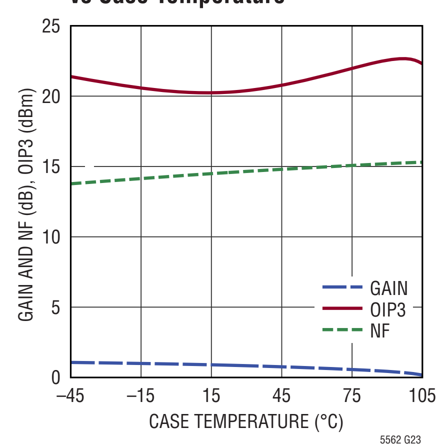

**2-Tone Output and IM3 Power vs Input Power**




**Input Isolation vs Frequency**




**Conversion Gain, OIP3 and NF vs Case Temperature**

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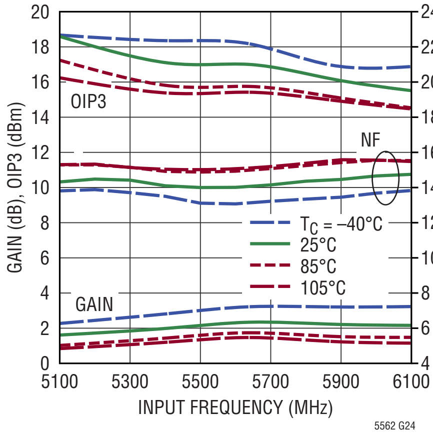
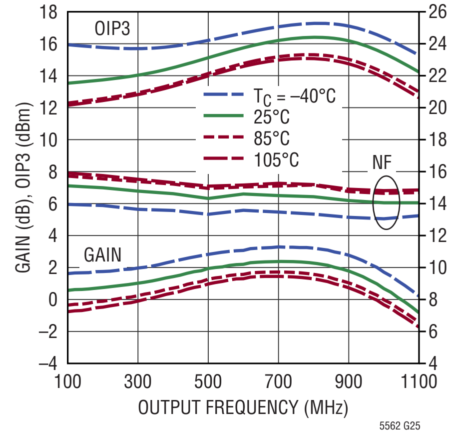
# TYPICAL PERFORMANCE CHARACTERISTICS

**5.8GHz Downconverting Application:** $V_{CC}$ = 3.3VDC, $T_C$ = 25°C, $f_{IN}$ = 5.8GHz, $P_{IN}$ = –12dBm (–12dBm/tone for 2-tone OIP3 tests, Δf = 2MHz). $P_{LO}$ = –1dBm, $f_{LO}$ = $f_{IN}$ – $f_{OUT}$ Low Side LO, R1 = 0Ω, Output Measured at 800MHz, unless otherwise noted. Test Circuit Shown in Figure 2.

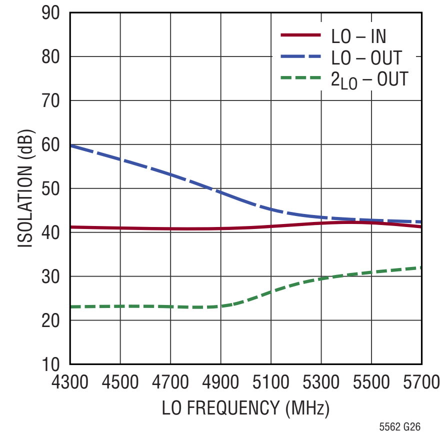
### Conversion Gain, OIP3 and NF vs Input Frequency, $f_{OUT}$ = 800MHz



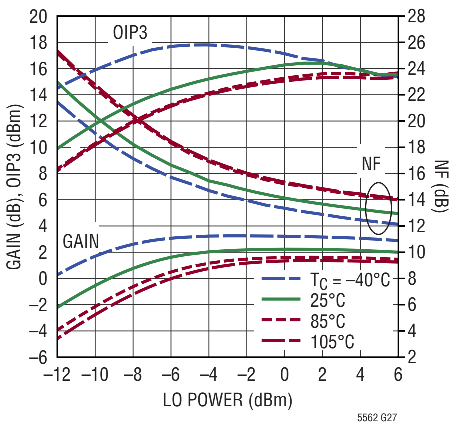

### Conversion Gain, OIP3 and NF vs Output Frequency, $f_{IN}$ = 5800MHz



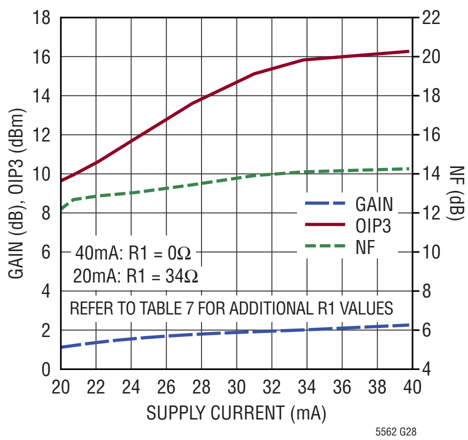

### LO Isolation vs LO Frequency



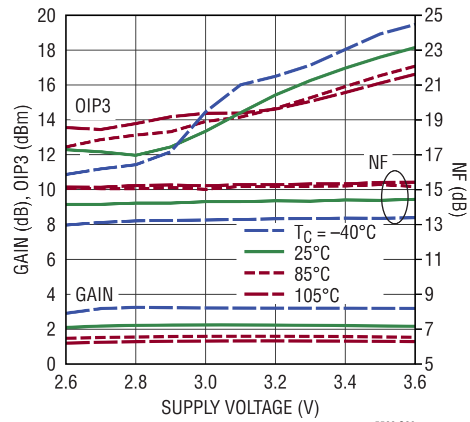

### Conversion Gain, OIP3 and NF vs LO Power



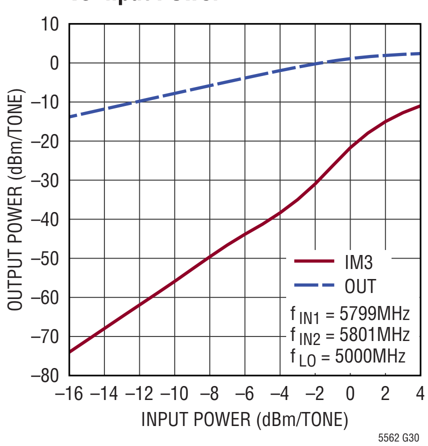

### Conversion Gain, OIP3 and NF vs Supply Current



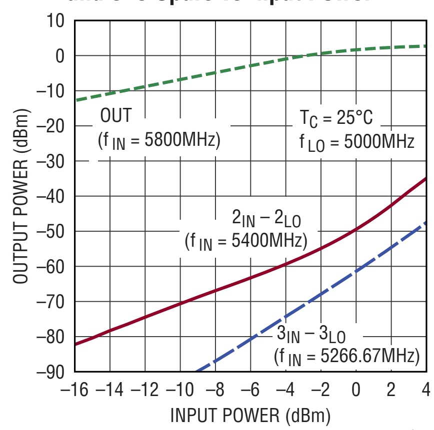

### Conversion Gain, OIP3 and NF vs Supply Voltage



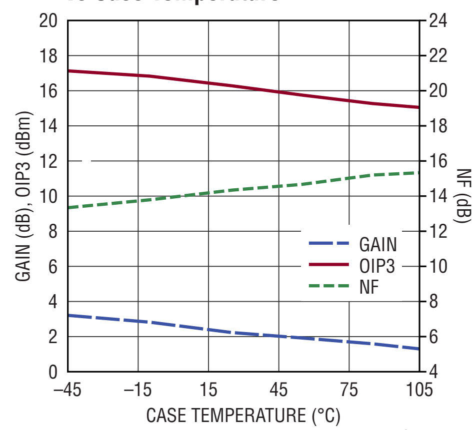

### 2-Tone Output and IM3 Power vs Input Power




### Single Tone Output Power, 2×2 and 3×3 Spurs vs Input Power




### Conversion Gain, OIP3, NF and vs Case Temperature



# PIN FUNCTIONS

**LO⁺, LO⁻ (Pins 1, 2):** Differential LO Input. The LO input impedance is approximately 220Ω, thus external impedance matching is recommended. An internal $V_{CC}$ referenced bias voltage is provided to the LO inputs, therefore, DC blocking capacitors are required. The LTC5562 is characterized and production tested with a single-ended LO drive; though a differential LO drive can be used.

**EN (Pin 3):** Enable Pin. The LTC5562 is enabled when the applied voltage on this pin is greater than 1.8V. An applied voltage less than 0.5V will disable the IC. The voltage on the EN pin should never exceed $V_{CC}$ by more than 0.3V.

**OUT⁺, OUT⁻ (Pins 4, 5):** Differential Output. External components are required for impedance matching and differential to single-ended conversion. These pins require a low resistance DC path to $V_{CC}$ to provide current to the mixer core. Typical DC current consumption is 18mA for each pin.

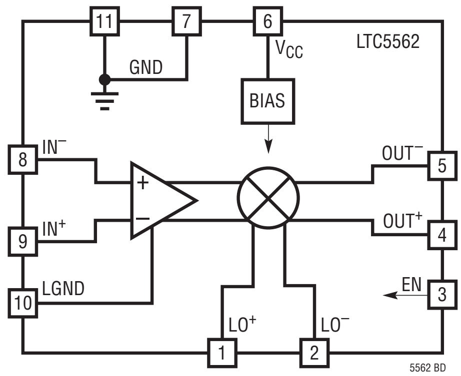
**$V_{CC}$ (Pin 6):** Power Supply Pin. The supply range is 2.7V to 3.6V. This pin should be bypassed with a 10nF capacitor located close to the IC. A low impedance power plane is recommended. Typical current consumption is 4.8mA.

**GND (Pins 7, 11(Exposed Pad)):** Ground. These pins must be soldered to the RF ground plane on the circuit board. The exposed pad on the package provides both electrical contact to the ground and a good thermal contact to the printed circuit board.

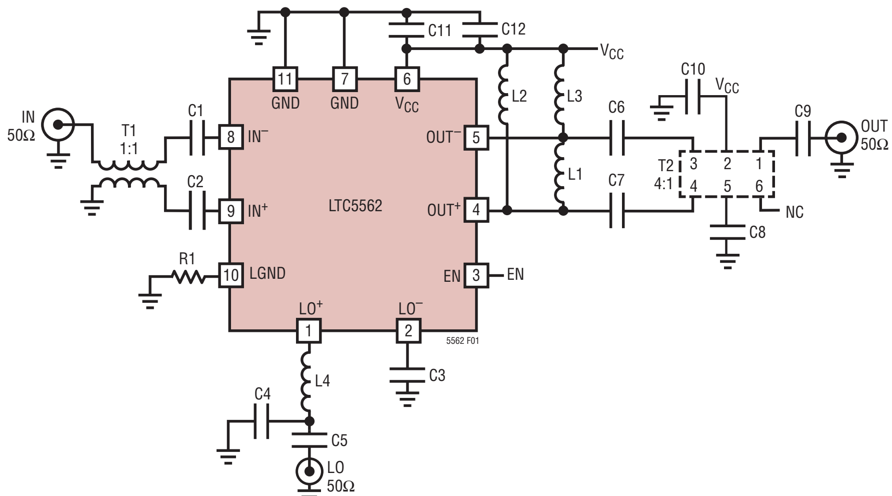
**IN⁻, IN⁺ (Pins 8, 9):** Differential Signal Input. For optimum performance these pins should be driven with a differential signal. The input can be driven single-ended, with some performance degradation, by connecting the unused pin to RF ground through a capacitor. An internally generated 1.65V ground referenced bias voltage is present on these pins, thus DC blocking is required.

**LGND (Pin 10):** DC Ground Return for the Input Amplifier. For the best performance, this pin must be connected to a good low impedance ground. The typical current from this pin is 36mA. For some applications, an external resistor may be used to reduce the total current in the mixer core, which could affect performance.

## BLOCK DIAGRAM



# TEST CIRCUITS



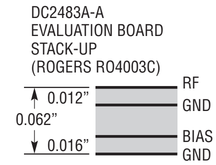
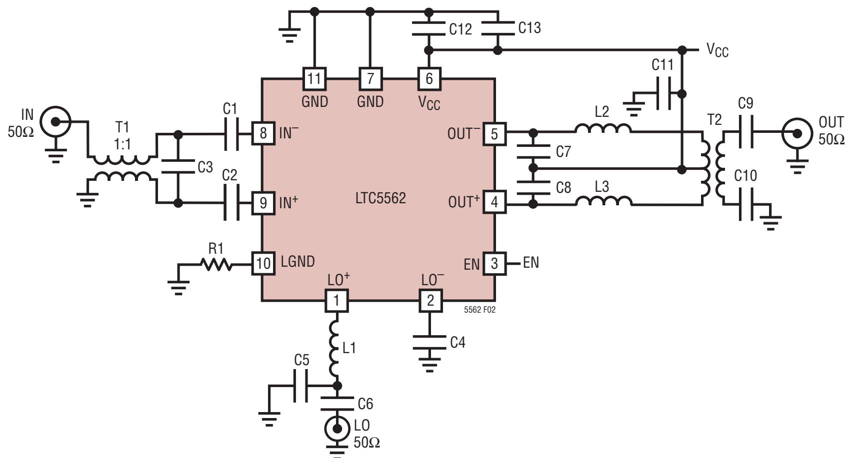




**Figure 1. Low Power Upconverting Mixer Test Schematic**

| REF DES | VALUE | SIZE | VENDOR |
|---|---|---|---|
| C1, C2, C3, C8, C9, C10, C11 | CAP, 1000pF | 0402 | Murata GRM Series |
| C12 | CAP, 2.2µF | 0603 | Murata GRM Series |
| R1 | 0Ω | 0402 | |
| T1 | XFMR, 1:1 (4.5MHz – 3000MHz) | AT224-1 | Mini-Circuits TC1-1-13M+ |
| **$f_{IN}$ = 140MHz, $f_{LO}$ = 1040MHz, $f_{OUT}$ = 900MHz** | | | |
| C6, C7 | CAP, 1.5pF | 0402 | Murata GRM Series |
| C4 | Not Used | 0402 | |
| C5 | CAP, 100pF | 0402 | Murata GRM Series |
| L1, L2, L3 | IND, 40nH | 0402 | Coilcraft 0402HP Series |
| L4 | IND, 7.5nH | 0402 | Coilcraft 0402HP Series |
| T2 | XFMR, 4:1 (800MHz – 2.6GHz) | 0805 | Anaren Model BD0826J50200AHF |
| **$f_{IN}$ = 240MHz, $f_{LO}$ = 3.36GHz, $f_{OUT}$ = 3.6GHz*** | | | |
| C4, C6, C7 | CAP, 1.2pF | 0402 | Murata GRM Series |
| C5 | CAP, 10pF | 0402 | Murata GRM Series |
| L1, L2, L3 | IND, 3.6nH | 0402 | Coilcraft 0402HP Series |
| L4 | IND, 1.5nH | 0402 | Murata LQG16HS1N5 |
| T2 | XFMR, 4:1 (3.3GHz – 4.2GHz) | GE0805C-1 | Mini-Circuits NCS4-442+ |
| **$f_{IN}$ = 900MHz, $f_{LO}$ = 4.9GHz, $f_{OUT}$ = 5.8GHz** | | | |
| C6, C7 | CAP, 100pF | 0402 | Murata GRM Series |
| C4 | CAP, 0.2pF | 0402 | Murata GJM Series |
| C5 | CAP, 0.5pF | 0402 | Murata GJM Series |
| L2, L3 | IND, 3.9nH | 0402 | Coilcraft 0402HP Series |
| L1, L4 | IND, 1nH | 0402 | Coilcraft 0402HP Series |
| T2 | XFMR, 4:1 (4.5GHz – 6GHz) | GE0805C-1 | Mini-Circuits NCS4-63+ |

*Standard Evaluation Board Schematic, DC2483A-A

# TEST CIRCUITS



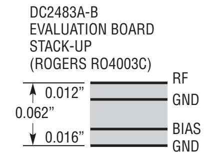




**Figure 2. Low Power Downconverting Mixer Test Schematic**

| REF DES | VALUE | SIZE | VENDOR |
|---|---|---|---|
| C1, C2, C4, C9, C10 | CAP, 1000pF | 0402 | Murata GRM Series |
| C11, C12 | CAP, 10nF, 10%, X5R, 10V | 0402 | Murata GRM Series |
| C13 | CAP, 2.2µF | 0603 | Murata GRM Series |
| R1 | 0Ω | 0402 | |
| **$f_{IN}$ = 900MHz, $f_{LO}$ = 1040MHz, $f_{OUT}$ = 140MHz*** | | | |
| C3, C5, C7, C8 | Not Used | | |
| C6 | CAP, 1000pF | 0402 | Murata GRM Series |
| L2, L3 | IND, 100nH | 0402 | Coilcraft 0402AF |
| L1 | IND, 7.5nH | 0402 | Coilcraft 0402HP |
| T1 | XFMR, 1:1 (4.5MHz – 3000MHz) | AT224-1 | Mini-Circuits TC1-1-13M+ |
| T2 | XFMR, 8:1 (2MHz – 500MHz) | AT224-1 | Mini-Circuits TC8-1-10LN+ |
| **$f_{IN}$ = 3.5GHz, $f_{LO}$ = 3.044GHz, $f_{OUT}$ = 456MHz** | | | |
| L2, L3 | CAP, 3.3pF | 0402 | Murata GRM Series |
| C3 | Not Used | | |
| C5 | CAP, 0.9pF | 0402 | Murata GRM Series |
| C6 | CAP, 10pF | 0402 | Murata GRM Series |
| C7, C8 | IND, 56nH | 0402 | Coilcraft 0402HP |
| L1 | IND, 1.5nH | 0402 | Murata LQG15HS1N5 |
| T1 | XFMR, 1:1 (10MHz – 8000MHz) | DB1627-1 | Mini-Circuits TCM1-83X+ |
| T2 | XFMR, 4:1 (10MHz – 1900MHz) | DB714 | Mini-Circuits TCM4-19 |
| **$f_{IN}$ = 5.8GHz, $f_{LO}$ = 4.9GHz, $f_{OUT}$ = 800MHz** | | | |
| C7, C8 | Not Used | | |
| C3, C6 | CAP, 0.5pF | 0402 | Murata GRM Series |
| C5 | CAP, 0.2pF | 0402 | Murata GRM Series |
| L2, L3 | IND, 33nH | 0402 | Coilcraft 0402HP |
| L1 | IND, 1.0nH | 0402 | Coilcraft 0402HP |
| T1 | XFMR, 1:1 (10MHz – 8000MHz) | DB1627-1 | Mini-Circuits TCM1-83X+ |
| T2 | XFMR, 4:1 (10MHz – 1900 MHz) | DB714 | Mini-Circuits TCM4-19 |

*Standard Evaluation Board Schematic, DC2483A-B

## APPLICATIONS INFORMATION

### Introduction

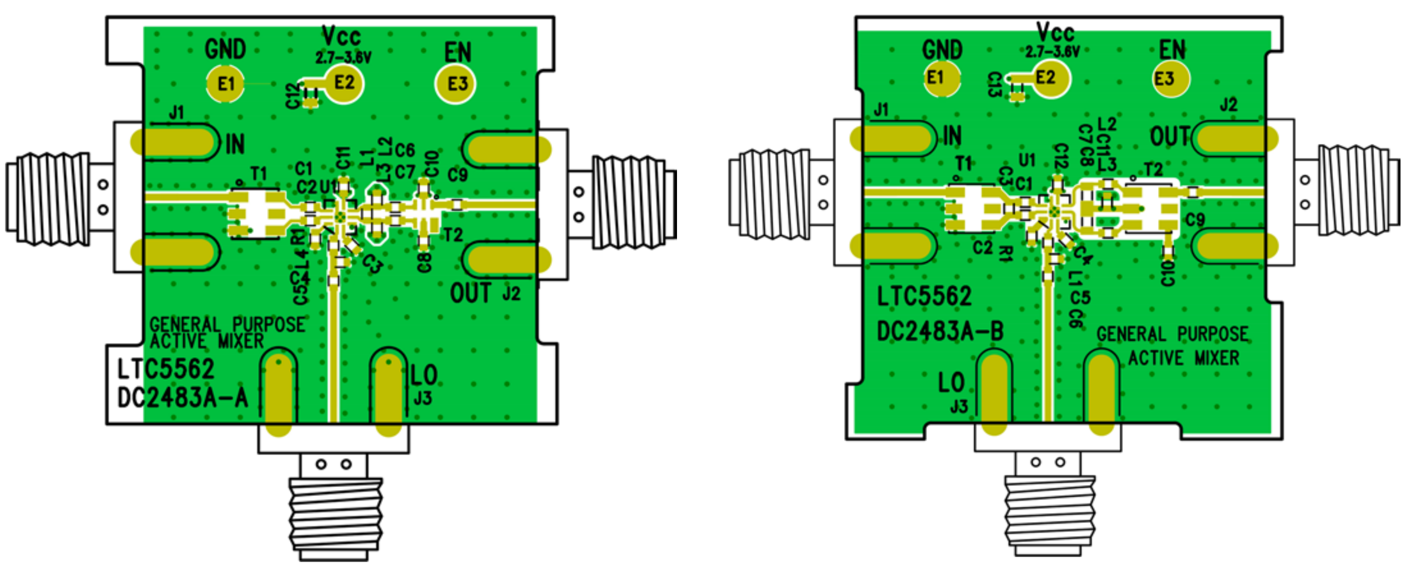
The LTC5562 is a general purpose, low power double balanced mixer. It can be configured as an upconverting or downconverting mixer that can be used in wideband or narrowband applications.

A differential common emitter stage at the mixer input allows for very broadband input matching. The IN port is differential but can be driven with a single-ended signal simply by adding a bypass cap to RF ground on one of the input pins. However, for best performance, the IN pins should be configured differentially. The LO port is differential, but can be driven with a single-ended signal, as well, simply by adding a bypass cap to RF ground on one of the input pins. LO leakage will be reduced if the LO is driven differentially. Additionally, low side or high side injection can be used on the LO port. The OUT ports have a higher impedance, designed to provide conversion gain while maintaining good linearity with lower current. External components are required to optimize the impedance match for the desired frequency range. See the Pin Functions and Block Diagram sections for a description of each pin.

The upconverting test circuit, shown in Figure 1, utilizes bandpass matching and a 4:1 multilayer chip balun to realize a single-ended output. The downconverting test circuit, in Figure 2, uses a 8:1 wire-wound balun. The outputs may also be used to provide a differential signal, if DC blocking capacitors are used to isolate the output. Test circuit schematics showing all external components required for the data sheet specified performance are shown in Figures 1 and 2. Additional components may be used to modify the DC supply current or frequency response, which will be discussed in the following sections.

The LTC5562 can be powered down by applying a low logic signal to the EN pin. Bias voltages are maintained during shutdown to enable a fast turn-on time. The part will default to shutdown mode if the EN pin is left floating.

The upconverting and downconverting evaluation boards are shown in Figures 3(a) and 3(b).




(a) Upconversion (DC2483A-A)

(b) Downconversion (DC2483A-B)

**Figure 3. LTC5562 Evaluation Board Layouts**

# APPLICATIONS INFORMATION

## IN Port Interface

A simplified schematic of the mixer's input is shown in Figure 4. The $IN^+$ and $IN^-$ pins drive the bases of the input amplifier and internal resistors are used for impedance matching. These pins are internally biased to a common mode voltage of 1.65V, thus capacitors C1 and C2 provide DC isolation and can be used for impedance matching. A small value capacitor, C3, can be used to improve the impedance match at higher frequencies. The 1:1 transformer, T1, provides the single-ended to differential conversion.

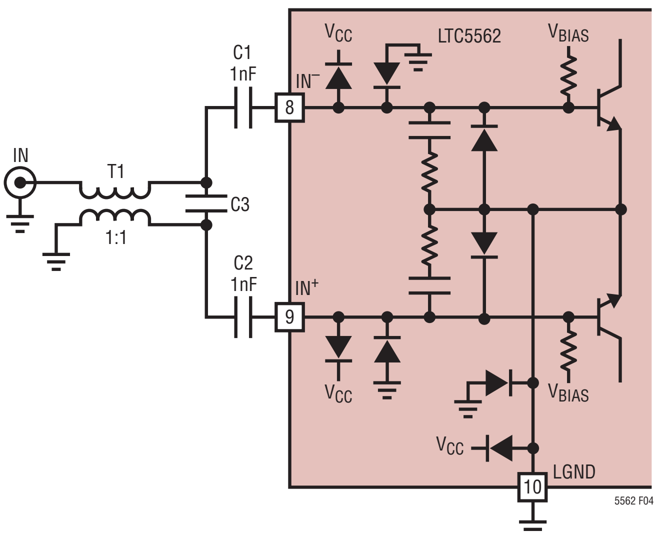



**Figure 4. IN Port with External Matching**

The typical return loss at the IN port is shown in Figure 5 for a selection of 1:1 transformers. Adding a 0.5pF capacitor at C3 will extend the impedance match.

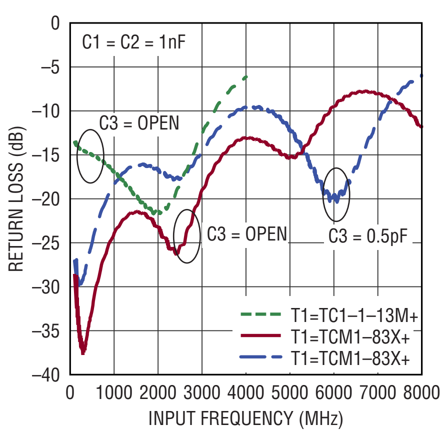



**Figure 5. IN Port Return Loss**

Parallel equivalent differential input impedances for various frequencies are listed in Table 1. At frequencies below 30MHz, the impedance match is limited by internal capacitors, thus additional external components may be needed to optimize the input impedance.

The tail current of the input amplifier flows through pin 10 (LGND). Typically this pin should be directly connected to ground; however, a resistor can be connected between LGND and the board ground plane to reduce the total current consumption of the LTC5562. See LGND (Reduced Current) section for more information.

**Table 1. IN Port Differential Impedance**

| FREQ (MHz) | IMPEDANCE (Ω) | | | REFL. COEFF. | |
|---|---|---|---|---|---|
| | REAL* | IMAG* | PARALLEL EQUIVALENT | MAG | ANG (°) |
| 10 | 133.3 | –159.0 | 100.1pF | 0.50 | –39.6 |
| 100 | 73.3 | –740.2 | 2.1pF | 0.19 | –14.3 |
| 500 | 72.1 | –1376.5 | 0.2pF | 0.18 | –8.0 |
| 1000 | 71.5 | –779.7 | 0.2pF | 0.18 | –14.2 |
| 1500 | 70.6 | –498.5 | 0.2pF | 0.18 | –22.3 |
| 2000 | 68.1 | –353.5 | 0.2pF | 0.17 | –32.7 |
| 2500 | 63.6 | –249.3 | 0.3pF | 0.16 | –49.6 |
| 3000 | 59.3 | –163.6 | 0.3pF | 0.18 | –72.3 |
| 3500 | 58.4 | –110.3 | 0.4pF | 0.25 | –86.1 |
| 4000 | 63.5 | –84.7 | 0.5pF | 0.33 | –88.5 |
| 4500 | 72.8 | –77.3 | 0.5pF | 0.40 | –85.2 |
| 5000 | 78.3 | –76.0 | 0.4pF | 0.43 | –83.1 |
| 5500 | 77.5 | –74.9 | 0.4pF | 0.43 | –84.1 |
| 6000 | 71.7 | –72.3 | 0.4pF | 0.41 | –88.6 |
| 6500 | 63.8 | –68.1 | 0.4pF | 0.40 | –96.0 |
| 7000 | 54 | –62.6 | 0.4pF | 0.39 | –107.2 |
| 7500 | 43.2 | –56.6 | 0.4pF | 0.38 | –122.3 |
| 8000 | 33.4 | –49.9 | 0.4pF | 0.42 | –138.3 |

* Parallel Equivalent Impedance

# APPLICATIONS INFORMATION

## LO Input Interface

The LTC5562 can be driven by a single-ended or differential LO. For the performance shown in the Electrical Characteristics tables and the Typical Performance curves, the LO is driven single-ended. If driven differentially, the LO to OUT leakage may improve. The LO input pins are internally biased to a $V_{CC}$ referenced voltage, thus external capacitors are required to provide DC isolation. External components are required to optimize the impedance match for the desired frequency range. The impedance match will be maintained when the part is disabled, as well.

Table 2 lists the single-ended input impedance and reflection coefficient vs frequency for the LO input, configured as shown in Figure 6. The differential impedance versus frequency are shown in Table 3.

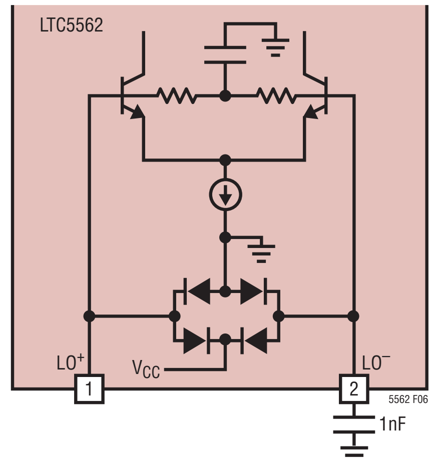



**Figure 6. LO Input Schematic**

**Table 2. Single-Ended LO Input Impedance**

| FREQ (MHz) | IMPEDANCE (Ω) REAL | IMAG | PARALLEL EQUIVALENT | REFL. COEFF. MAG | ANG (°) |
|---|---|---|---|---|---|
| 10 | 195.29 | –2576.34 | 6.18pF | 0.59 | –2.38 |
| 100 | 146.83 | –414.95 | 3.84pF | 0.5 | –15.49 |
| 500 | 109.66 | –231.63 | 1.37pF | 0.4 | –30.07 |
| 1000 | 97.6 | –134.35 | 1.18pF | 0.39 | –51.17 |
| 1500 | 83.74 | –88.92 | 1.19pF | 0.41 | –73.77 |
| 2000 | 69.2 | –61.86 | 1.29pF | 0.45 | –96.19 |
| 2500 | 55.43 | –43.99 | 1.45pF | 0.51 | –115.94 |
| 3000 | 46.27 | –33.62 | 1.58pF | 0.58 | –128.66 |
| 3500 | 41.73 | –28.88 | 1.57pF | 0.62 | –134.75 |
| 4000 | 35.81 | –26.5 | 1.5pF | 0.63 | –140.08 |
| 4500 | 27.13 | –26.16 | 1.35pF | 0.61 | –147.71 |
| 5000 | 18.47 | –27.4 | 1.16pF | 0.6 | –159.29 |
| 5500 | 12.46 | –45.33 | 0.64pF | 0.63 | –172.3 |
| 6000 | 10.37 | 60.6 | 1.61nH | 0.66 | –184.12 |
| 6500 | 12.45 | 30.73 | 0.75nH | 0.65 | –190.37 |
| 7000 | 12.18 | 18.8 | 0.43nH | 0.71 | –193.06 |
| 7500 | 12.9 | 17.26 | 0.37nH | 0.72 | –194.49 |
| 8000 | 11.05 | 14.2 | 0.28nH | 0.76 | –192.46 |
| 8500 | 10.9 | 17.57 | 0.33nH | 0.73 | –191.44 |
| 9000 | 12.7 | 24.24 | 0.43nH | 0.67 | –192.41 |
| 9500 | 23.78 | 26.13 | 0.44nH | 0.61 | –208.38 |

**Table 3. Differential LO Input Impedance**

| FREQ (MHz) | IMPEDANCE (Ω) REAL | IMAG | PARALLEL EQUIVALENT | REFL. COEFF. MAG | ANG (°) |
|---|---|---|---|---|---|
| 10 | 222.3 | –5085.3 | 3.1pF | 0.63 | –1.2 |
| 100 | 208.3 | –2039.9 | 0.8pF | 0.61 | –3 |
| 500 | 201.4 | –410.5 | 0.8pF | 0.61 | –14.8 |
| 1000 | 181.7 | –200 | 0.8pF | 0.59 | –30.1 |
| 1500 | 155.7 | –127.7 | 0.8pF | 0.57 | –46.5 |
| 2000 | 128.6 | –88.6 | 0.9pF | 0.56 | –64.8 |
| 2500 | 104.5 | –63.4 | 1pF | 0.56 | –84.6 |
| 3000 | 93.3 | –49.1 | 1.1pF | 0.61 | –99 |
| 3500 | 97.8 | –43.3 | 1.1pF | 0.66 | –104.5 |
| 4000 | 99.6 | –40.2 | 1pF | 0.69 | –107.8 |
| 4500 | 77 | –36.7 | 1pF | 0.66 | –115.1 |
| 5000 | 46.5 | –31.4 | 1pF | 0.61 | –130.2 |
| 5500 | 25.7 | –28.0 | 1pF | 0.59 | –149.1 |
| 6000 | 15.2 | –31.6 | 0.8pF | 0.61 | –165.6 |
| 6500 | 11.9 | –243.2 | 0.1pF | 0.62 | –178.6 |
| 7000 | 11.3 | 73.5 | 1.7nH | 0.64 | –184.1 |
| 7500 | 11.2 | 64.8 | 1.4nH | 0.64 | –184.5 |
| 8000 | 10.7 | –109.2 | 0.2pF | 0.65 | –177.5 |
| 8500 | 12.1 | –53.5 | 0.4pF | 0.63 | –173.8 |
| 9000 | 15.1 | –100.4 | 0.2pF | 0.55 | –174.4 |
| 9500 | 21.2 | 62.7 | 1.1nH | 0.46 | –197.0 |

# APPLICATIONS INFORMATION

The measured return loss of the matched LO input port, as drawn in Figure 7, is shown in Figure 8. The component values required for each frequency band are given in Table 4.

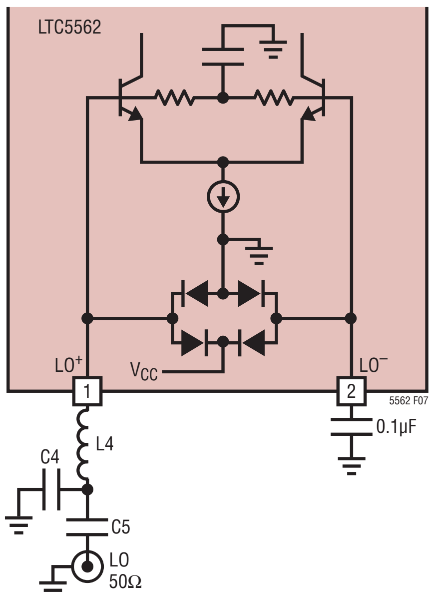



Figure 7. LO Input Schematic with External Matching

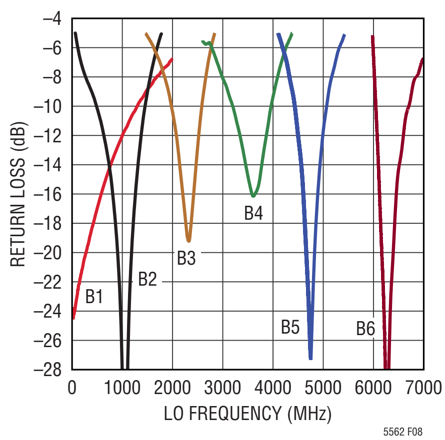



Figure 8. Single-Ended LO Input Return Loss

**Table 4. Components for LO Match**

| FREQUENCY BAND | FREQUENCY RANGE (MHz) | L4 (Ω/nH) | C4 (Ω/pF) | C5 (pF) |
|---|---|---|---|---|
| B1 | 10 to 1200 | 0Ω | 85Ω | 1000 |
| B2 | 500 to 1400 | 7.5nH | Open | 1000 |
| B3 | 2000 to 2550 | 3.3nH | 1.2pF | 3.3 |
| B4 | 3200 to 3950 | 1.5nH | 0.9pF | 10 |
| B5 | 4250 to 5050 | 1nH | 0.2pF | 0.5 |
| B6 | 6050 to 6700 | 0Ω | Open | 0.25 |

## OUT Port Interface

The differential output interface is shown in Figure 9. The $OUT^+$ and $OUT^-$ pins are open-collector outputs with internal load resistors that provide a 720Ω differential output resistance at very low frequencies. The output matching network must include a low resistance DC current path to $V_{CC}$ to properly bias the mixer core. $OUT^+$ and $OUT^-$ pins each require approximately 18mA of current at the maximum operating bias condition.

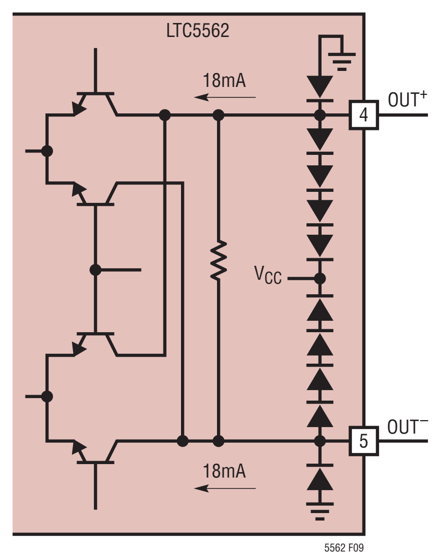



Figure 9. Output Interface

## APPLICATIONS INFORMATION

Figure 10 shows the equivalent circuit of the output and Table 5 lists differential impedances for various frequencies. The impedance values are listed in parallel equivalent form, with equivalent capacitances also shown. For optimum single-ended performance, the differential output signal must be combined through an external transformer or a discrete balun circuit. In applications where differential filters or amplifiers follow the mixer, it is possible to eliminate the transformer and drive these components differentially.

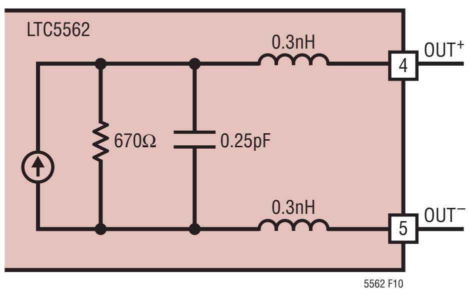



**Figure 10. OUT Port Equivalent Circuit**

**Table 5. Differential OUT Port Impedance**

| FREQ (MHz) | IMPEDANCE (Ω) | | | REFL. COEFF. | |
|---|---|---|---|---|---|
| | REAL* | IMAG* | PARALLEL EQUIVALENT | MAG | ANG (°) |
| 10 | 664.3 | –26193.2 | 0.6pF | 0.86 | –0.2 |
| 100 | 626.6 | –5116.1 | 0.3pF | 0.85 | –1.1 |
| 500 | 634.2 | –858.4 | 0.4pF | 0.85 | –6.7 |
| 1000 | 598.9 | –432.6 | 0.4pF | 0.85 | –13.3 |
| 1500 | 538 | –293.7 | 0.4pF | 0.83 | –19.5 |
| 2000 | 487.5 | –220.1 | 0.4pF | 0.82 | –25.9 |
| 2500 | 444.4 | –168.6 | 0.4pF | 0.81 | –33.4 |
| 3000 | 413 | –130.5 | 0.4pF | 0.81 | –42.4 |
| 3500 | 414.7 | –107.9 | 0.4pF | 0.82 | –50.2 |
| 4000 | 477.6 | –97.9 | 0.4pF | 0.85 | –54.5 |
| 4500 | 569.7 | –94.7 | 0.4pF | 0.87 | –56.0 |
| 5000 | 587.8 | –91.7 | 0.4pF | 0.88 | –57.5 |
| 5500 | 533.4 | –86.8 | 0.3pF | 0.87 | –60.2 |
| 6000 | 454.2 | –79.9 | 0.3pF | 0.85 | –64.5 |
| 6500 | 375.4 | –73.3 | 0.3pF | 0.83 | –69.2 |
| 7000 | 334 | –67.4 | 0.3pF | 0.82 | –73.9 |
| 7500 | 275.4 | –59.6 | 0.4pF | 0.81 | –81.1 |
| 8000 | 249.7 | –52.0 | 0.4pF | 0.81 | –89 |

* Parallel Equivalent Impedance

### Output Matching

The output matching networks for several popular frequency bands are shown in Table 6 for both upconverting and downconverting applications. Please refer to the schematic shown in Figure 11 for component placement. Most of the matching networks in Table 6 are designed using a 4:1 impedance transformer which is convenient to transform the match from 200Ω to 50Ω, while providing a wide bandwidth output. For very low frequency applications, an 8:1 impedance transformer is used as shown in Table 6, Downconverting Application. The transformation network B1 provides a low frequency, wide bandwidth match with only 2 matching inductors. The return loss data for each matching network is shown in Figures 12 and 13.

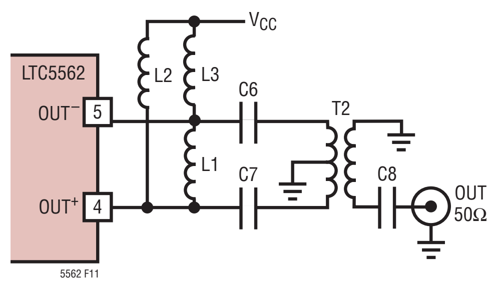



**Figure 11. Output Matching Network Schematic**

## APPLICATIONS INFORMATION

**Table 6. OUT Port Component Values**

| Upconverting Application | | | | | | |
|---|---|---|---|---|---|---|
| FREQUENCY BAND | FREQUENCY (GHz) | L2, L3 (nH) | L1 (nH) | C6, C7 (pF/nH) | C8 (pF) | T2 |
| B1 | 0.65 to 0.95 | 40 | 40 | 1.5pF | 1000 | Anaren 4:1 BD0826J50200AHF |
| B2 | 2.3 to 2.7 | 12 | 10 | 4.7nH | 1000 | Mini Circuits 4:1 NCS4-272+ |
| B3 | 3.55 to 3.9 | 3.6 | 3.6 | 1.2pF | 1000 | Mini Circuits 4:1 NCS4-442+ |
| B4 | 5.2 to 6.1 | 3.9 | 1 | 100pF | 1000 | Mini Circuits 4:1 NCS4-63+ |
| **Downconverting Application** | | | | | | |
| FREQUENCY BAND | FREQUENCY (MHz) | L2, L3 (nH) | L1 (nH) | C6, C7 (pF/nH) | C8 (pF) | T2 |
| B1 | 2 to 400 | Open | Open | 100nH | 1000 | Mini Circuits TC8-1-10LN+ |
| B2 | 600 to 980 | Open | Open | 33nH | 1000 | Mini Circuits 4:1 TCM4-19+ |
| B3 | 1400 to 1600 | 5.6nH | Open | 1.2pF | 1000 | Mini Circuits 4:1 TCM4-25+ |

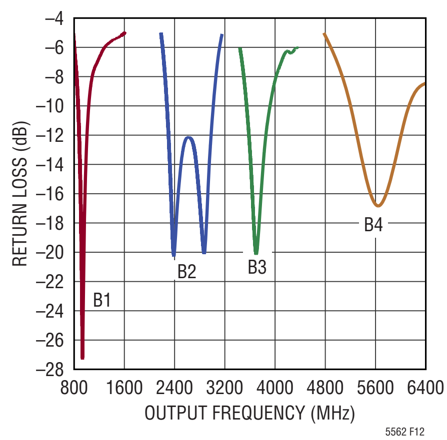



**Figure 12. Output Return Loss for Upconverting Application (Refer to Table 6 for Component Values)**

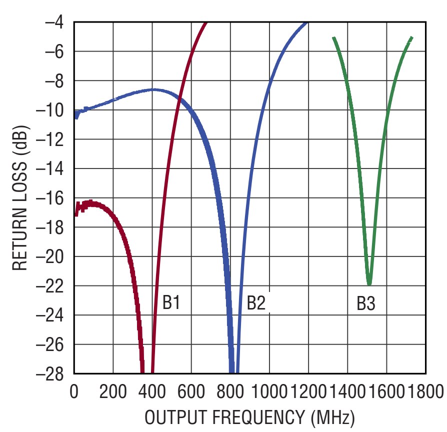



**Figure 13. Output Return Loss for Downconverting Application (Refer to Table 6 for Component Values)**

## APPLICATIONS INFORMATION

### DC and RF Grounding

The LTC5562 relies on the backside ground for both RF and thermal performance. The exposed pad must be soldered to the low impedance top-side ground plane of the board. The top-side ground should also be connected to other ground layers to aid in thermal dissipation and insure a low inductance RF ground. The LTC5562 evaluation boards (Figure 3) utilize 4 vias under the exposed pad for this purpose. In addition, pin 7, GND, is shorted to the exposed pad on the top layer.

### Enable Interface

Figure 14 shows a simplified schematic of the EN pin interface. To enable the part, the applied EN voltage must be greater than 1.8V. If the enable function is not required, EN may be connected directly to $V_{CC}$. The voltage at the enable pin must not exceed the power supply voltage by more than 0.3V. Otherwise, supply current may be sourced through the upper ESD diode. If this is unavoidable, a current limiting resistor should be added in series with the EN pin.

When the EN voltage is less than 0.5V, the LTC5562 is in shutdown mode. Internal bias voltages are maintained to enable fast turn-on times. Refer to the Electrical Characteristics table for typical performance.

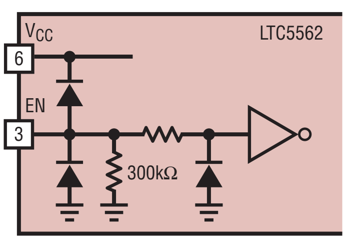



**Figure 14. Enable Pin Interface**

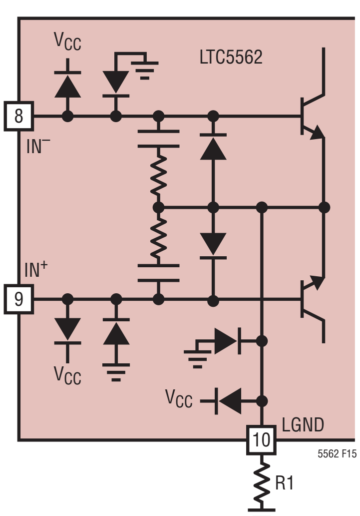



**Figure 15. LGND Current Adjust Interface**

### LGND (Reduced Current)

To achieve the highest linearity, LGND, pin 10, should be connected directly to the ground plane. However, LGND may be used to reduce the DC current consumption of the LTC5562 by connecting a small series resistor between LGND and GND. In general, a lower bias current will reduce the linearity of the LTC5562, but will also reduce the noise figure. At low frequencies, the performance degradation due to reduced current will be small. As the operating frequency increases, the performance will decrease by a more significant amount. Refer to Table 7 for measured performance data vs LGND resistance.

**Table 7. Performance Comparison vs LGND Resistance**

| UP MIXER | | $f_{IN}$ = 140MHz, $f_{OUT}$ = 900MHz | | | $f_{IN}$ = 240MHz, $f_{OUT}$ = 3.6GHz | | |
|---|---|---|---|---|---|---|---|
| R1 (Ω) | $I_{Total}$ (mA) | Gain (dB) | $OIP_3$ (dBm) | NF (dB) | Gain (dB) | $OIP_3$ (dBm) | NF (dB) |
| 0 | 40 | 1.7 | 21.4 | 13.5 | 1.2 | 21 | 14.6 |
| 5 | 35 | 1.7 | 21.3 | 13.1 | 1.2 | 21 | 13.4 |
| 10 | 30 | 1.7 | 21.3 | 12.5 | 1.1 | 20.5 | 13.1 |
| 20 | 25 | 1.55 | 20.9 | 11.8 | 1 | 16 | 12.2 |
| 33 | 20 | 1.38 | 17.5 | 11.2 | 0.8 | 11.1 | 11.9 |
| 60 | 15 | 1.3 | 12.2 | 10.8 | | | |

| DOWN MIXER | | $f_{IN}$ = 5.8GHz, $f_{OUT}$ = 800MHz | | |
|---|---|---|---|---|
| R1 (Ω) | $I_{Total}$ (mA) | Gain (dB) | $OIP_3$ (dBm) | NF (dB) |
| 0 | 40 | 2.2 | 16.3 | 14.3 |
| 5 | 35 | 2 | 15.8 | 14.1 |
| 10 | 30 | 1.8 | 14.5 | 13.7 |
| 20 | 25 | 1.6 | 11.8 | 13 |
| 33 | 20 | 1.1 | 8.9 | 12.2 |

## APPLICATIONS INFORMATION

### Supply Voltage

High quality ceramic capacitors such as X5R or X7R should be used as bypass capacitors for $V_{CC}$. The capacitors should be located on the same side of the PCB as the LTC5562 and as close to pin 6 as possible. Wide, low inductance traces should be used. The ground connection to the bypass capacitor should connect to the top side ground and to the low inductance ground plane. If possible, multiple ground vias should be used.

Fast ramping of the supply voltage can cause a current glitch in the internal ESD protection circuits. Depending on the supply inductance, this could result in a supply voltage transient that exceeds the maximum rating. A supply voltage ramp time of greater than 1ms is recommended.

### Spurious Output Levels

Mixer spurious output levels vs harmonics of the RF and LO are tabulated in Tables 8 and 9. The spur levels were measured on a standard evaluation board using the test circuit shown in Figures 1 and 2. The spur frequencies can be calculated using the following equation:

$$F_{SPUR} = |M \bullet f_{IN} \pm N \bullet f_{LO}|$$

**Table 8. Downconversion Output Spur Levels (dBc), $F_{SPUR} = |M \bullet f_{IN} – N \bullet f_{LO}|$**
($f_{IN}$ = 5.8GHz, $P_{IN}$ = –12dBm, $f_{LO}$ = 5.0GHz, $P_{LO}$ = 0dBm, $V_{CC}$ = 3.3V, $f_{OUT}$ = 800MHz

| | | N | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| M | 0 | – | –41.6 | –15.6 | –59.4 | –39.6 | * |
| | 1 | 53.6 | 0** | < –75 | –38.5 | < –75 | –69.3 |
| | 2 | –65.7 | < –75 | –73.9 | < –75 | < –75 | < –75 |
| | 3 | < –75 | < –75 | < –75 | < –75 | < –75 | < –75 |
| | 4 | * | < –75 | < –75 | < –75 | < –75 | < –75 |
| | 5 | * | < –75 | < –75 | < –75 | < –75 | < –75 |

*Out of Range for Test Equipment
**Carrier Frequency

**Table 9. Downconversion Output Spur Levels (dBc), $F_{SPUR} = |M \bullet f_{IN} + N \bullet f_{LO}|$**
($f_{IN}$ = 5.8GHz, $P_{IN}$ = –12dBm, $f_{LO}$ = 5.0GHz, $P_{LO}$ = 0dBm, $V_{CC}$ = 3.3V, $f_{OUT}$ = 800MHz

| | | N | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| M | 0 | – | –41.6 | –15.7 | –59.5 | –39.6 | * |
| | 1 | –53.7 | –34.4** | –71.4 | * | * | * |
| | 2 | –65.8 | < –75 | * | * | * | * |
| | 3 | < –75 | * | * | * | * | * |
| | 4 | * | * | * | * | * | * |
| | 5 | * | * | * | * | * | * |

*Out of Range for Test Equipment
**Image Frequency

# TYPICAL APPLICATIONS

The following examples illustrate the wide ranging capabilities of the LTC5562, with performance in both up mixing and down mixing applications shown. These circuits were evaluated using the board layouts shown in Figures 3(a) and 3(b).

## Upconverter with 2.45GHz Output

In this example, the LTC5562 was evaluated for an application with the input frequency at 140MHz, an RF output of 2.45GHz and low side LO injection. The schematic is shown in Figure 16 and the Gain, NF and OIP3 performance vs Input Frequency is shown in Figure 17. Also, for port matching data refer to Figures 5, 8 and 12.

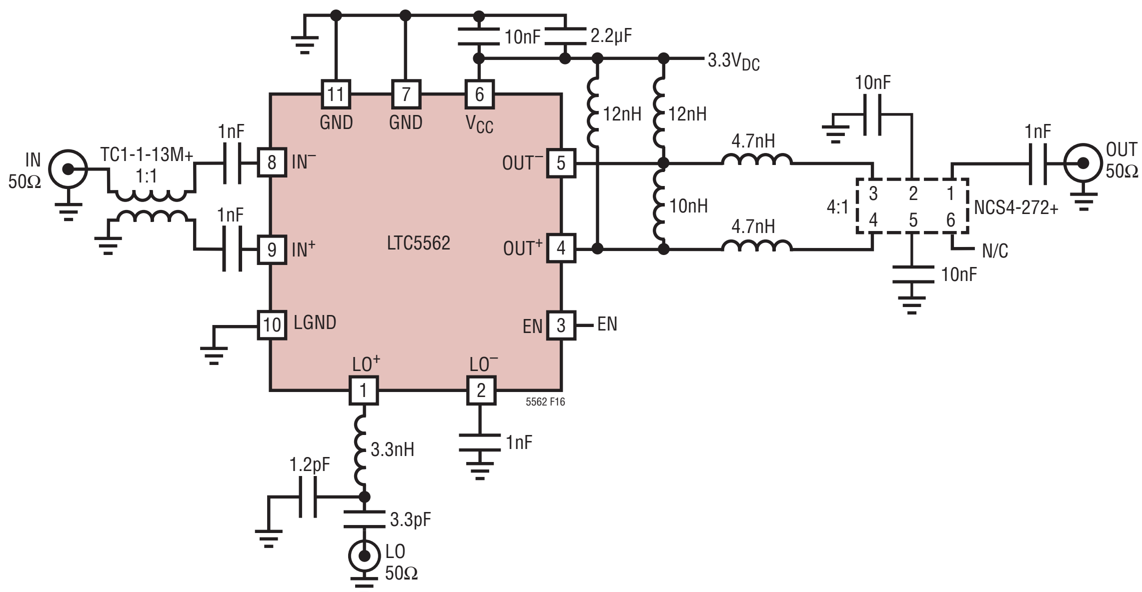



**Figure 16. Upconverter Schematic with 2.45GHz Output**

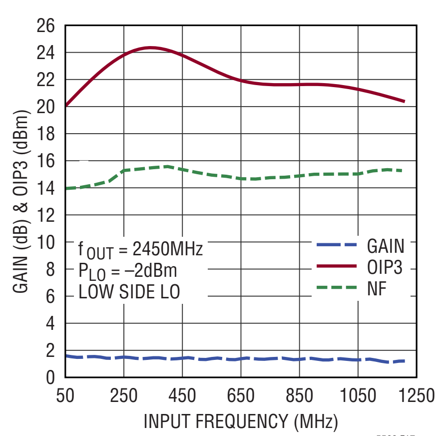



**Figure 17. Gain, Noise Figure and OIP3 vs Input Frequency in the 2.45GHz Application**

# TYPICAL APPLICATIONS

## LTC5562 Phase Detector

The output of the LTC5562 is DC-coupled and differential, therefore, it is suitable to be used as a phase detector with a positive or a negative response. The schematic is shown in Figure 18 and the phase detector gain and phase response with positive slope is shown in Figure 19 for a 200MHz input frequency. In this application, a 5V supply voltage is used to accommodate the voltage drop across the resistor network R1, R2 and R3 while providing the proper bias for the OUT pins. The EN pin is connected directly to $V_{CC}$ to prevent exceeding the ABS MAX limit when powered down The IN and LO ports are matched between 20MHz to 600MHz, however, the LTC5562 can be used as a phase detector at higher frequencies with proper matching. The LTC5562 has a low 1/f corner and a low thermal noise floor. Refer to the Electrical Characteristics table for typical noise floor specifications.

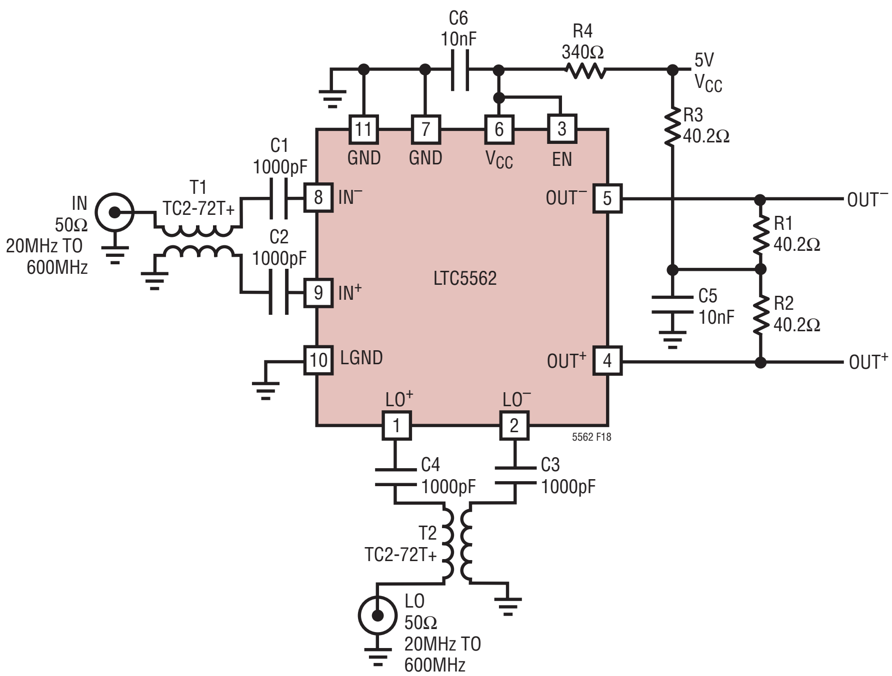



**Figure 18. Phase Detector Test Schematic**

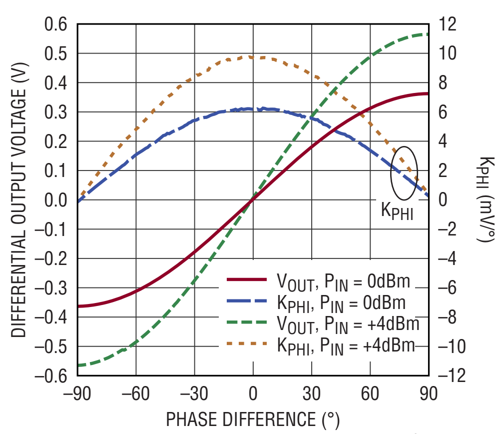



**Figure 19. Phase Detector DC Output and Gain vs Phase**
**$f_{IN} = f_{LO} = 200MHz$, $P_{LO} = 0dBm$**

## TYPICAL APPLICATIONS

### LTC5562 Low Power Broadband Downconverter with Single-Ended Input

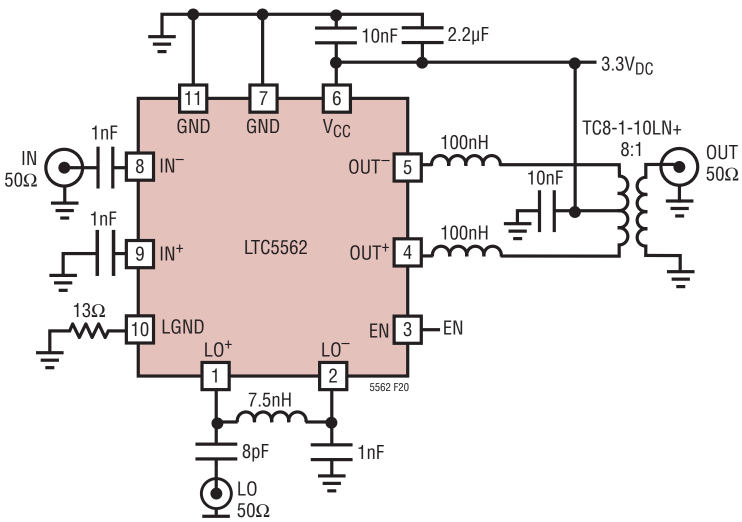



Figure 20. Low Power, Single-Ended Input, Downconverting Mixer

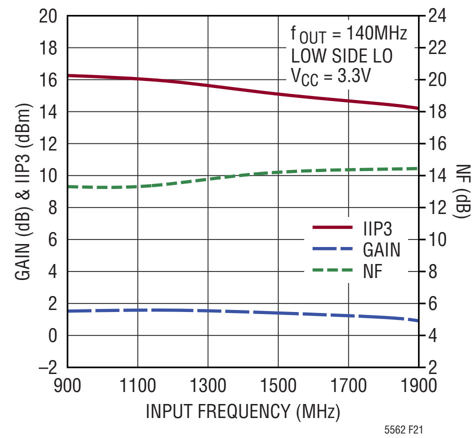



Figure 21. Conversion Gain, IIP3 and NF vs Input Frequency R1 = 13Ω, $I_{TOTAL}$ = 28.5mA, $P_{LO}$ = –2dBm

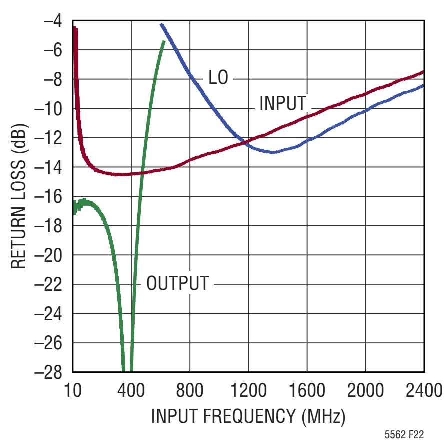



Figure 22. Return Loss vs Frequency R1 = 13Ω, $I_{TOTAL}$ = 28.5mA

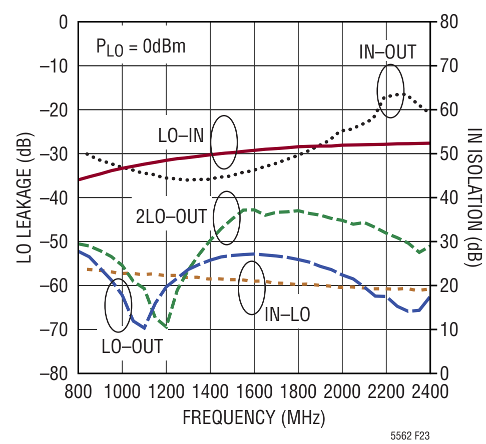
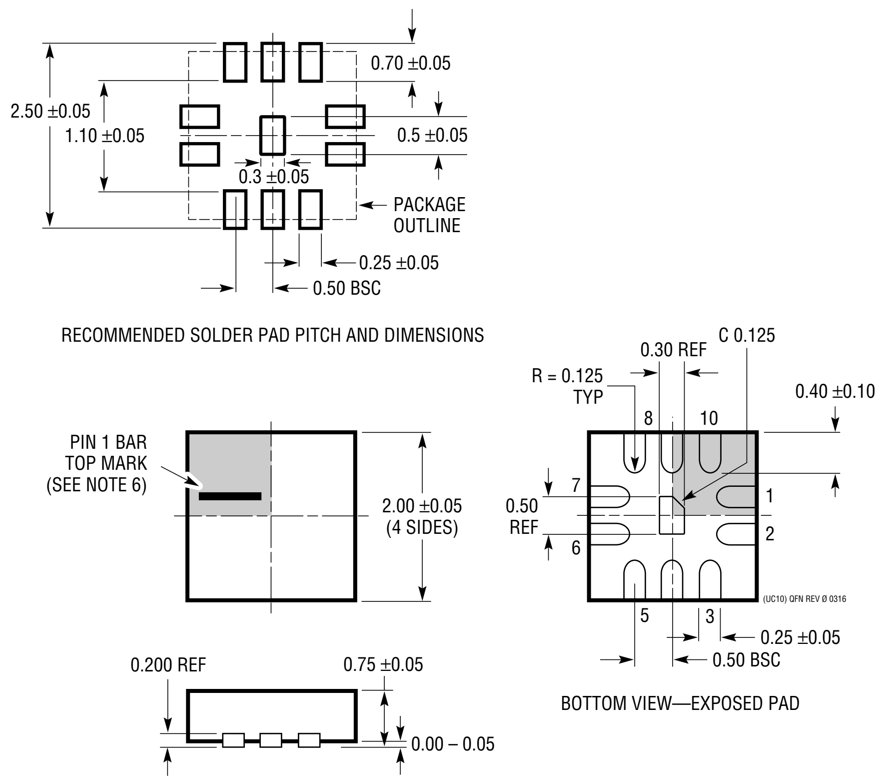



Figure 23. IN Isolation and LO Leakage vs Frequency

# PACKAGE DESCRIPTION

**Please refer to http://www.linear.com/product/LTC5562#packaging for the most recent package drawings.**

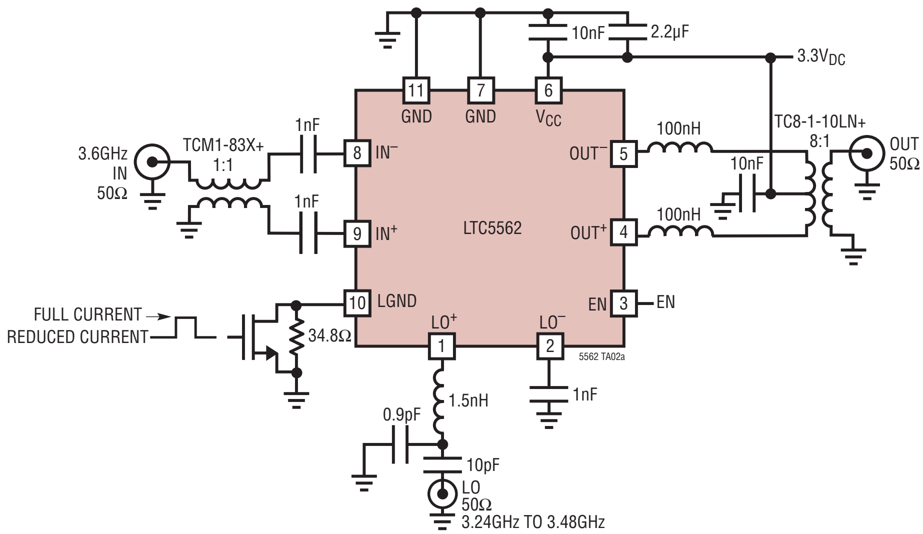
**UC10 Package**
**10-Lead Plastic QFN (2mm × 2mm), Flip Chip**
(Reference LTC DWG # 05-08-1534 Rev Ø)



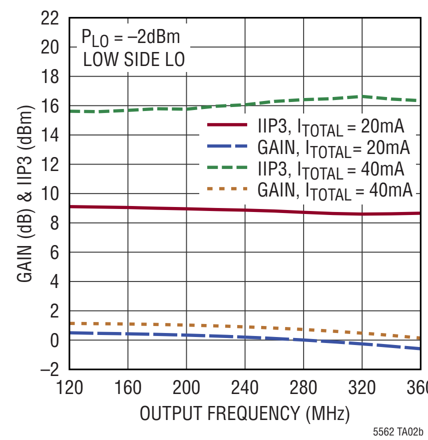

NOTE:
1. DRAWING NOT TO SCALE
2. ALL DIMENSIONS ARE IN MILLIMETERS
3. DIMENSIONS OF EXPOSED PAD ON BOTTOM OF PACKAGE DO NOT INCLUDE MOLD FLASH. MOLD FLASH, IF PRESENT, SHALL NOT EXCEED 0.15mm ON ANY SIDE
4. EXPOSED PAD SHALL BE SOLDER PLATED
5. SHADED AREA IS ONLY A REFERENCE FOR PIN 1 LOCATION ON THE TOP AND BOTTOM OF PACKAGE

# TYPICAL APPLICATION

**3.6GHz Downconverter with Switchable Current**




**Conversion Gain and IIP3 vs Output Frequency, $f_{IN}$ = 3.6GHz**




# RELATED PARTS

| PART NUMBER | DESCRIPTION | COMMENTS |
|---|---|---|
| **Mixers and Modulators** | | |
| LTC5510 | 1MHz to 6GHz Wideband High Linearity Active Mixer | 27dBm OIP3, 1.5dB Gain, Up/Downconversion, 3.3V or 5V Supply, $I_{CC}$ = 105mA |
| LT®5560 | 0.01MHz to 4GHz Low Power Active Mixer | 9dBm IIP3, 2.4dB Gain, Up/Downconversion, 3.3V or 5V Supply, $I_{CC}$ = 10mA |
| LTC5567 | 300MHz to 4GHz, 3.3V Dual Active Downconverting Mixer | 2dB Gain, 26.8dBm IIP3 and 11.7dB NF, 3.3V/180mA Supply |
| LTC5576 | 3GHz to 8GHz High Linearity Active Upconverting Mixer | 25dBm OIP3, –0.6dB Gain, –154dBm/Hz Output Noise Floor, 3.3V or 5V Supply, $I_{CC}$ = 99mA |
| **Amplifiers** | | |
| LTC6430-15 | High Linearity Differential IF Amp | 20MHz to 2GHz Bandwidth, 15.2dB Gain, 50dBm OIP3, 3dB NF at 240MHz |
| LTC6431-15 | High Linearity Single-Ended IF Amp | 20MHz to 1.7GHz Bandwidth, 15.5dB Gain, 47dBm OIP3, 3.3dB NF at 240MHz |
| LTC6412 | 31dB Linear Analog VGA | 35dBm OIP3 at 240MHz, Continuous Gain Range –14dB to 17dB |
| **RF Power Detectors** | | |
| LT5538 | 40MHz to 3.8GHz Log Detector | ±0.8dB Accuracy Over Temperature, –72dBm Sensitivity, 75dB Dynamic Range |
| LT5581 | 6GHz Low Power RMS Detector | 40dB Dynamic Range, ±1dB Accuracy Over Temperature, 1.5mA Supply Current |
| LTC5582 | 40MHz to 10GHz RMS Detector | ±0.5dB Accuracy Over Temperature, ±0.2dB Linearity Error, 57dB Dynamic Range |
| **ADCs** | | |
| LTC2208 | 16-Bit, 130Msps ADC | 78dBFS Noise Floor, >83dB SFDR at 250MHz |
| LTC2153-14 | 14-Bit, 310Msps Low Power ADC | 68.8dBFS SNR, 88dB SFDR, 401mW Power Consumption |
| **RF PLL/Synthesizer with VCO** | | |
| LTC6946-1/ LTC6946-2/ LTC6946-3 | Low Noise, Low Spurious Integer-N PLL with Integrated VCO | 373MHz to 5.79GHz, –157dBc/Hz Wideband Phase Noise Floor, –100dBc/Hz Closed-Loop Phase Noise |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