



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## General Description

The MAX19998 single, high-linearity downconversion mixer provides 8.7dB of conversion gain, +24.3dBm input IP3, +11.3dBm 1dB input compression point, and a noise figure of 9.7dB for 2300MHz to 4000MHz WiMAX™, LTE, and MMDS receiver applications. With an ultra-wide LO 2600MHz to 4300MHz frequency range, the MAX19998 can be used in either low-side or high-side LO injection architectures for virtually all 2.5GHz and 3.5GHz applications. For a 2.5GHz variant tuned specifically for high-side injection, refer to the MAX19996A.

In addition to offering excellent linearity and noise performance, the MAX19998 also yields a high level of component integration. This device includes a double-balanced passive mixer core, an IF amplifier, and an LO buffer. On-chip baluns are also integrated to allow for single-ended RF and LO inputs. The MAX19998 requires a nominal LO drive of 0dBm, and supply current is typically 230mA at  $V_{CC} = 5.0V$  or 150mA at  $V_{CC} = 3.3V$ .

The MAX19998 is pin compatible with the MAX19996/MAX19996A 2000MHz to 3900MHz mixer family. The device is also pin similar with the MAX9984/MAX9986/MAX9986A 400MHz to 1000MHz mixers and the MAX9993/MAX9994/MAX9996 1700MHz to 2200MHz mixers, making this entire family of downconverters ideal for applications where a common PCB layout is used for multiple frequency bands.

The MAX19998 is available in a compact, 5mm x 5mm, 20-pin thin QFN with an exposed pad. Electrical performance is guaranteed over the extended -40°C to +85°C temperature range.

## Applications

2.5GHz WiMAX and LTE Base Stations  
2.7GHz MMDS Base Stations  
3.5GHz WiMAX and LTE Base Stations  
Fixed Broadband Wireless Access  
Wireless Local Loop  
Private Mobile Radios  
Military Systems

## Features

- ◆ 2300MHz to 4000MHz RF Frequency Range
- ◆ 2600MHz to 4300MHz LO Frequency Range
- ◆ 50MHz to 500MHz IF Frequency Range
- ◆ 8.7dB Conversion Gain
- ◆ 9.7dB Noise Figure
- ◆ +24.3dBm Typical Input IP3
- ◆ +11.3dBm Typical Input 1dB Compression Point
- ◆ 67dBc Typical 2RF - 2LO Spurious Rejection at PRF = -10dBm
- ◆ Integrated LO Buffer
- ◆ Integrated RF and LO Baluns for Single-Ended Inputs
- ◆ Low -3dBm to +3dBm LO Drive
- ◆ Pin Compatible with the MAX19996/MAX19996A 2000MHz to 3900MHz Mixers
- ◆ Pin Similar with the MAX9984/MAX9986/MAX9986A Series of 400MHz to 1000MHz Mixers and the MAX9993/MAX9994/MAX9996 Series of 1700MHz to 2200MHz Mixers
- ◆ Single 5.0V or 3.3V Supply
- ◆ External Current-Setting Resistors Provide Option for Operating Device in Reduced-Power/Reduced-Performance Mode

## Ordering Information

| PART          | TEMP RANGE     | PIN-PACKAGE     |
|---------------|----------------|-----------------|
| MAX19998ETP+  | -40°C to +85°C | 20 Thin QFN-EP* |
| MAX19998ETP+T | -40°C to +85°C | 20 Thin QFN-EP* |

+ Denotes a lead(Pb)-free/RoHS-compliant package.

\*EP = Exposed pad.

T = Tape and reel.

WiMAX is a trademark of WiMAX Forum.



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## ABSOLUTE MAXIMUM RATINGS

V<sub>CC</sub> to GND.....-0.3V to +5.5V  
 IF+, IF-, LOBIAS, IFBIAS to GND..... -0.3V to (V<sub>CC</sub> + 0.3V)  
 RF, LO Input Power..... +12dBm  
 RF, LO Current  
 (RF and LO is DC shorted to GND through balun).....50mA  
 Continuous Power Dissipation (Note 1) .....5W

θ<sub>JA</sub> (Notes 2, 3)..... +38°C/W  
 θ<sub>JC</sub> (Notes 1, 3)..... +13°C/W  
 Operating Case Temperature Range  
 (Note 4)..... T<sub>C</sub> = -40°C to +85°C  
 Junction Temperature .....+150°C  
 Storage Temperature Range..... -65°C to +150°C  
 Lead Temperature (soldering, 10s) .....+300°C

**Note 1:** Based on junction temperature  $T_J = T_C + (\theta_{JC} \times V_{CC} \times I_{CC})$ . This formula can be used when the temperature of the exposed pad is known while the device is soldered down to a PCB. See the *Applications Information* section for details. The junction temperature must not exceed +150°C.

**Note 2:** Junction temperature  $T_J = T_A + (\theta_{JA} \times V_{CC} \times I_{CC})$ . This formula can be used when the ambient temperature of the PCB is known. The junction temperature must not exceed +150°C.

**Note 3:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maxim-ic.com/thermal-tutorial](http://www.maxim-ic.com/thermal-tutorial).

**Note 4:** T<sub>C</sub> is the temperature on the exposed pad of the package. T<sub>A</sub> is the ambient temperature of the device and PCB.

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

## 5.0V SUPPLY DC ELECTRICAL CHARACTERISTICS

(Typical Application Circuit, R<sub>1</sub> = 698Ω, R<sub>2</sub> = 604Ω, V<sub>CC</sub> = 4.75V to 5.25V, no input RF or LO signals. T<sub>C</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>CC</sub> = 5.0V, T<sub>C</sub> = +25°C, all parameters are production tested.)

| PARAMETER      | SYMBOL          | CONDITIONS           | MIN  | TYP | MAX  | UNITS |
|----------------|-----------------|----------------------|------|-----|------|-------|
| Supply Voltage | V <sub>CC</sub> |                      | 4.75 | 5.0 | 5.25 | V     |
| Supply Current | I <sub>CC</sub> | Total supply current |      | 230 | 247  | mA    |

## 3.3V SUPPLY DC ELECTRICAL CHARACTERISTICS

(Typical Application Circuit, R<sub>1</sub> = 845Ω, R<sub>2</sub> = 1.1kΩ, V<sub>CC</sub> = 3.0V to 3.6V, no input RF or LO signals. T<sub>C</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>CC</sub> = 3.3V, T<sub>C</sub> = +25°C, parameters are guaranteed by design, unless otherwise noted.) (Note 5)

| PARAMETER      | SYMBOL          | CONDITIONS           | MIN | TYP | MAX | UNITS |
|----------------|-----------------|----------------------|-----|-----|-----|-------|
| Supply Voltage | V <sub>CC</sub> |                      | 3.0 | 3.3 | 3.6 | V     |
| Supply Current | I <sub>CC</sub> | Total supply current |     | 150 |     | mA    |

## RECOMMENDED AC OPERATING CONDITIONS

| PARAMETER          | SYMBOL          | CONDITIONS                                                                                                                                                               | MIN  | TYP | MAX  | UNITS |
|--------------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-----|------|-------|
| RF Frequency Range | f <sub>RF</sub> | (Notes 5, 6)                                                                                                                                                             | 2300 |     | 4000 | MHz   |
| LO Frequency       | f <sub>LO</sub> | (Notes 5, 6)                                                                                                                                                             | 2600 |     | 4300 | MHz   |
| IF Frequency       | f <sub>IF</sub> | Using a Mini-Circuits TC4-1W-17 4:1 transformer as defined in the <i>Typical Application Circuit</i> , IF matching components affect the IF frequency range (Notes 5, 6) | 100  |     | 500  | MHz   |
|                    |                 | Using a Mini-Circuits TC4-1W-7A 4:1 transformer as defined in the <i>Typical Application Circuit</i> , IF matching components affect the IF frequency range (Notes 5, 6) | 50   |     | 250  |       |
| LO Drive           | P <sub>LO</sub> |                                                                                                                                                                          | -3   | 0   | +3   | dBm   |

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## 5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , LOW-SIDE LO INJECTION

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 698\Omega$ ,  $R2 = 604\Omega$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ , RF and LO ports are driven from  $50\Omega$  sources,  $P_{LO} = -3\text{dBm}$  to  $+3\text{dBm}$ ,  $P_{RF} = -5\text{dBm}$ ,  $f_{RF} = 3100\text{MHz}$  to  $3900\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ ,  $f_{LO} = 2800\text{MHz}$  to  $3600\text{MHz}$ ,  $f_{RF} > f_{LO}$ ,  $T_C = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are for  $T_C = +25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $P_{RF} = -5\text{dBm}$ ,  $P_{LO} = 0\text{dBm}$ ,  $f_{RF} = 3500\text{MHz}$ ,  $f_{LO} = 3200\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ . All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

| PARAMETER                               | SYMBOL            | CONDITIONS                                                                                                                                                                                                                               |                                           | MIN   | TYP  | MAX  | UNITS |
|-----------------------------------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------|------|------|-------|
| Small-Signal Conversion Gain            | G <sub>C</sub>    | T <sub>C</sub> = +25°C (Notes 8, 9)                                                                                                                                                                                                      |                                           | 7.6   | 8.7  | 9.4  | dB    |
| Gain Variation vs. Frequency            | ΔG <sub>C</sub>   | f <sub>RF</sub> = 3100MHz to 3900MHz, any 100MHz band                                                                                                                                                                                    |                                           | 0.15  |      |      | dB    |
|                                         |                   | f <sub>RF</sub> = 3100MHz to 3900MHz, any 200MHz band                                                                                                                                                                                    |                                           | 0.3   |      |      |       |
| Conversion Gain Temperature Coefficient | T <sub>CCG</sub>  | f <sub>RF</sub> = 3100MHz to 3900MHz, T <sub>C</sub> = -40°C to +85°C                                                                                                                                                                    |                                           | -0.01 |      |      | dB/°C |
| Input 1dB Compression Point             | IP <sub>1dB</sub> | (Note 10)                                                                                                                                                                                                                                |                                           | 10.0  | 11.4 |      | dBm   |
| Third-Order Input Intercept Point       | IIP3              | f <sub>RF1</sub> - f <sub>RF2</sub> = 1MHz, P <sub>RF1</sub> = P <sub>RF2</sub> = -5dBm/tone, T <sub>C</sub> = +25°C (Note 9)                                                                                                            |                                           | 22    | 24.3 |      | dBm   |
| IIP3 Variation with T <sub>C</sub>      |                   | f <sub>RF</sub> = 3100MHz to 3900MHz, f <sub>RF1</sub> - f <sub>RF2</sub> = 1MHz, P <sub>RF1</sub> = P <sub>RF2</sub> = -5dBm/tone, T <sub>C</sub> = -40°C to +85°C                                                                      |                                           | ±0.2  |      |      | dBm   |
| Single-Sideband Noise Figure            | NF <sub>SSB</sub> | No blockers present (Note 5)                                                                                                                                                                                                             |                                           | 9.7   |      | 12.5 | dB    |
|                                         |                   | No blockers present, T <sub>C</sub> = +25°C (Note 5)                                                                                                                                                                                     |                                           | 9.7   |      | 11.0 |       |
| Noise Figure Temperature Coefficient    | T <sub>CNF</sub>  | Single sideband, no blockers present, T <sub>C</sub> = -40°C to +85°C                                                                                                                                                                    |                                           | 0.018 |      |      | dB/°C |
| Noise Figure Under Blocking             | N <sub>FB</sub>   | +8dBm blocker tone applied to RF port, f <sub>RF</sub> = 3500MHz, f <sub>LO</sub> = 3200MHz, f <sub>BLOCKER</sub> = 3750MHz, P <sub>LO</sub> = 0dBm, V <sub>CC</sub> = +5.0V, T <sub>C</sub> = +25°C (Notes 5, 11)                       |                                           | 21    |      | 25   | dB    |
| 2RF - 2LO Spur Rejection                | 2 x 2             | f <sub>SPUR</sub> = f <sub>LO</sub> + 150MHz                                                                                                                                                                                             | P <sub>RF</sub> = -10dBm (Note 5)         | 63    | 67   |      | dBc   |
|                                         |                   |                                                                                                                                                                                                                                          | P <sub>RF</sub> = -5dBm (Note 9)          | 58    | 62   |      |       |
| 3RF - 3LO Spur Rejection                | 3 x 3             | f <sub>SPUR</sub> = f <sub>LO</sub> + 100MHz                                                                                                                                                                                             | P <sub>RF</sub> = -10dBm (Note 5)         | 80    | 85   |      | dBc   |
|                                         |                   |                                                                                                                                                                                                                                          | P <sub>RF</sub> = -5dBm (Note 9)          | 70    | 75   |      |       |
| RF Input Return Loss                    | RL <sub>RF</sub>  | LO on and IF terminated into a matched impedance                                                                                                                                                                                         |                                           | 25    |      |      | dB    |
| LO Input Return Loss                    | RL <sub>LO</sub>  | RF and IF terminated into a matched impedance                                                                                                                                                                                            |                                           | 16    |      |      | dB    |
| IF Output Impedance                     | Z <sub>IF</sub>   | Nominal differential impedance at the IC's IF outputs                                                                                                                                                                                    |                                           | 200   |      |      | Ω     |
| IF Output Return Loss                   | RL <sub>IF</sub>  | RF terminated into 50Ω, LO driven by 50Ω source, IF transformed to 50Ω using external components shown in the <i>Typical Application Circuit</i> . See the <i>Typical Operating Characteristics</i> for performance vs. inductor values. | f <sub>IF</sub> = 450MHz, L1 = L2 = 120nH | 20    |      |      | dB    |
|                                         |                   |                                                                                                                                                                                                                                          | f <sub>IF</sub> = 350MHz, L1 = L2 = 270nH | 20    |      |      |       |
|                                         |                   |                                                                                                                                                                                                                                          | f <sub>IF</sub> = 300MHz, L1 = L2 = 390nH | 20    |      |      |       |

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## 5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , LOW-SIDE LO INJECTION (continued)

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 698\Omega$ ,  $R2 = 604\Omega$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ , RF and LO ports are driven from  $50\Omega$  sources,  $P_{LO} = -3\text{dBm}$  to  $+3\text{dBm}$ ,  $P_{RF} = -5\text{dBm}$ ,  $f_{RF} = 3100\text{MHz}$  to  $3900\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ ,  $f_{LO} = 2800\text{MHz}$  to  $3600\text{MHz}$ ,  $f_{RF} > f_{LO}$ ,  $T_C = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are for  $T_C = +25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $P_{RF} = -5\text{dBm}$ ,  $P_{LO} = 0\text{dBm}$ ,  $f_{RF} = 3500\text{MHz}$ ,  $f_{LO} = 3200\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ . All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

| PARAMETER              | SYMBOL | CONDITIONS                                                                       | MIN | TYP  | MAX | UNITS |
|------------------------|--------|----------------------------------------------------------------------------------|-----|------|-----|-------|
| RF-to-IF Isolation     |        | $f_{RF} = 3500\text{MHz}$ , $P_{LO} = +3\text{dBm}$ (Note 9)                     | 27  | 29.5 |     | dB    |
| LO Leakage at RF Port  |        | $f_{LO} = 2800\text{MHz}$ to $3600\text{MHz}$ , $P_{LO} = +3\text{dBm}$ (Note 9) |     | -26  |     | dBm   |
| 2LO Leakage at RF Port |        | $P_{LO} = +3\text{dBm}$                                                          |     | -29  |     | dBm   |
| LO Leakage at IF Port  |        | $P_{LO} = +3\text{dBm}$ (Note 9)                                                 |     | -22  |     | dBm   |

## 3.3V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , LOW-SIDE LO INJECTION

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 845\Omega$ ,  $R2 = 1.1\text{k}\Omega$ , RF and LO ports are driven from  $50\Omega$  sources,  $f_{RF} > f_{LO}$ . Typical values are for  $T_C = +25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{V}$ ,  $P_{RF} = -5\text{dBm}$ ,  $P_{LO} = 0\text{dBm}$ ,  $f_{RF} = 3500\text{MHz}$ ,  $f_{LO} = 3200\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ , unless otherwise noted.) (Note 7)

| PARAMETER                               | SYMBOL       | CONDITIONS                                                                                                                      | MIN                      | TYP       | MAX | UNITS                |
|-----------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------|-----|----------------------|
| Small-Signal Conversion Gain            | $G_C$        |                                                                                                                                 |                          | 8.4       |     | dB                   |
| Gain Variation vs. Frequency            | $\Delta G_C$ | $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , any 100MHz band                                                                 |                          | 0.15      |     | dB                   |
| Conversion Gain Temperature Coefficient | $TC_{CG}$    | $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , $T_C = -40^\circ\text{C}$ to $+85^\circ\text{C}$                                |                          | -0.01     |     | dB/ $^\circ\text{C}$ |
| Input 1dB Compression Point             | $IP_{1dB}$   | (Note 10)                                                                                                                       |                          | 7.7       |     | dBm                  |
| Third-Order Input Intercept Point       | $IIP3$       | $f_{RF1} - f_{RF2} = 1\text{MHz}$ , $P_{RF1} = P_{RF2} = -5\text{dBm/ tone}$                                                    |                          | 20.1      |     | dBm                  |
| $IIP3$ Variation with $T_C$             |              | $f_{RF1} - f_{RF2} = 1\text{MHz}$ , $P_{RF1} = P_{RF2} = -5\text{dBm/ tone}$ , $T_C = -40^\circ\text{C}$ to $+85^\circ\text{C}$ |                          | $\pm 0.2$ |     | dB                   |
| Single-Sideband Noise Figure            | $NF_{SSB}$   | No blockers present                                                                                                             |                          | 9.3       |     | dB                   |
| Noise Figure Temperature Coefficient    | $TC_{NF}$    | Single sideband, no blockers present, $T_C = -40^\circ\text{C}$ to $+85^\circ\text{C}$                                          |                          | 0.018     |     | dB/ $^\circ\text{C}$ |
| 2RF - 2LO Spur Rejection                | $2 \times 2$ | $f_{SPUR} = f_{LO} + 150\text{MHz}$                                                                                             | $P_{RF} = -10\text{dBm}$ | 64        |     | dBc                  |
|                                         |              |                                                                                                                                 | $P_{RF} = -5\text{dBm}$  | 59        |     |                      |
| 3RF - 3LO Spur Rejection                | $3 \times 3$ | $f_{SPUR} = f_{LO} + 100\text{MHz}$                                                                                             | $P_{RF} = -10\text{dBm}$ | 74        |     | dBc                  |
|                                         |              |                                                                                                                                 | $P_{RF} = -5\text{dBm}$  | 64        |     |                      |
| RF Input Return Loss                    | $RL_{RF}$    | LO on and IF terminated into a matched impedance                                                                                |                          | 30        |     | dB                   |
| LO Input Return Loss                    | $RL_{LO}$    | RF and IF terminated into a matched impedance                                                                                   |                          | 20        |     | dB                   |
| IF Output Impedance                     | $Z_{IF}$     | Nominal differential impedance at the IC's IF outputs                                                                           |                          | 200       |     | $\Omega$             |

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## 3.3V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , LOW-SIDE LO INJECTION (continued)

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 845\Omega$ ,  $R2 = 1.1k\Omega$ , RF and LO ports are driven from  $50\Omega$  sources,  $f_{RF} > f_{LO}$ . Typical values are for  $T_C = +25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{V}$ ,  $P_{RF} = -5\text{dBm}$ ,  $P_{LO} = 0\text{dBm}$ ,  $f_{RF} = 3500\text{MHz}$ ,  $f_{LO} = 3200\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ , unless otherwise noted.) (Note 7)

| PARAMETER              | SYMBOL    | CONDITIONS                                                                                                                                                                                                                                                     | MIN | TYP   | MAX | UNITS |
|------------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-------|-----|-------|
| IF Output Return Loss  | $RL_{IF}$ | RF terminated into $50\Omega$ , LO driven by $50\Omega$ source, IF transformed to $50\Omega$ using external components shown in the <i>Typical Application Circuit</i> . See the <i>Typical Operating Characteristics</i> for performance vs. inductor values. |     | 17    |     | dB    |
|                        |           | $f_{IF} = 450\text{MHz}$ ,<br>$L1 = L2 = 120\text{nH}$                                                                                                                                                                                                         |     |       |     |       |
|                        |           | $f_{IF} = 350\text{MHz}$ ,<br>$L1 = L2 = 270\text{nH}$                                                                                                                                                                                                         |     | 17    |     |       |
|                        |           | $f_{IF} = 300\text{MHz}$ ,<br>$L1 = L2 = 390\text{nH}$                                                                                                                                                                                                         |     | 17    |     |       |
| RF-to-IF Isolation     |           | $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , $P_{LO} = +3\text{dBm}$                                                                                                                                                                                        |     | 27    |     | dB    |
| LO Leakage at RF Port  |           | $f_{LO} = 2800\text{MHz}$ to $3600\text{MHz}$ , $P_{LO} = +3\text{dBm}$                                                                                                                                                                                        |     | -30   |     | dBm   |
| 2LO Leakage at RF Port |           | $f_{LO} = 2800\text{MHz}$ to $3600\text{MHz}$ , $P_{LO} = +3\text{dBm}$                                                                                                                                                                                        |     | -26.5 |     | dBm   |
| LO Leakage at IF Port  |           | $f_{LO} = 2800\text{MHz}$ to $3600\text{MHz}$ , $P_{LO} = +3\text{dBm}$                                                                                                                                                                                        |     | -27.5 |     | dBm   |

## 5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , HIGH-SIDE LO INJECTION

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 698\Omega$ ,  $R2 = 604\Omega$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ , RF and LO ports are driven from  $50\Omega$  sources,  $P_{LO} = -3\text{dBm}$  to  $+3\text{dBm}$ ,  $P_{RF} = -5\text{dBm}$ ,  $f_{RF} = 3100\text{MHz}$  to  $3900\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ ,  $f_{LO} = 3400\text{MHz}$  to  $4200\text{MHz}$ ,  $f_{RF} < f_{LO}$ ,  $T_C = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are for  $T_C = +25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $P_{RF} = -5\text{dBm}$ ,  $P_{LO} = 0\text{dBm}$ ,  $f_{RF} = 3500\text{MHz}$ ,  $f_{LO} = 3800\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ , unless otherwise noted.) (Note 7)

| PARAMETER                               | SYMBOL       | CONDITIONS                                                                                                                                                                         | MIN                      | TYP       | MAX | UNITS                |
|-----------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|-----------|-----|----------------------|
| Small-Signal Conversion Gain            | $G_C$        | $T_C = +25^\circ\text{C}$                                                                                                                                                          |                          | 8.4       |     | dB                   |
| Gain Variation vs. Frequency            | $\Delta G_C$ | $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , any 100MHz band                                                                                                                    |                          | 0.15      |     | dB                   |
|                                         |              | $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , any 200MHz band                                                                                                                    |                          | 0.3       |     |                      |
| Conversion Gain Temperature Coefficient | $TC_{CG}$    | $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ ,<br>$T_C = -40^\circ\text{C}$ to $+85^\circ\text{C}$                                                                                |                          | -0.01     |     | dB/ $^\circ\text{C}$ |
| Input 1dB Compression Point             | $IP_{1dB}$   | (Note 10)                                                                                                                                                                          |                          | 11.4      |     | dBm                  |
| Third-Order Input Intercept Point       | $IIP3$       | $f_{RF1} - f_{RF2} = 1\text{MHz}$ , $P_{RF1} = P_{RF2} = -5\text{dBm/ tone}$ ,<br>$T_C = +25^\circ\text{C}$                                                                        |                          | 24.8      |     | dBm                  |
| IIP3 Variation with $T_C$               |              | $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , $f_{RF1} - f_{RF2} = 1\text{MHz}$ ,<br>$P_{RF1} = P_{RF2} = -5\text{dBm/ tone}$ , $T_C = -40^\circ\text{C}$ to $+85^\circ\text{C}$ |                          | $\pm 0.2$ |     | dBm                  |
| Single-Sideband Noise Figure            | $NF_{SSB}$   | No blockers present                                                                                                                                                                |                          | 9.8       |     | dB                   |
| Noise Figure Temperature Coefficient    | $TC_{NF}$    | Single sideband, no blockers present,<br>$T_C = -40^\circ\text{C}$ to $+85^\circ\text{C}$                                                                                          |                          | 0.018     |     | dB/ $^\circ\text{C}$ |
| 2LO - 2RF Spur Rejection                | $2 \times 2$ | $f_{SPUR} = f_{LO} - 150\text{MHz}$                                                                                                                                                | $P_{RF} = -10\text{dBm}$ | 70        |     | dBc                  |
|                                         |              |                                                                                                                                                                                    | $P_{RF} = -5\text{dBm}$  | 65        |     |                      |
| 3LO - 3RF Spur Rejection                | $3 \times 3$ | $f_{SPUR} = f_{LO} - 100\text{MHz}$                                                                                                                                                | $P_{RF} = -10\text{dBm}$ | 89        |     | dBc                  |
|                                         |              |                                                                                                                                                                                    | $P_{RF} = -5\text{dBm}$  | 79        |     |                      |

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## 5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF} = 3100\text{MHz}$ to $3900\text{MHz}$ , HIGH-SIDE LO INJECTION (continued)

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 698\Omega$ ,  $R2 = 604\Omega$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ , RF and LO ports are driven from  $50\Omega$  sources,  $P_{LO} = -3\text{dBm}$  to  $+3\text{dBm}$ ,  $P_{RF} = -5\text{dBm}$ ,  $f_{RF} = 3100\text{MHz}$  to  $3900\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ ,  $f_{LO} = 3400\text{MHz}$  to  $4200\text{MHz}$ ,  $f_{RF} < f_{LO}$ ,  $T_C = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are for  $T_C = +25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $P_{RF} = -5\text{dBm}$ ,  $P_{LO} = 0\text{dBm}$ ,  $f_{RF} = 3500\text{MHz}$ ,  $f_{LO} = 3800\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ , unless otherwise noted.) (Note 7)

| PARAMETER              | SYMBOL    | CONDITIONS                                                                                                                                                                                                                                      | MIN                                                    | TYP   | MAX | UNITS    |
|------------------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-------|-----|----------|
| RF Input Return Loss   | $RL_{RF}$ | LO on and IF terminated into a matched impedance                                                                                                                                                                                                |                                                        | 24    |     | dB       |
| LO Input Return Loss   | $RL_{LO}$ | RF and IF terminated into a matched impedance                                                                                                                                                                                                   |                                                        | 18    |     | dB       |
| IF Output Impedance    | $Z_{IF}$  | Nominal differential impedance at the IC's IF outputs                                                                                                                                                                                           |                                                        | 200   |     | $\Omega$ |
| IF Output Return Loss  | $RL_{IF}$ | RF terminated into $50\Omega$ , LO driven by $50\Omega$ source, IF transformed to $50\Omega$ using external components shown in the Typical Application Circuit. See the Typical Operating Characteristics for performance vs. inductor values. | $f_{IF} = 450\text{MHz}$ ,<br>$L1 = L2 = 120\text{nH}$ | 20    |     | dB       |
|                        |           |                                                                                                                                                                                                                                                 | $f_{IF} = 350\text{MHz}$ ,<br>$L1 = L2 = 270\text{nH}$ | 20    |     |          |
|                        |           |                                                                                                                                                                                                                                                 | $f_{IF} = 300\text{MHz}$ ,<br>$L1 = L2 = 390\text{nH}$ | 20    |     |          |
| RF-to-IF Isolation     |           | $P_{LO} = +3\text{dBm}$                                                                                                                                                                                                                         |                                                        | 30    |     | dB       |
| LO Leakage at RF Port  |           | $P_{LO} = +3\text{dBm}$                                                                                                                                                                                                                         |                                                        | -30.3 |     | dBm      |
| 2LO Leakage at RF Port |           | $P_{LO} = +3\text{dBm}$                                                                                                                                                                                                                         |                                                        | -19   |     | dBm      |
| LO Leakage at IF Port  |           | $P_{LO} = +3\text{dBm}$                                                                                                                                                                                                                         |                                                        | -23   |     | dBm      |

## 5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF} = 2300\text{MHz}$ to $2900\text{MHz}$ , HIGH-SIDE LO INJECTION

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 698\Omega$ ,  $R2 = 604\Omega$ ,  $V_{CC} = 4.75\text{V}$  to  $5.25\text{V}$ , RF and LO ports are driven from  $50\Omega$  sources,  $P_{LO} = -3\text{dBm}$  to  $+3\text{dBm}$ ,  $P_{RF} = -5\text{dBm}$ ,  $f_{RF} = 2300\text{MHz}$  to  $2900\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ ,  $f_{LO} = 2600\text{MHz}$  to  $3200\text{MHz}$ ,  $f_{RF} < f_{LO}$ ,  $T_C = -40^\circ\text{C}$  to  $+85^\circ\text{C}$ . Typical values are for  $T_C = +25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $P_{RF} = -5\text{dBm}$ ,  $P_{LO} = 0\text{dBm}$ ,  $f_{RF} = 2600\text{MHz}$ ,  $f_{LO} = 2900\text{MHz}$ ,  $f_{IF} = 300\text{MHz}$ , unless otherwise noted.) (Note 7)

| PARAMETER                               | SYMBOL      | CONDITIONS                                                                                                  | MIN | TYP   | MAX | UNITS                |
|-----------------------------------------|-------------|-------------------------------------------------------------------------------------------------------------|-----|-------|-----|----------------------|
| Small-Signal Conversion Gain            | GC          | $T_C = +25^\circ\text{C}$                                                                                   |     | 8.4   |     | dB                   |
| Gain Variation vs. Frequency            | $\Delta GC$ | $f_{RF} = 2300\text{MHz}$ to $2900\text{MHz}$ , any 100MHz band                                             |     | 0.15  |     | dB                   |
|                                         |             | $f_{RF} = 2300\text{MHz}$ to $2900\text{MHz}$ , any 200MHz band                                             |     | 0.3   |     |                      |
| Conversion Gain Temperature Coefficient | $TC_{CG}$   | $f_{RF} = 2300\text{MHz}$ to $2900\text{MHz}$ ,<br>$T_C = -40^\circ\text{C}$ to $+85^\circ\text{C}$         |     | -0.01 |     | dB/ $^\circ\text{C}$ |
| Input 1dB Compression Point             | $IP_{1dB}$  | (Note 10)                                                                                                   |     | 11.4  |     | dBm                  |
| Third-Order Input Intercept Point       | IIP3        | $f_{RF1} - f_{RF2} = 1\text{MHz}$ , $P_{RF1} = P_{RF2} = -5\text{dBm/ tone}$ ,<br>$T_C = +25^\circ\text{C}$ |     | 25.0  |     | dBm                  |

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## 5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS— $f_{RF}$ = 2300MHz to 2900MHz, HIGH-SIDE LO INJECTION (continued)

(Typical Application Circuit, with tuning elements outlined in Table 1,  $R1 = 698\Omega$ ,  $R2 = 604\Omega$ ,  $V_{CC} = 4.75V$  to  $5.25V$ , RF and LO ports are driven from  $50\Omega$  sources,  $P_{LO} = -3dBm$  to  $+3dBm$ ,  $PRF = -5dBm$ ,  $f_{RF} = 2300MHz$  to  $2900MHz$ ,  $f_{IF} = 300MHz$ ,  $f_{LO} = 2600MHz$  to  $3200MHz$ ,  $f_{RF} < f_{LO}$ ,  $T_C = -40^\circ C$  to  $+85^\circ C$ . Typical values are for  $T_C = +25^\circ C$ ,  $V_{CC} = 5.0V$ ,  $PRF = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $f_{RF} = 2600MHz$ ,  $f_{LO} = 2900MHz$ ,  $f_{IF} = 300MHz$ , unless otherwise noted. (Note 7)

| PARAMETER                            | SYMBOL          | CONDITIONS                                                                                                                                                                                                                                                     |                                       | MIN | TYP       | MAX | UNITS          |
|--------------------------------------|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|-----|-----------|-----|----------------|
| IIP3 Variation with $T_C$            |                 | $f_{RF} = 2300MHz$ to $2900MHz$ , $f_{RF1} - f_{RF2} = 1MHz$ , $PRF1 = PRF2 = -5dBm/ tone$ , $T_C = -40^\circ C$ to $+85^\circ C$                                                                                                                              |                                       |     | $\pm 0.2$ |     | dBm            |
| Single-Sideband Noise Figure         | NFSSB           | No blockers present                                                                                                                                                                                                                                            |                                       |     | 10.0      |     | dB             |
| Noise Figure Temperature Coefficient | TCNF            | Single sideband, no blockers present, $T_C = -40^\circ C$ to $+85^\circ C$                                                                                                                                                                                     |                                       |     | 0.018     |     | dB/ $^\circ C$ |
| 2LO - 2RF Spur Rejection             | 2 x 2           | $f_{SPUR} = f_{LO} - 50MHz$                                                                                                                                                                                                                                    | $PRF = -10dBm$                        |     | 77        |     | dBc            |
|                                      |                 |                                                                                                                                                                                                                                                                | $PRF = -5dBm$                         |     | 72        |     |                |
| 3LO - 3RF Spur Rejection             | 3 x 3           | $f_{SPUR} = f_{LO} - 100MHz$                                                                                                                                                                                                                                   | $PRF = -10dBm$                        |     | 86        |     | dBc            |
|                                      |                 |                                                                                                                                                                                                                                                                | $PRF = -5dBm$                         |     | 76        |     |                |
| RF Input Return Loss                 | RLRF            | LO on and IF terminated into a matched impedance                                                                                                                                                                                                               |                                       |     | 30        |     | dB             |
| LO Input Return Loss                 | RLLO            | RF and IF terminated into a matched impedance                                                                                                                                                                                                                  |                                       |     | 18        |     | dB             |
| IF Output Impedance                  | Z <sub>IF</sub> | Nominal differential impedance at the IC's IF outputs                                                                                                                                                                                                          |                                       |     | 200       |     | $\Omega$       |
| IF Output Return Loss                | RLIF            | RF terminated into $50\Omega$ , LO driven by $50\Omega$ source, IF transformed to $50\Omega$ using external components shown in the <i>Typical Application Circuit</i> . See the <i>Typical Operating Characteristics</i> for performance vs. inductor values. | $f_{IF} = 450MHz$ , $L1 = L2 = 120nH$ |     | 25        |     | dB             |
|                                      |                 |                                                                                                                                                                                                                                                                | $f_{IF} = 350MHz$ , $L1 = L2 = 270nH$ |     | 25        |     |                |
|                                      |                 |                                                                                                                                                                                                                                                                | $f_{IF} = 300MHz$ , $L1 = L2 = 390nH$ |     | 25        |     |                |
| RF-to-IF Isolation                   |                 | $P_{LO} = +3dBm$                                                                                                                                                                                                                                               |                                       |     | 45        |     | dB             |
| LO Leakage at RF Port                |                 | $P_{LO} = +3dBm$                                                                                                                                                                                                                                               |                                       |     | -28.8     |     | dBm            |
| 2LO Leakage at RF Port               |                 | $P_{LO} = +3dBm$                                                                                                                                                                                                                                               |                                       |     | -42.3     |     | dBm            |
| LO Leakage at IF Port                |                 | $P_{LO} = +3dBm$                                                                                                                                                                                                                                               |                                       |     | -26.3     |     | dBm            |

**Note 5:** Not production tested.

**Note 6:** Operation outside this range is possible, but with degraded performance of some parameters. See the *Typical Operating Characteristics*.

**Note 7:** All limits reflect losses of external components, including a 0.8dB loss at  $f_{IF} = 300MHz$  due to the 4:1 impedance transformer. Output measurements were taken at IF outputs of the *Typical Application Circuit*.

**Note 8:** Guaranteed by design and characterization.

**Note 9:** 100% production tested for functional performance.

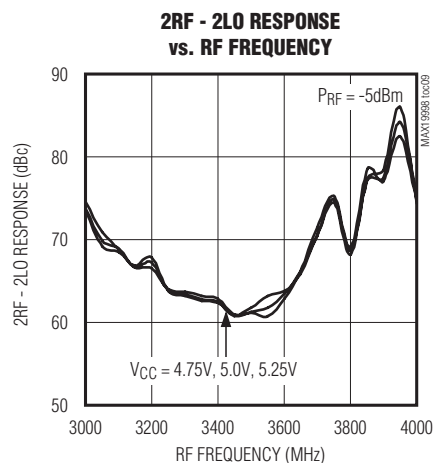
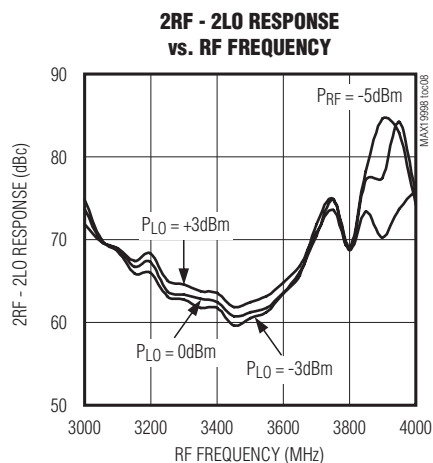
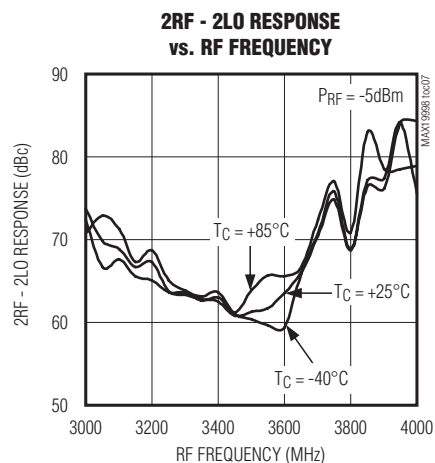
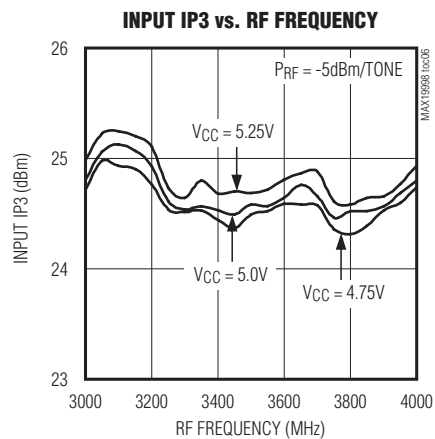
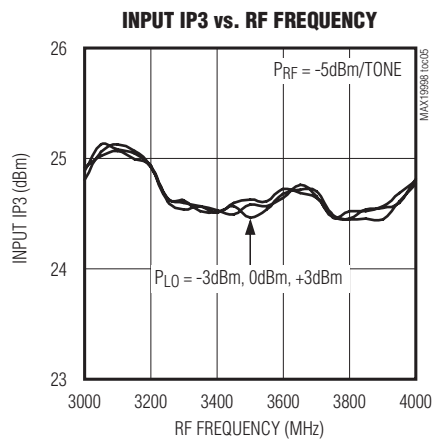
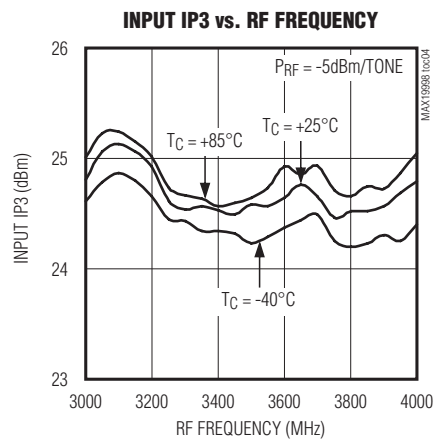
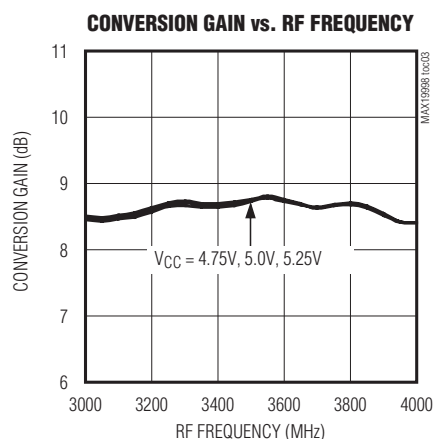
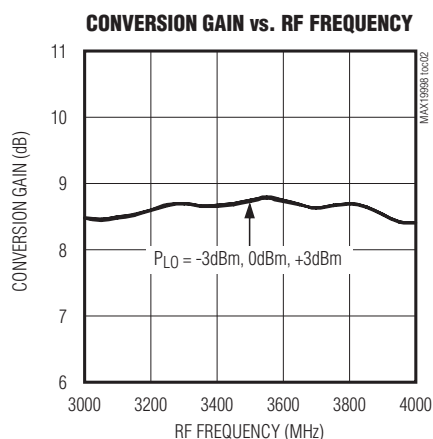
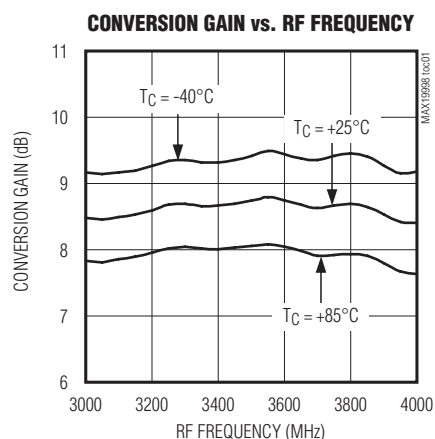
**Note 10:** Maximum reliable continuous input power applied to the RF port of this device is  $+12dBm$  from a  $50\Omega$  source.

**Note 11:** Measured with external LO source noise filtered so that the noise floor is  $-174dBm/Hz$ . This specification reflects the effects of all SNR degradations in the mixer including the LO noise, as defined in Application Note 2021: *Specifications and Measurement of Local Oscillator Noise in Integrated Circuit Base Station Mixers*.

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics

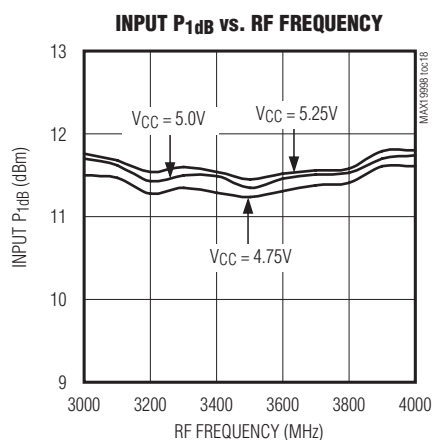
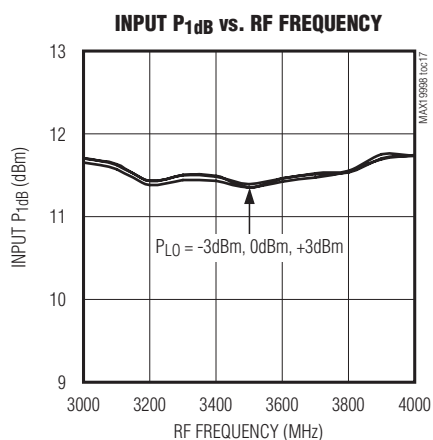
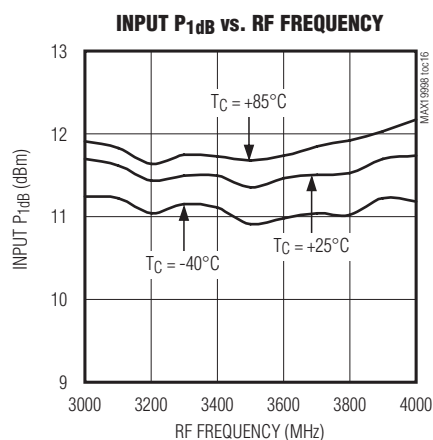
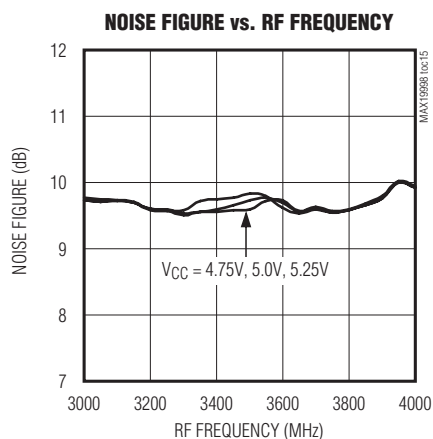
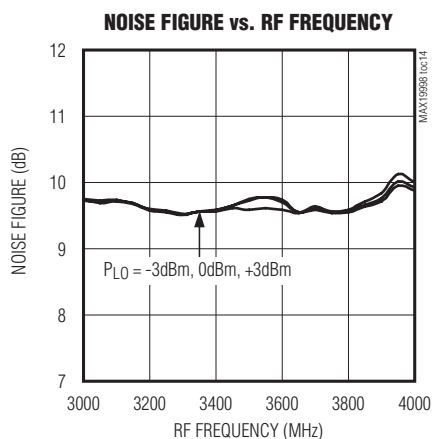
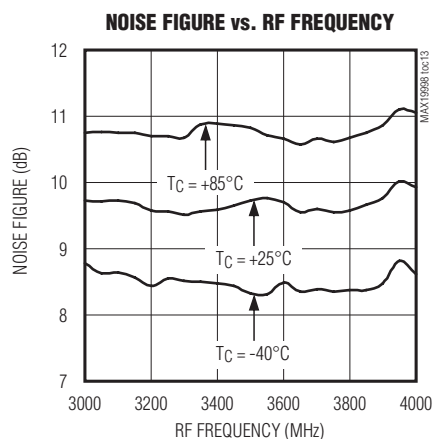
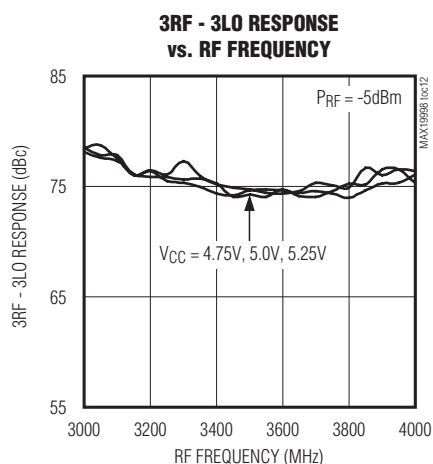
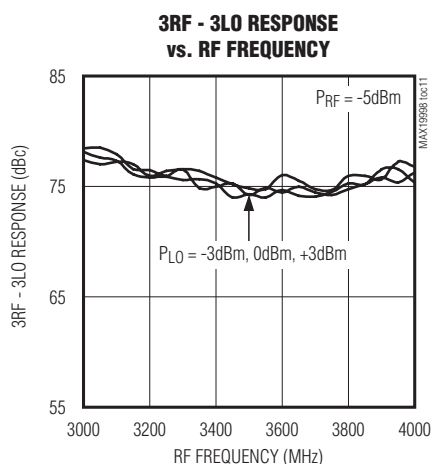
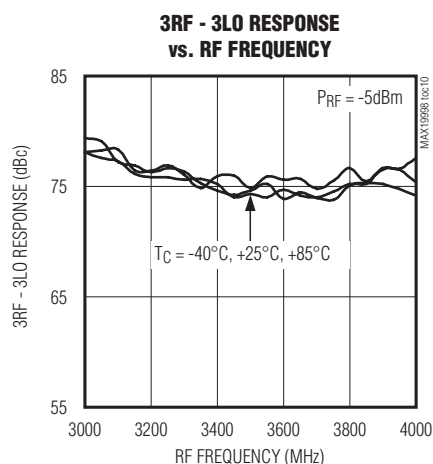
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

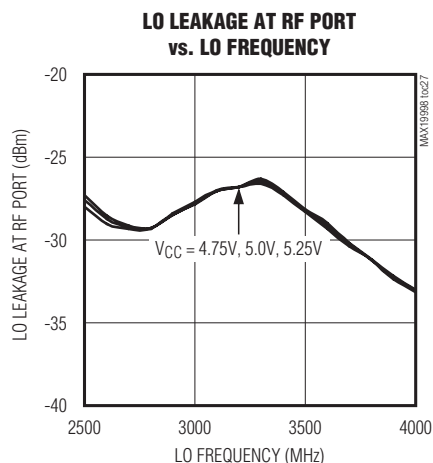
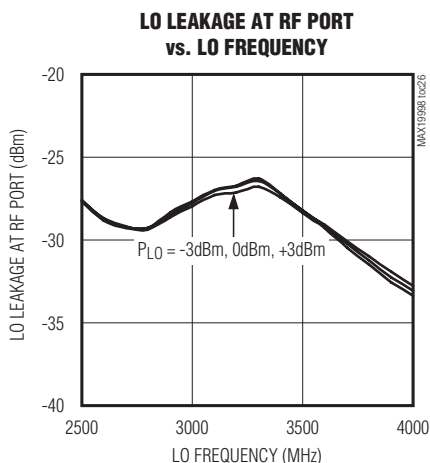
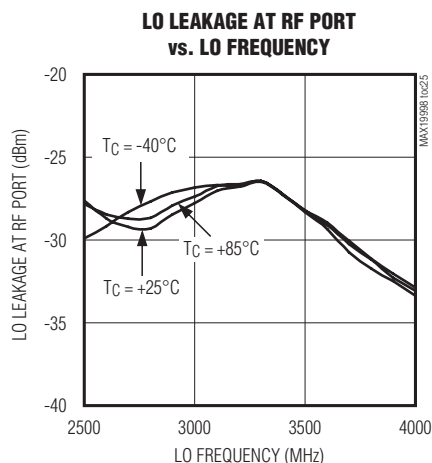
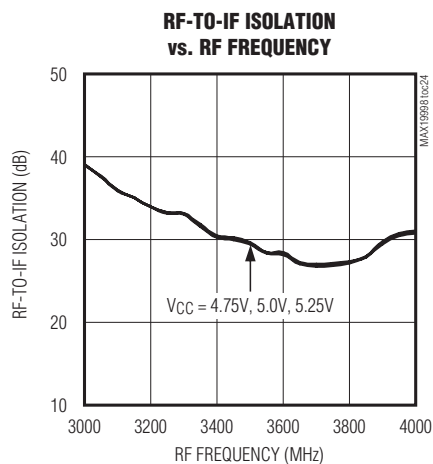
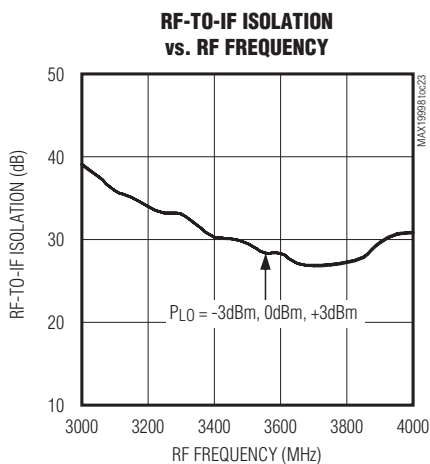
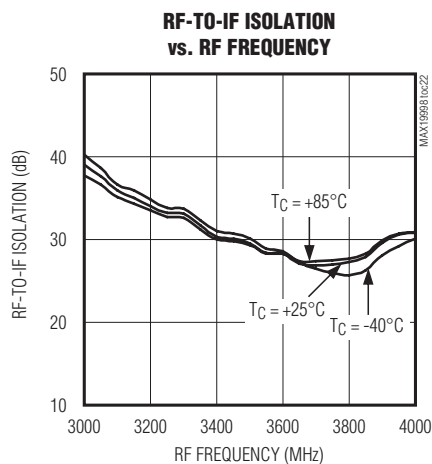
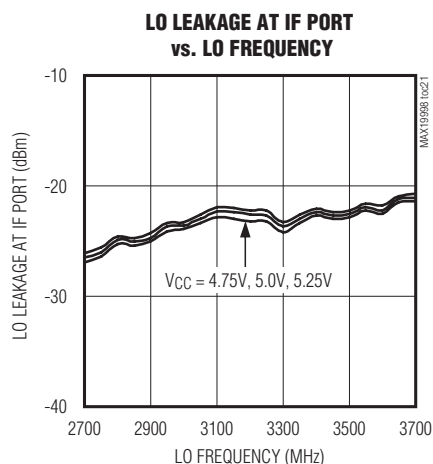
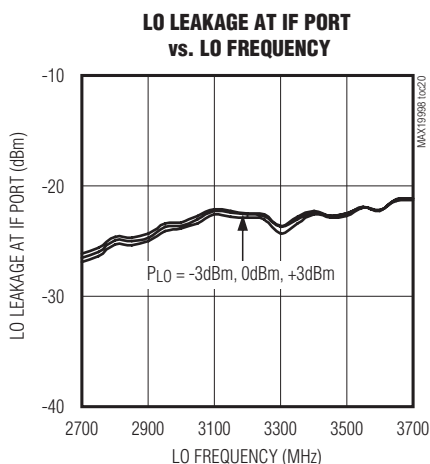
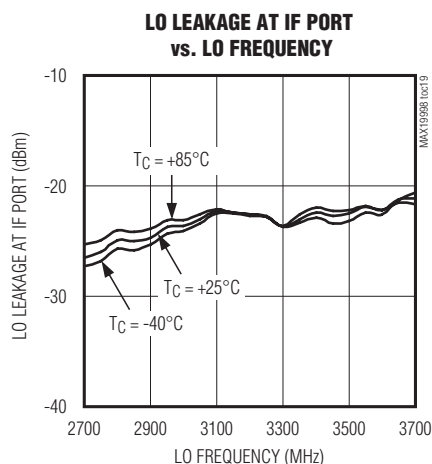
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

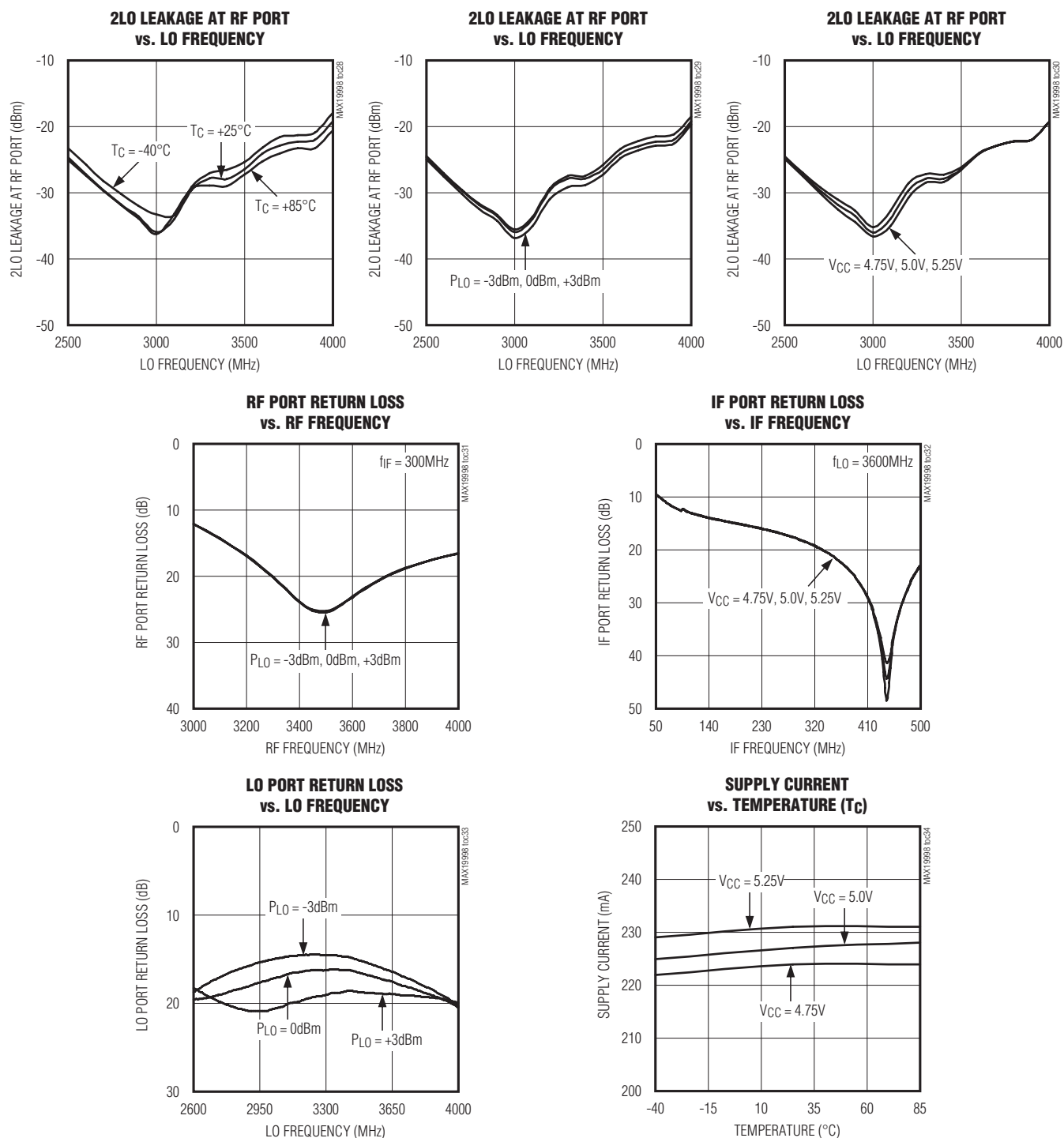
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

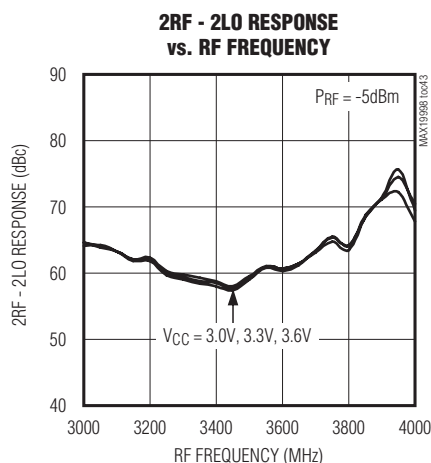
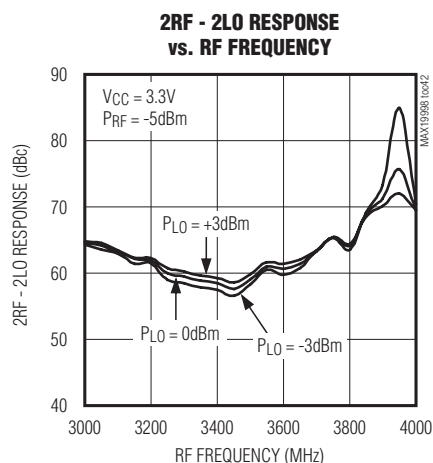
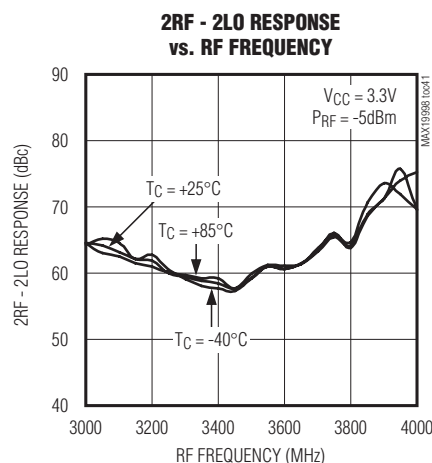
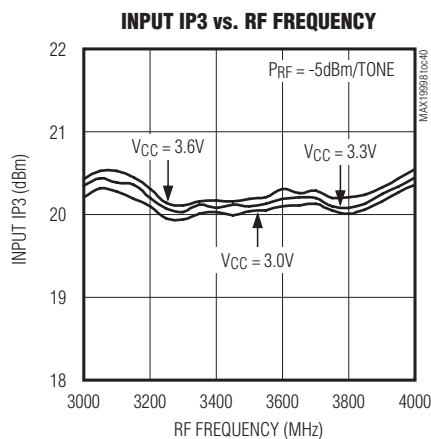
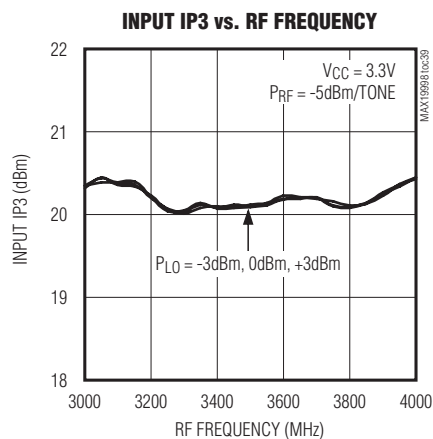
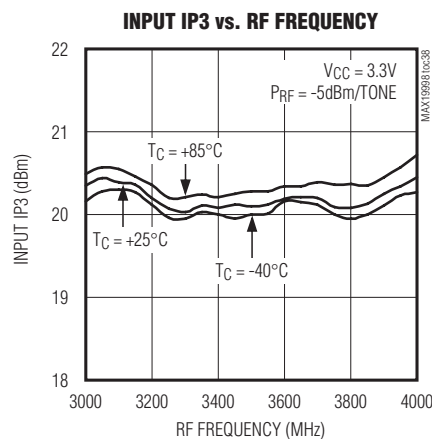
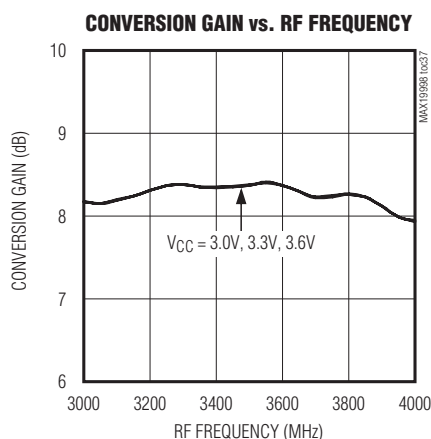
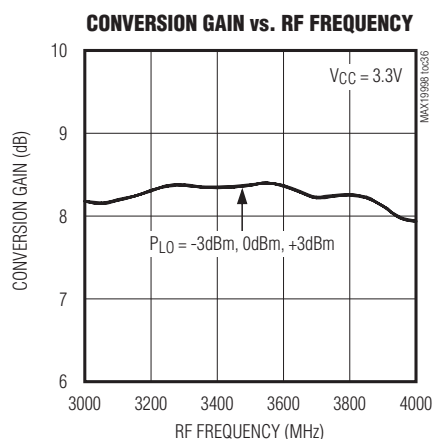
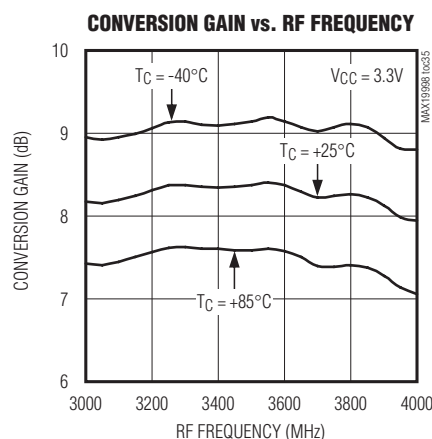
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

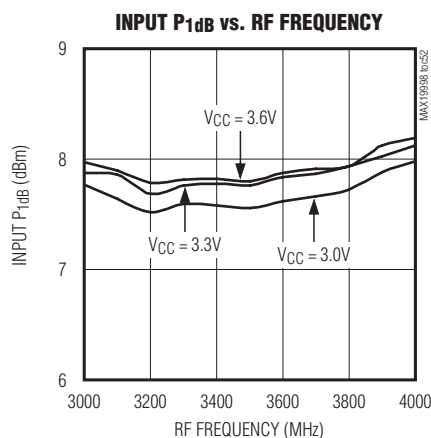
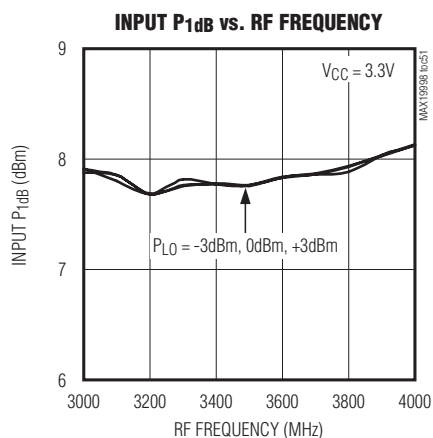
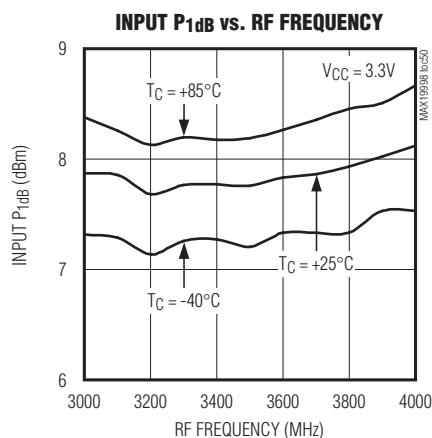
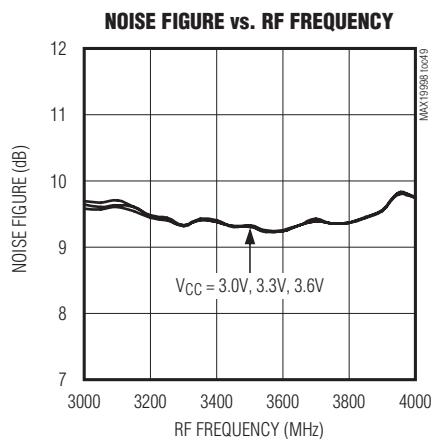
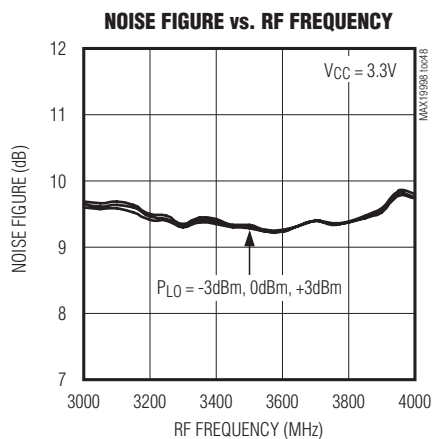
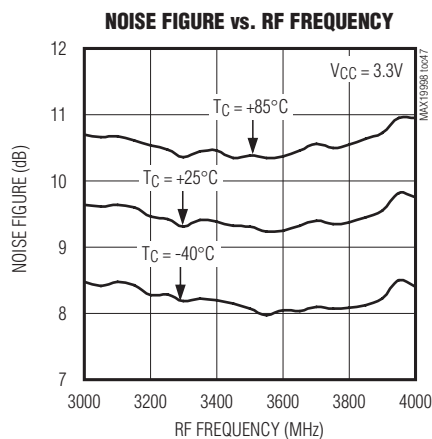
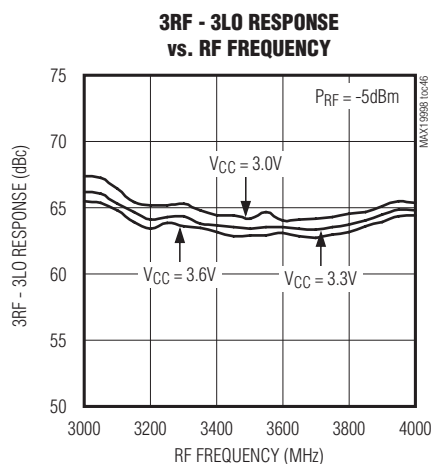
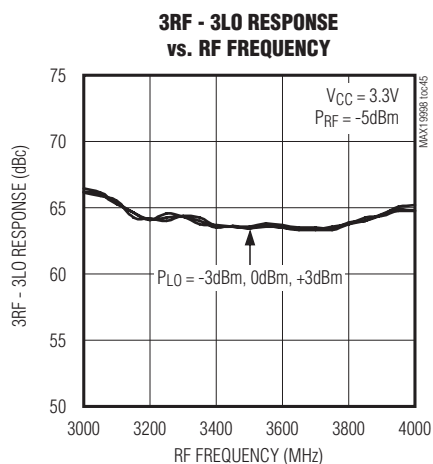
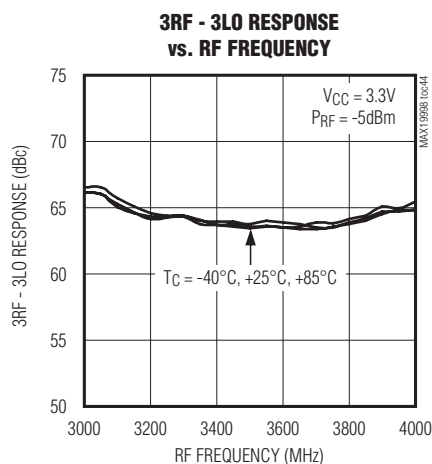
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 3.3V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

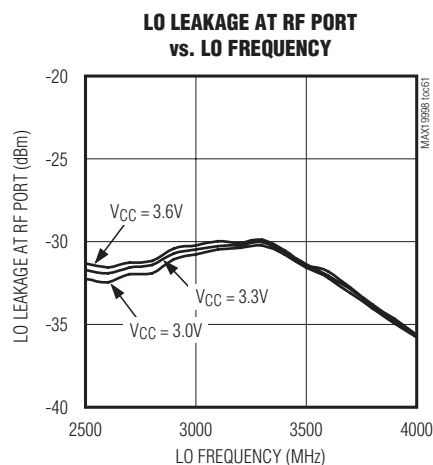
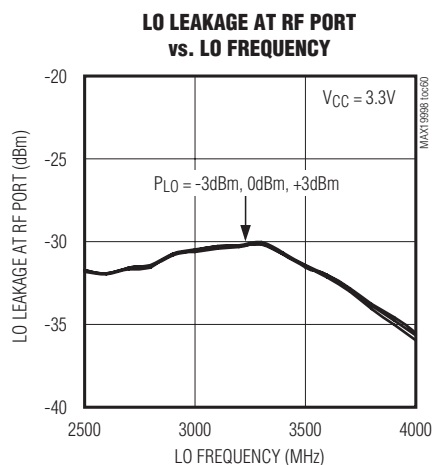
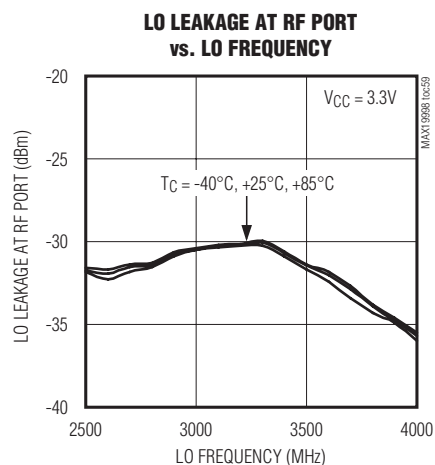
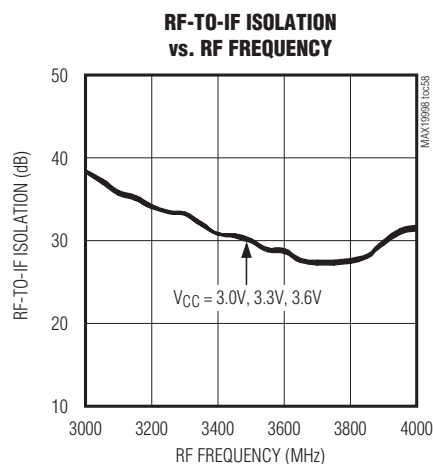
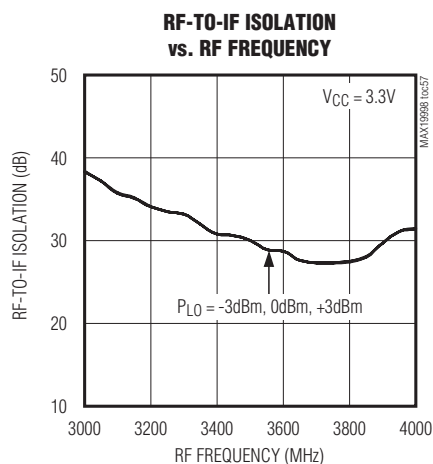
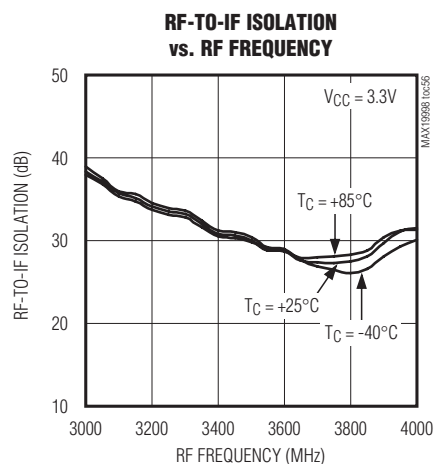
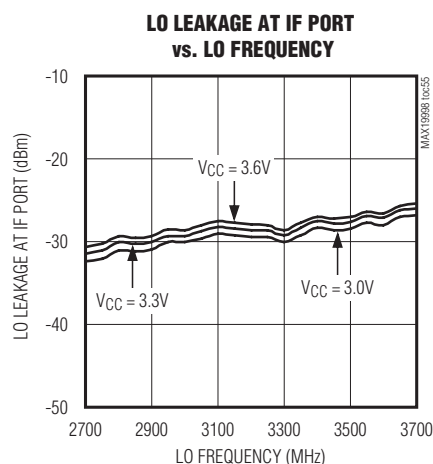
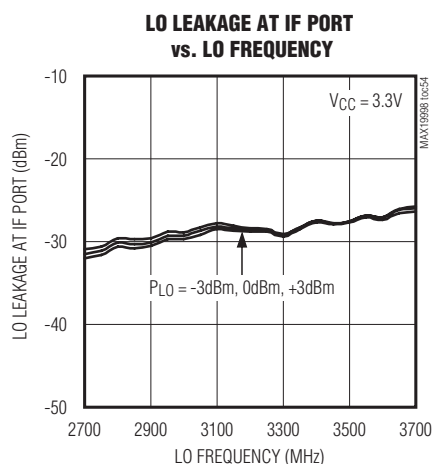
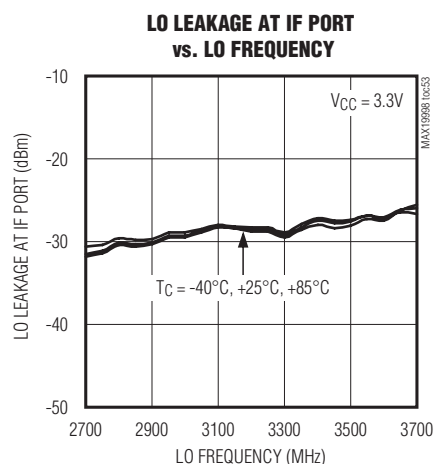
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 3.3V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

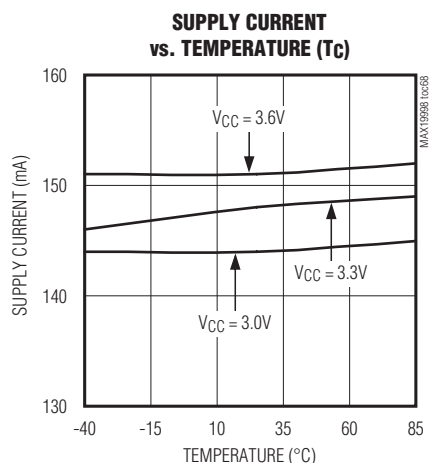
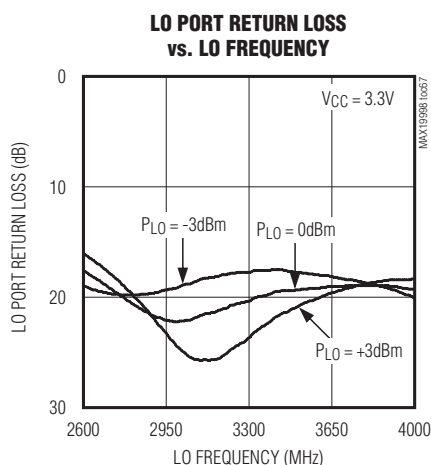
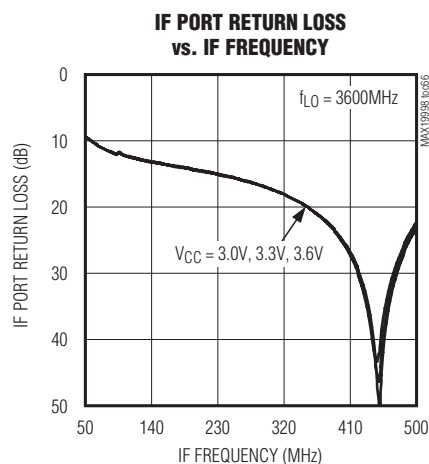
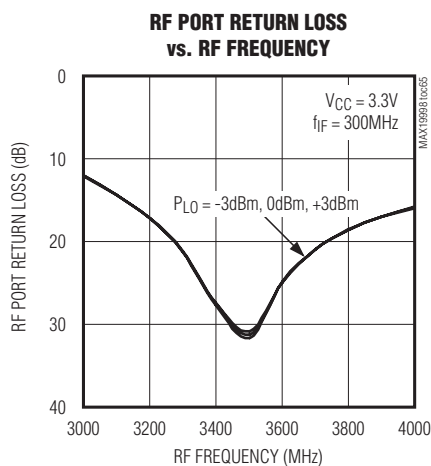
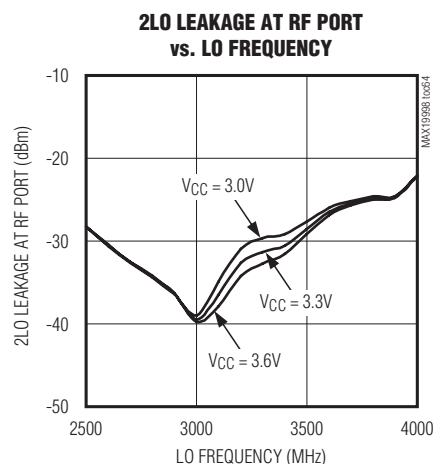
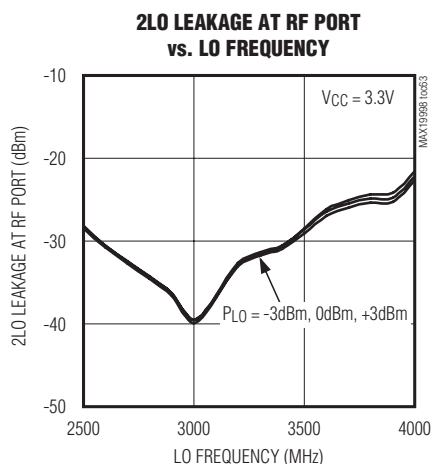
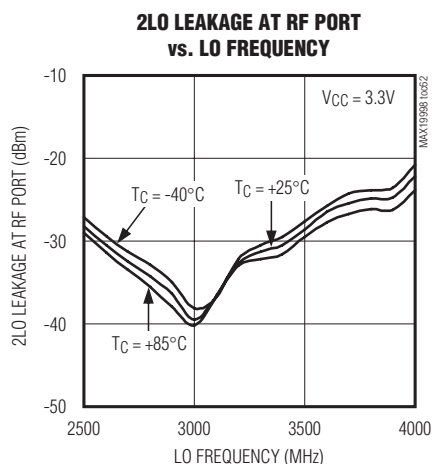
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 3.3V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

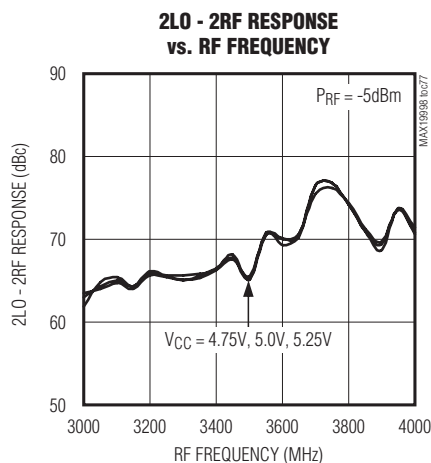
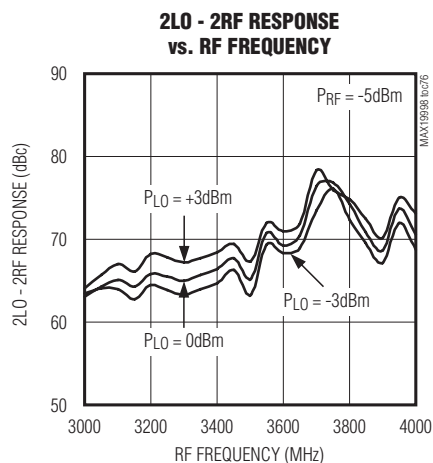
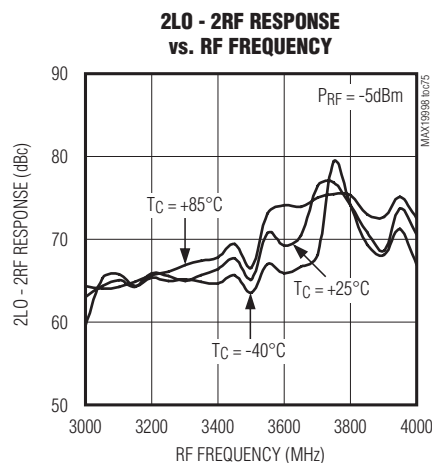
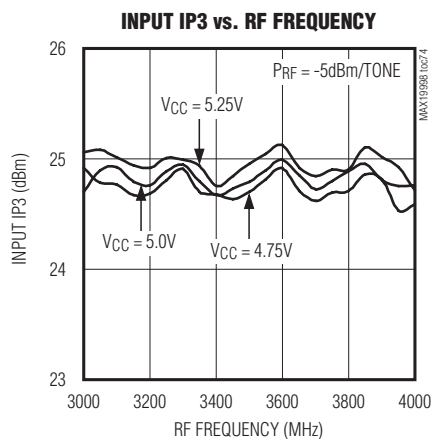
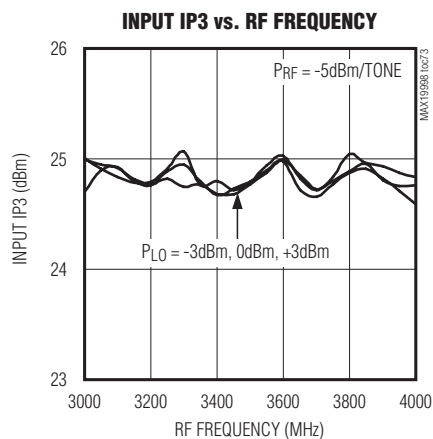
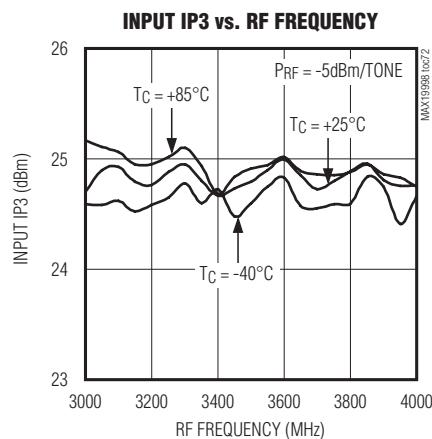
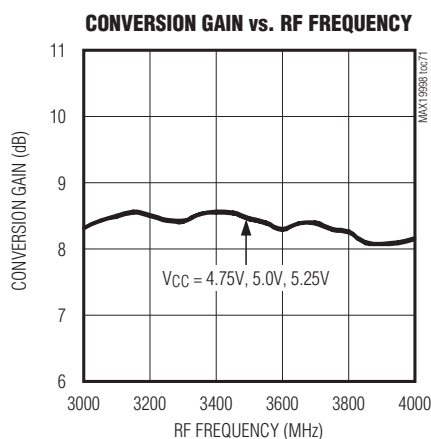
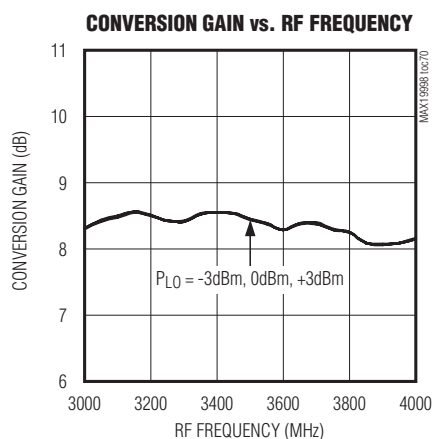
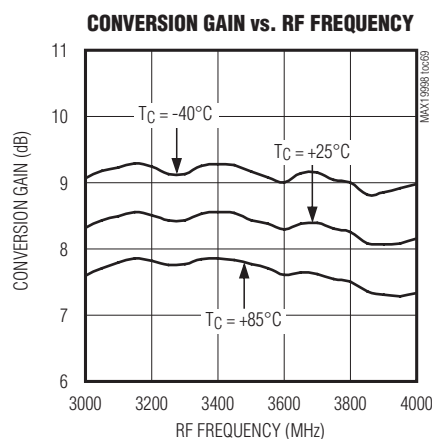
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 3.3V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is low-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

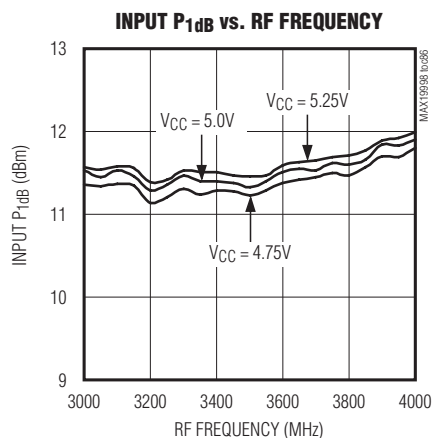
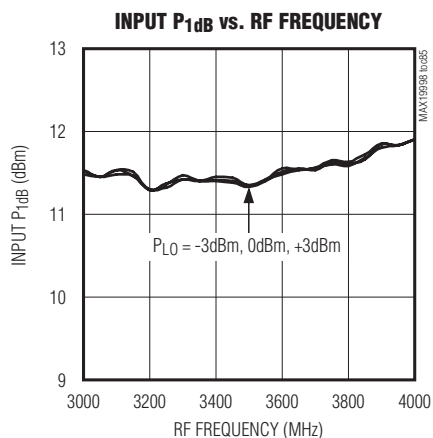
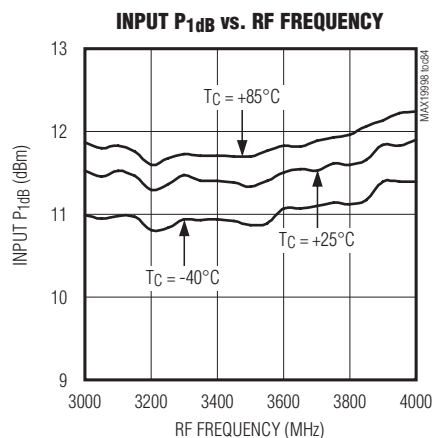
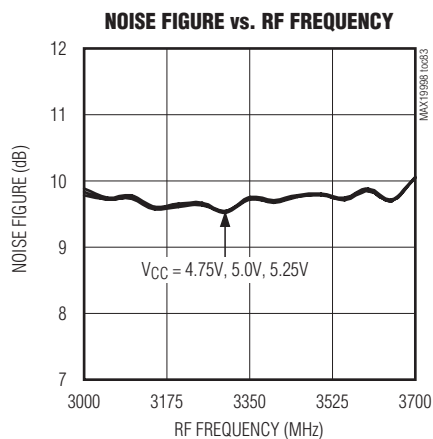
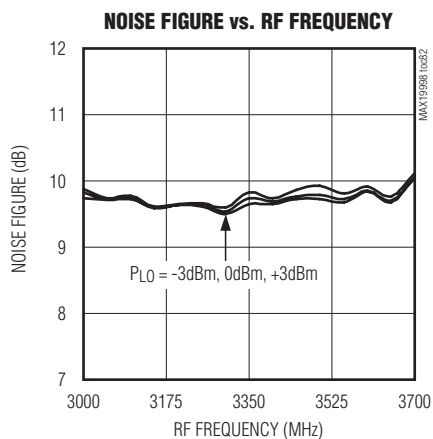
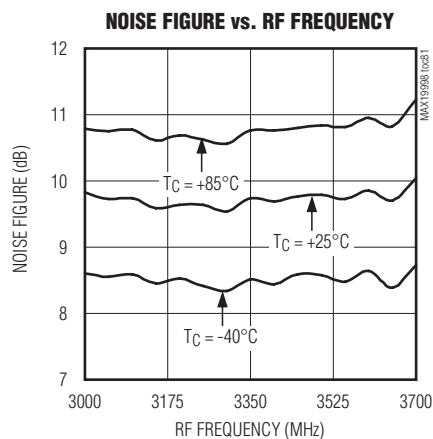
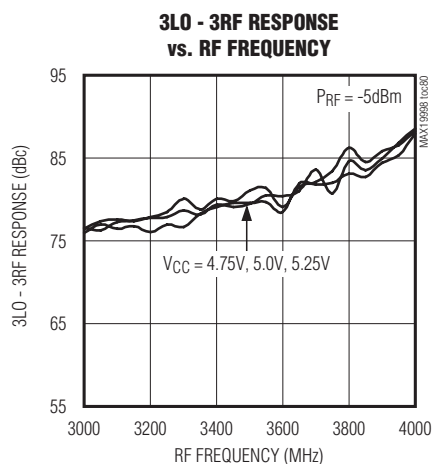
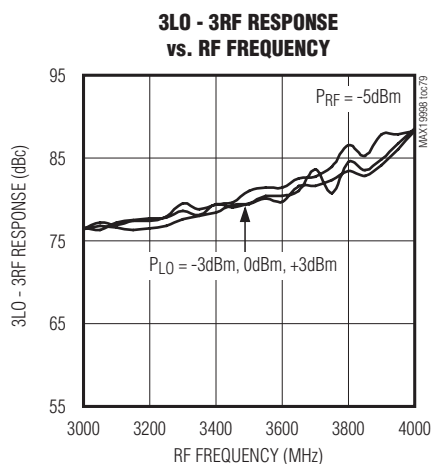
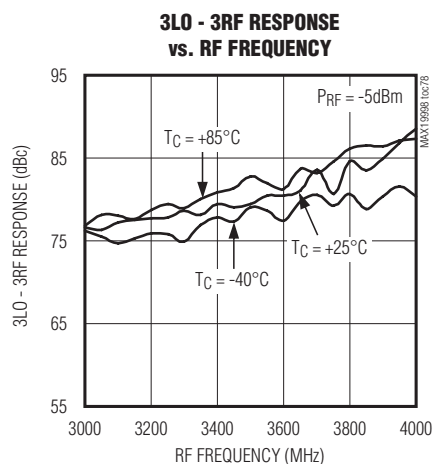
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

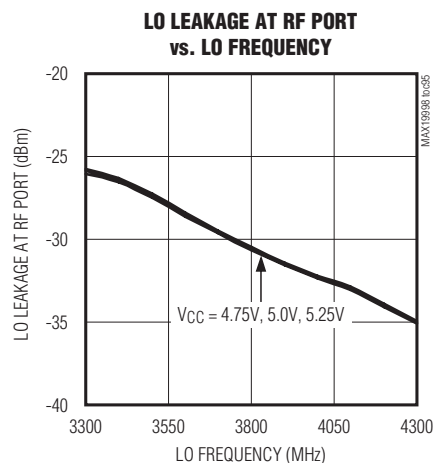
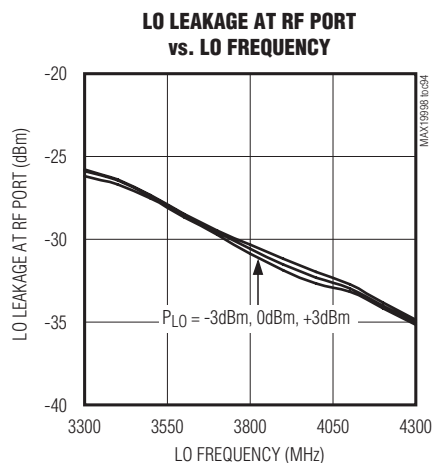
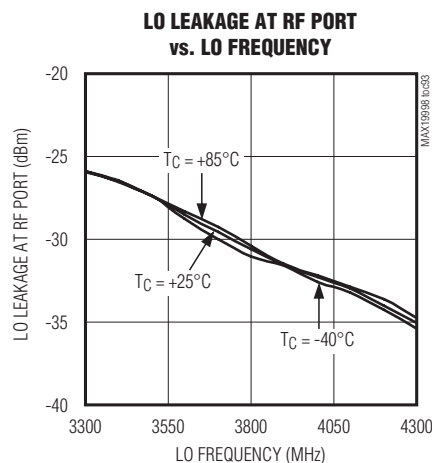
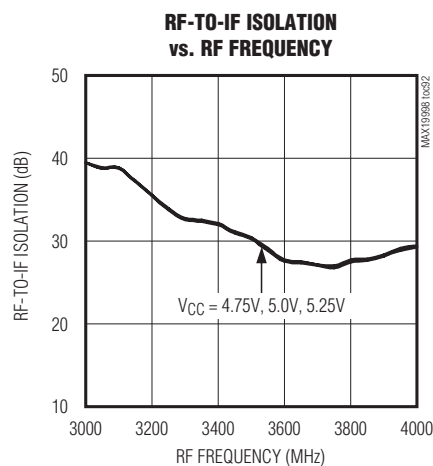
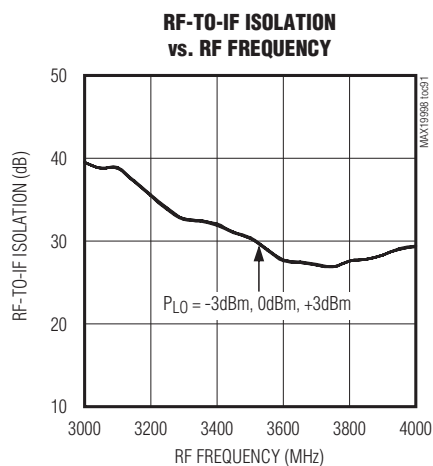
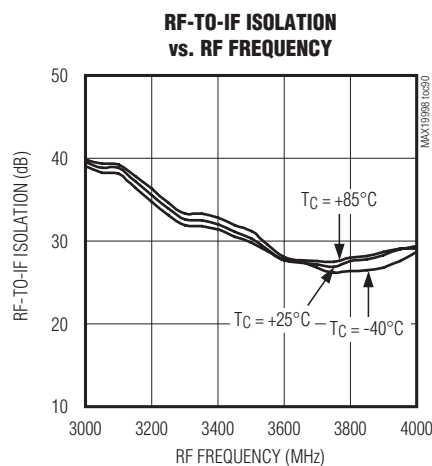
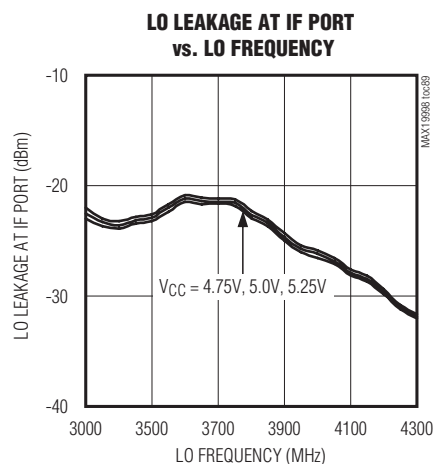
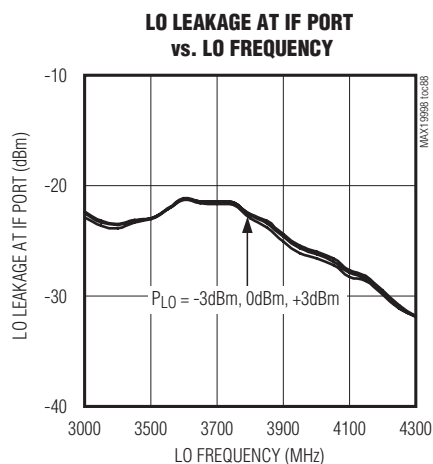
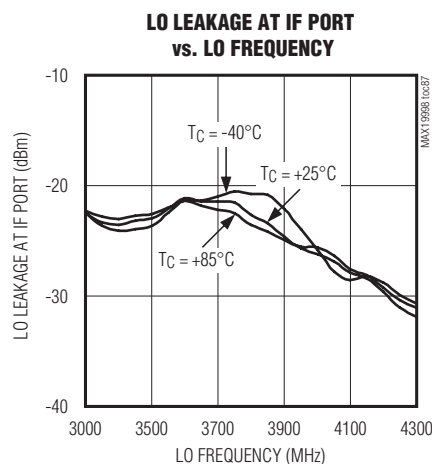
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

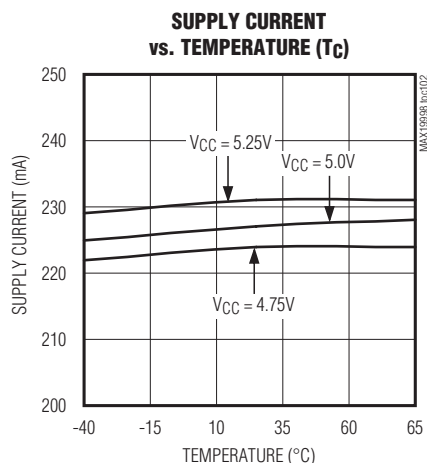
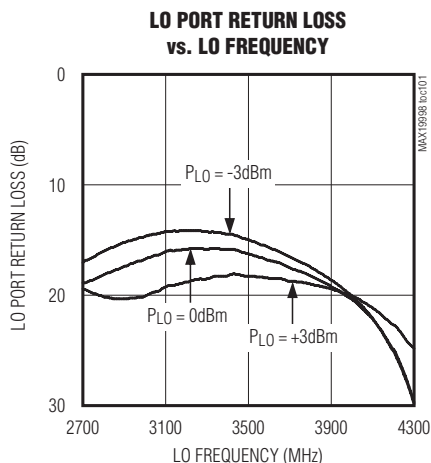
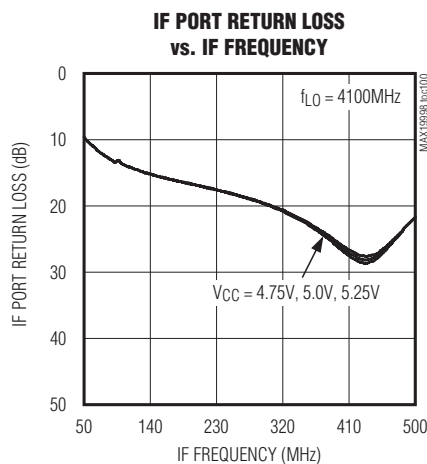
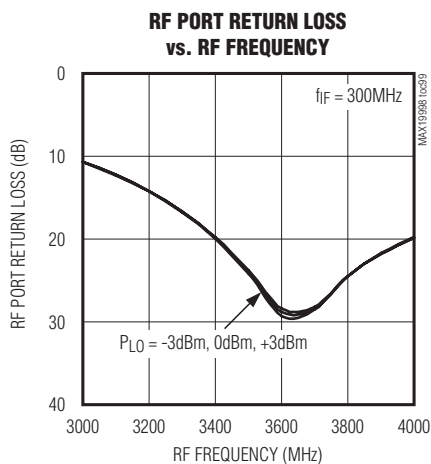
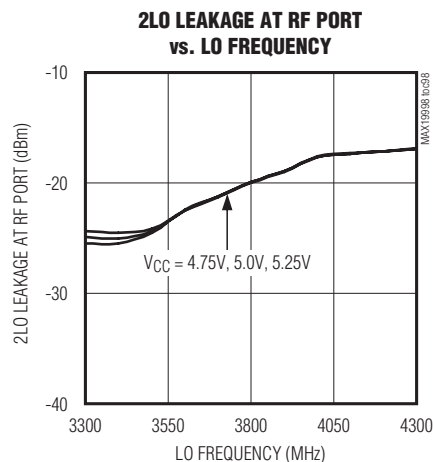
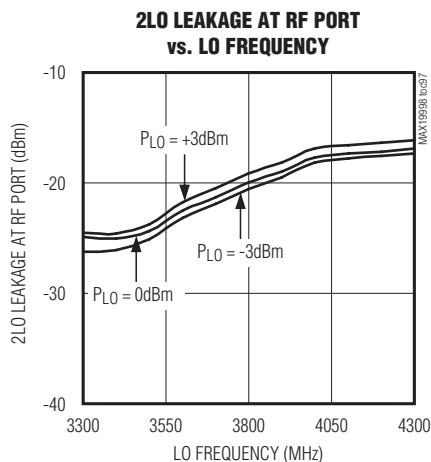
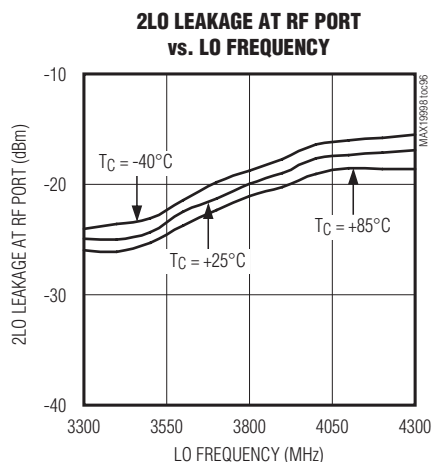
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

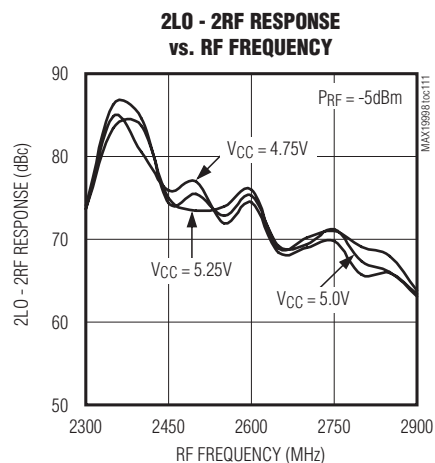
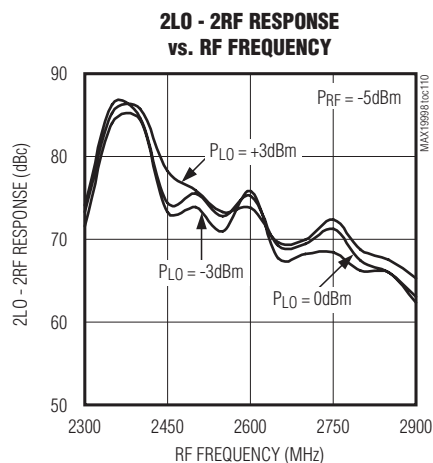
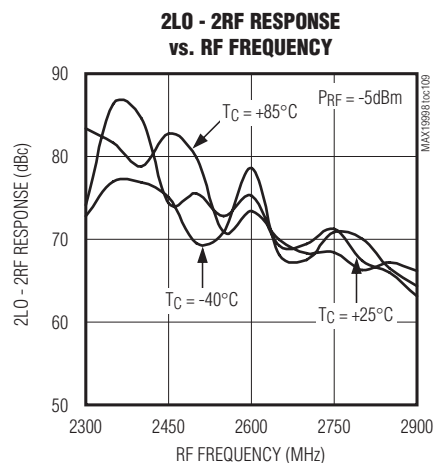
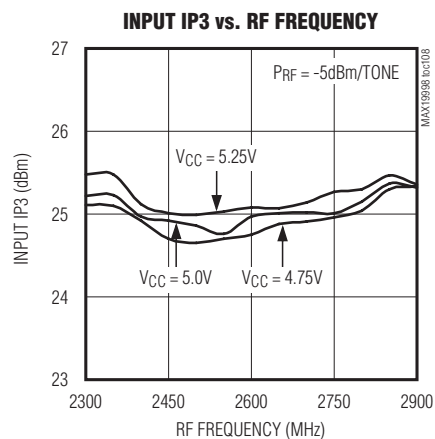
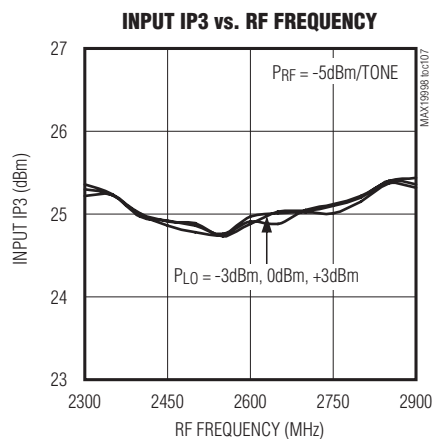
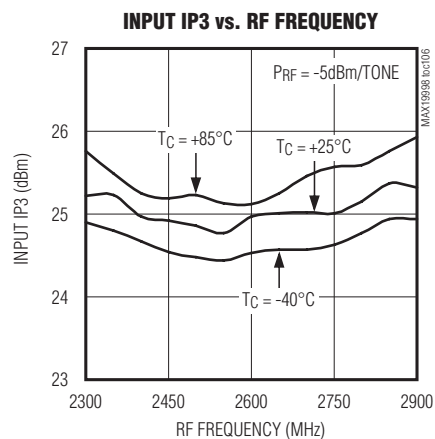
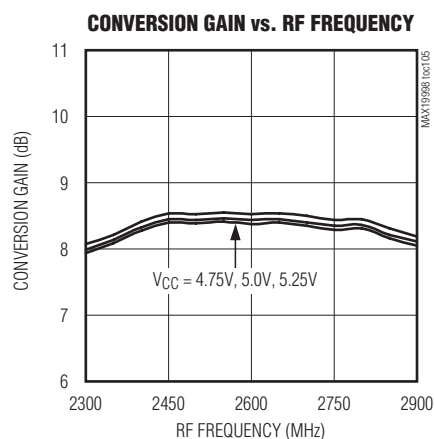
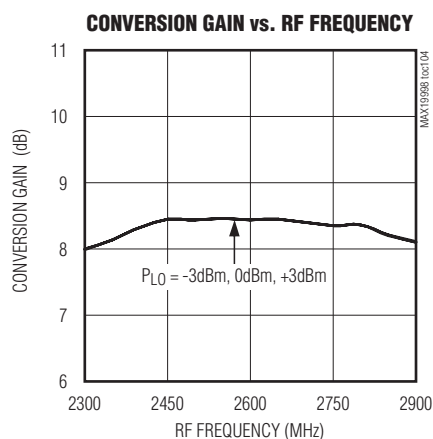
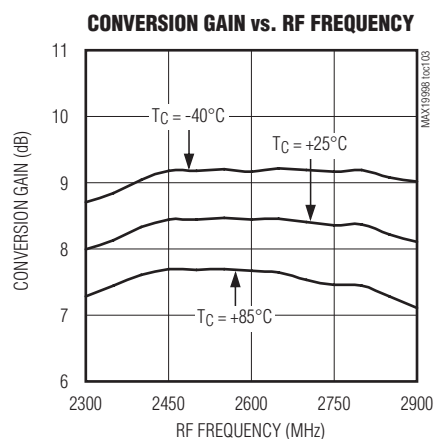
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 3100MHz$  to  $3900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

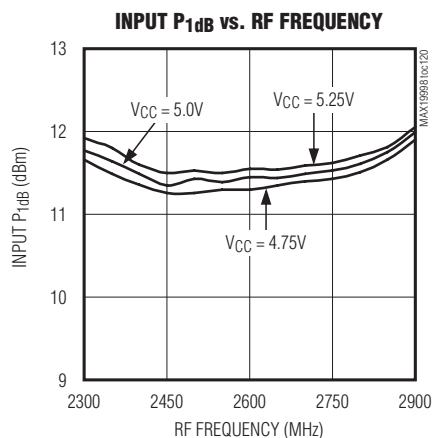
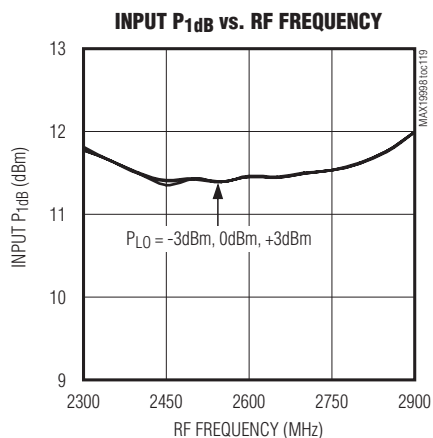
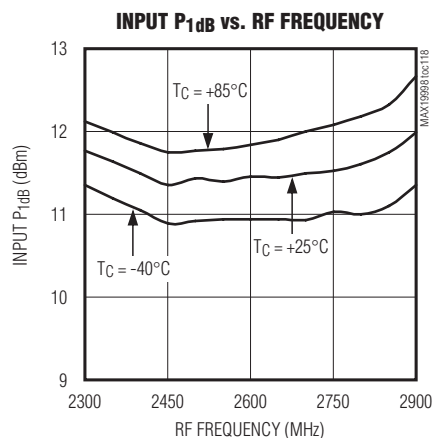
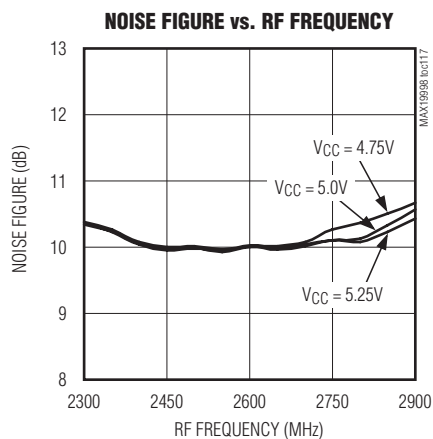
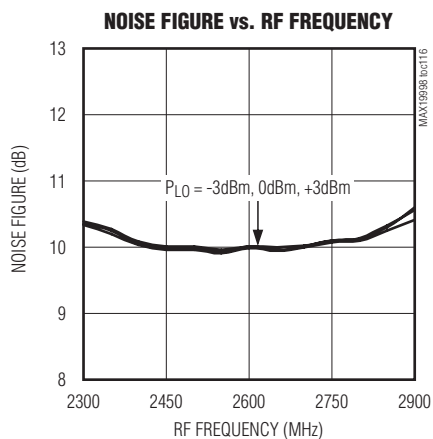
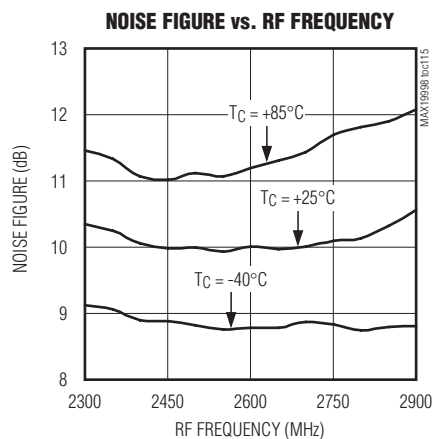
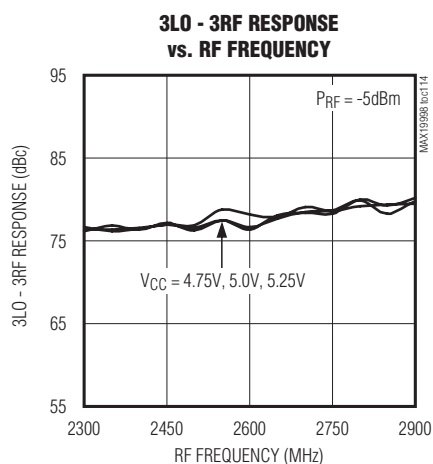
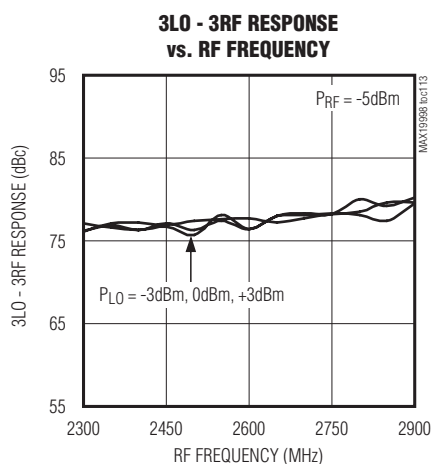
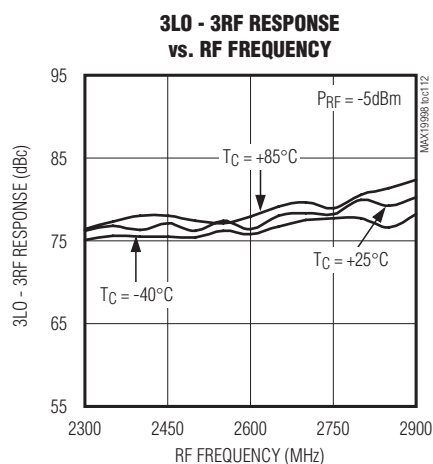
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 2300MHz$  to  $2900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

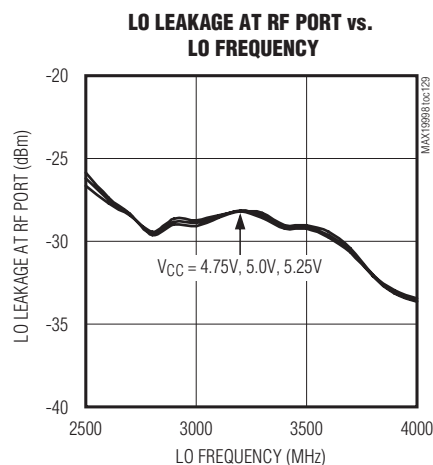
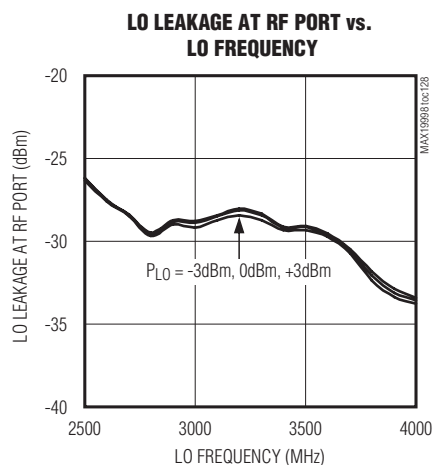
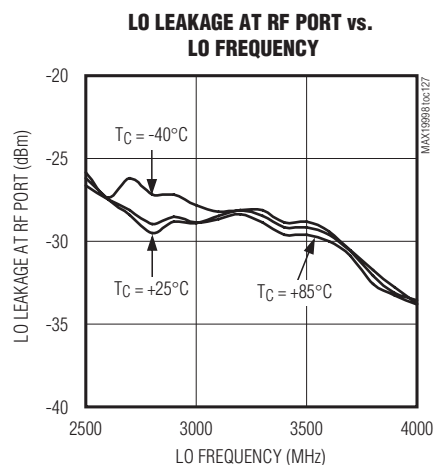
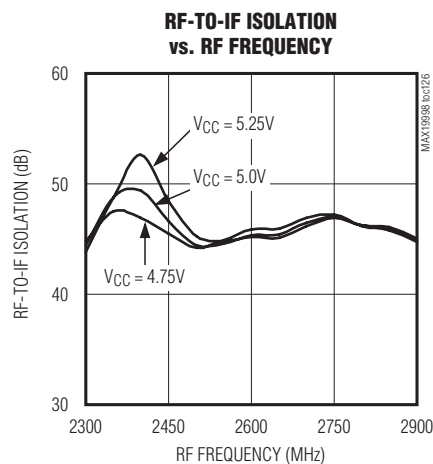
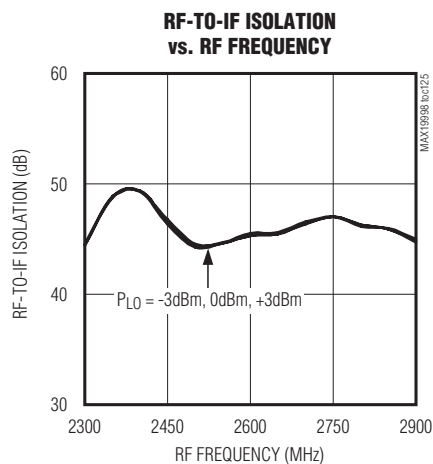
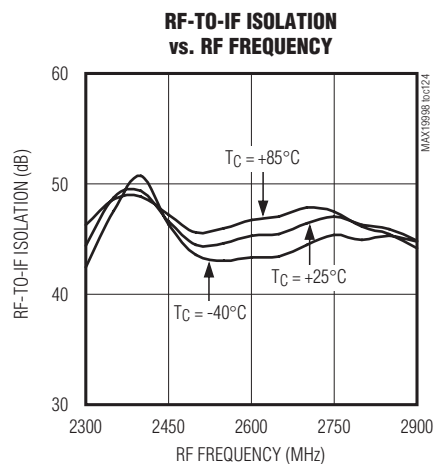
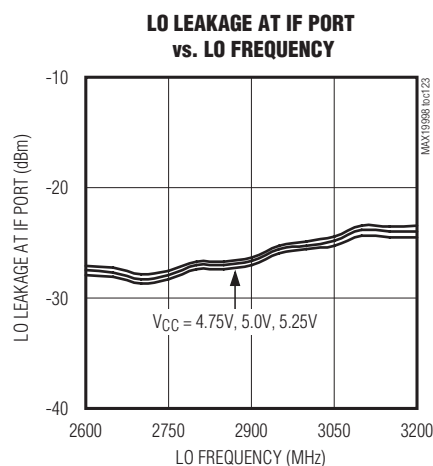
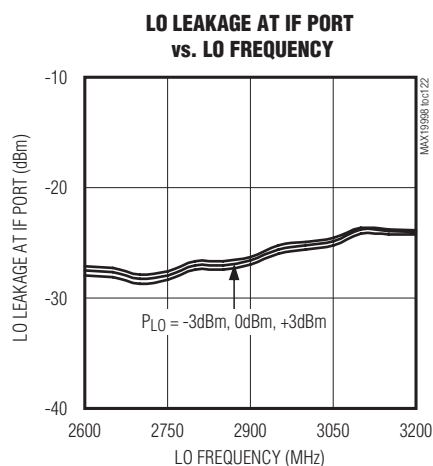
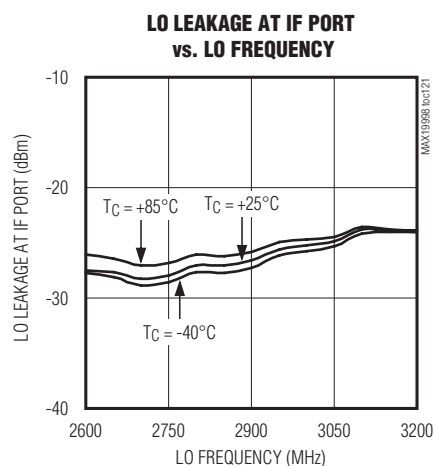
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 2300MHz$  to  $2900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Typical Operating Characteristics (continued)

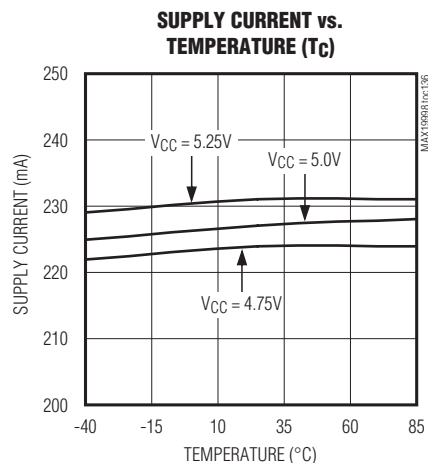
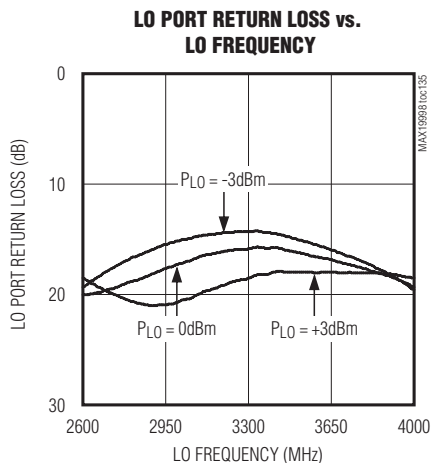
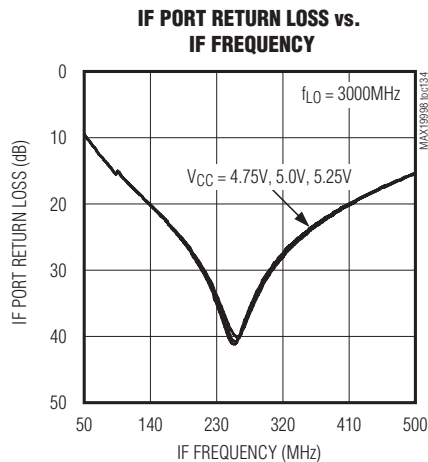
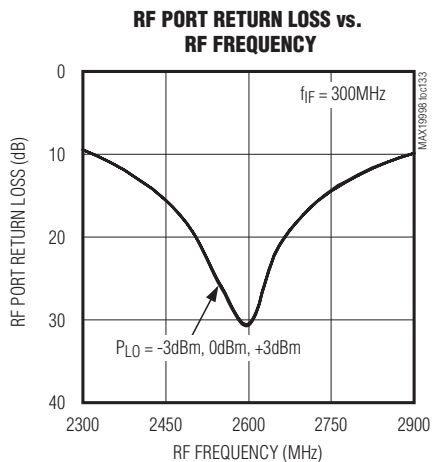
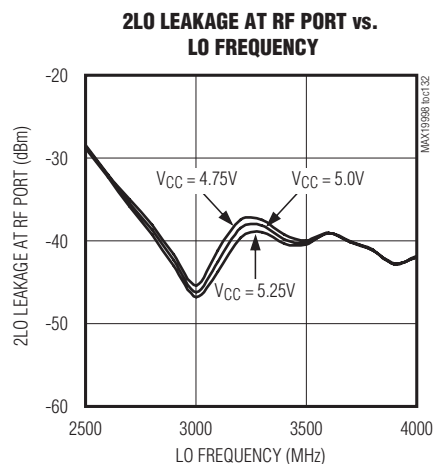
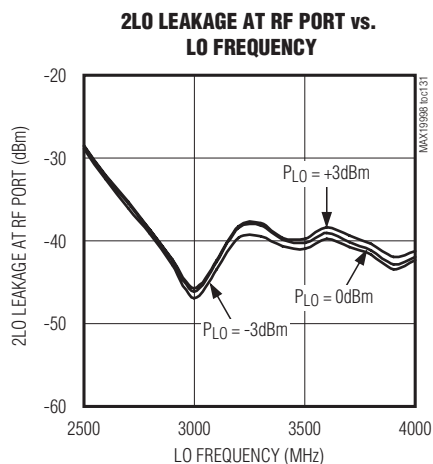
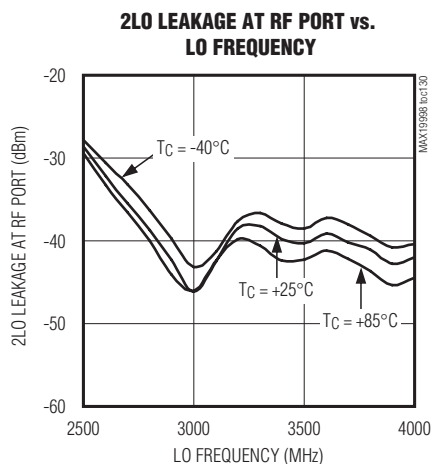
(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 2300MHz$  to  $2900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

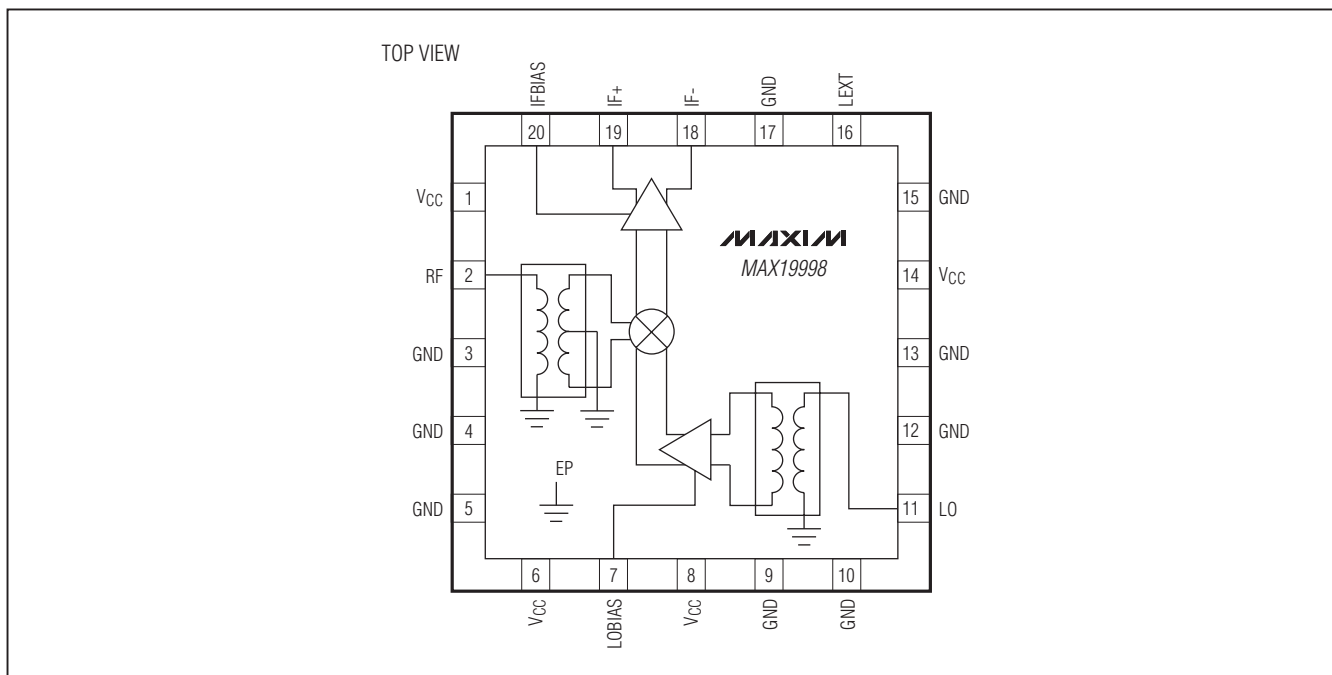
## Typical Operating Characteristics (continued)

(Typical Application Circuit with tuning elements outlined in Table 1,  $V_{CC} = 5.0V$ ,  $f_{RF} = 2300MHz$  to  $2900MHz$ , LO is high-side injected for a 300MHz IF,  $P_{RF} = -5dBm$ ,  $P_{LO} = 0dBm$ ,  $T_C = +25^\circ C$ , unless otherwise noted.)



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Pin Configuration/Functional Diagram



## Pin Description

| PIN              | NAME     | FUNCTION                                                                                                                                                                                                                                                               |
|------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 6, 8, 14      | VCC      | Power Supply. Bypass to GND with 0.01 $\mu$ F capacitors as close as possible to the pin.                                                                                                                                                                              |
| 2                | RF       | Single-Ended 50 $\Omega$ RF Input. Internally matched and DC shorted to GND through a balun. Provide an input DC-blocking capacitor if required.                                                                                                                       |
| 3, 9, 13, 15     | GND      | Ground. Not internally connected. Pins can be grounded.                                                                                                                                                                                                                |
| 4, 5, 10, 12, 17 | GND      | Ground. Internally connected to the exposed pad. Connect all ground pins and the exposed pad (EP) together.                                                                                                                                                            |
| 7                | LOBIAS   | LO Amplifier Bias Control. Output bias resistor for the LO buffer. Connect a 604 $\Omega$ (5V, 230mA bias condition) from LOBIAS to ground.                                                                                                                            |
| 11               | LO       | Local Oscillator Input. This input is internally matched to 50 $\Omega$ . Requires an input DC-blocking capacitor.                                                                                                                                                     |
| 16               | LEXT     | External Inductor Connection. Connect a low-ESR 4.7nH inductor from this pin to ground to increase the RF-to-IF and LO-to-IF isolation. Connect this pin directly to ground to reduce the component count at the expense of reduced RF-to-IF and LO-to-IF isolation.   |
| 18, 19           | IF-, IF+ | Mixer Differential IF Output. Connect pullup inductors from each of these pins to VCC (see the <i>Typical Application Circuit</i> ).                                                                                                                                   |
| 20               | IFBIAS   | IF Amplifier Bias Control. IF bias resistor connection for the IF amplifier. Connect a 698 $\Omega$ (5V, 230mA bias condition) from IFBIAS to GND.                                                                                                                     |
| —                | EP       | Exposed Pad. Internally connected to GND. Solder this exposed pad to a PCB pad that uses multiple ground vias to provide heat transfer out of the device into the PCB ground planes. These multiple via grounds are also required to achieve the noted RF performance. |

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Detailed Description

The MAX19998 provides high linearity and low noise figure for a multitude of 2300MHz to 4000MHz WiMAX, LTE, and MMDS base-station applications. This device operates over a 2600MHz to 4300MHz LO range and a 50MHz to 500MHz IF range. Integrated baluns and matching circuitry allow 50 $\Omega$  single-ended interfaces to the RF and LO ports. The integrated LO buffer provides a high drive level to the mixer core, reducing the LO drive required at the MAX19998's input to a range of -3dBm to +3dBm. The IF port incorporates a differential output, which is ideal for providing enhanced 2RF - 2LO and 2LO - 2RF performance.

### RF Input and Balun

The MAX19998 RF input provides a 50 $\Omega$  match when combined with a series DC-blocking capacitor. This DC-blocking capacitor is required as the input is internally DC shorted to ground through the on-chip balun. When using an 8.2pF DC-blocking capacitor, the RF port input return loss is typically 17dB over the RF frequency range of 3200MHz to 3900MHz. See Table 1 for lower band tuning.

### LO Inputs, Buffer, and Balun

The LO input is internally matched to 50 $\Omega$ , requiring only a 2pF DC-blocking capacitor. A two-stage internal LO buffer allows for a -3dBm to +3dBm LO input power range. The on-chip low-loss balun, along with an LO buffer, drives the double-balanced mixer. All interfacing and matching components from the LO inputs to the IF outputs are integrated on-chip.

### High-Linearity Mixer

The core of the MAX19998 is a double-balanced, high-performance passive mixer. Exceptional linearity is provided by the large LO swing from the on-chip LO buffer. When combined with the integrated IF amplifier, IIP3, 2RF - 2LO rejection, and noise-figure performance are typically +24.3dBm, 67dBc, and 9.7dB, respectively, for low-side LO injection architectures covering the 3000MHz to 4000MHz RF band.

### Differential IF Output Amplifier

The MAX19998 has a 50MHz to 500MHz IF frequency range, where the low-end frequency depends on the frequency response of the external IF components. The MAX19998 mixer is tuned for a 300MHz IF using 390nH external pullup bias inductors. Lower IF frequencies

would require higher L1 and L2 inductor values to maintain a good IF match. The differential, open-collector IF output ports require that these inductors be connected to VCC.

Note that these differential ports are ideal for providing enhanced 2RF - 2LO performance. Single-ended IF applications require a 4:1 (impedance ratio) balun to transform the 200 $\Omega$  differential IF impedance to a 50 $\Omega$  single-ended system. Use the TC4-1W-17 4:1 transformer for IF frequencies above 200MHz and the TC4-1W-7A 4:1 transformer for frequencies below 200MHz. The user can use a differential IF amplifier or SAW filter on the mixer IF port, but a DC block is required on both IF+/IF- ports to keep external DC from entering the IF ports of the mixer.

## Applications Information

### Input and Output Matching

The RF and LO inputs provide 50 $\Omega$  matches when combined with the proper tuning. Use an 8.2pF capacitor value on the RF port for frequencies ranging from 3000MHz to 4000MHz. Use a 3.3nH series inductor and a 0.3pF shunt capacitor on the RF port for frequencies ranging from 2300MHz to 2900MHz. On the LO port, use a 2pF DC-blocking capacitor to cover operations spanning the 2600MHz to 4300MHz range.

The IF output impedance is 200 $\Omega$  (differential). For evaluation, an external low-loss 4:1 (impedance ratio) balun transforms this impedance down to a 50 $\Omega$  single-ended output (see the *Typical Application Circuit*).

### Reduced-Power Mode

The MAX19998 has two pins (LOBIAS, IFBIAS) that allow external resistors to set the internal bias currents. See Table 1 for nominal values for these resistors. Larger value resistors can be used to reduce power dissipation at the expense of some performance loss. If  $\pm 1\%$  resistors are not readily available, substitute with  $\pm 5\%$  resistors.

Significant reductions in power consumption can also be realized by operating the mixer with an optional supply voltage of 3.3V. Doing so reduces the overall power consumption by 57% (typ). See the 3.3V Supply AC Electrical Characteristics table and the relevant 3.3V curves in the *Typical Operating Characteristics* section to evaluate the power vs. performance trade-offs.

# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## LEXT Inductor

Short LEXT to ground using a  $0\Omega$  resistor. For applications requiring improved RF-to-IF and LO-to-IF isolation, L3 can be changed to optimize performance (see the *Typical Operating Characteristics*). However, the load impedance presented to the mixer must be such that any capacitances from IF- and IF+ to ground do not exceed several picofarads to ensure stable operating conditions. Since approximately 120mA flows through LEXT, it is important to use a low-DCR wire-wound inductor.

## Layout Considerations

A properly designed PCB is an essential part of any RF/microwave circuit. Keep RF signal lines as short as possible to reduce losses, radiation, and inductance. The load impedance presented to the mixer must be such that any capacitance from both IF- and IF+ to ground

does not exceed several picofarads. For the best performance, route the ground pin traces directly to the exposed pad under the package. The PCB exposed pad **MUST** be connected to the ground plane of the PCB. It is suggested that multiple vias be used to connect this pad to the lower level ground planes. This method provides a good RF/thermal-conduction path for the device. Solder the exposed pad on the bottom of the device package to the PCB. The MAX19998 evaluation kit can be used as a reference for board layout. Gerber files are available upon request at [www.maxim-ic.com](http://www.maxim-ic.com).

## Power-Supply Bypassing

Proper voltage supply bypassing is essential for high-frequency circuit stability. Bypass each VCC pin with the capacitors shown in the *Typical Application Circuit* and see Table 1 for component values.

**Table 1. Component Values**

| DESIGNATION     | QTY | DESCRIPTION                                                                               | COMPONENT SUPPLIER                     |
|-----------------|-----|-------------------------------------------------------------------------------------------|----------------------------------------|
| C1              | 1   | 8.2pF microwave capacitor (0402). Use for RF frequencies ranging from 3000MHz to 4000MHz. | Murata Electronics North America, Inc. |
|                 |     | 3.3nH microwave inductor (0402). Use for RF frequencies ranging from 2300MHz to 2900MHz.  | Coilcraft, Inc.                        |
| C2, C6, C8, C11 | 4   | 0.01 $\mu$ F microwave capacitors (0402)                                                  | Murata Electronics North America, Inc. |
| C3, C9          | 0   | Not installed, capacitors                                                                 | —                                      |
| C10             | 1   | 2pF microwave capacitor (0402)                                                            | Murata Electronics North America, Inc. |
| C13, C14        | 2   | 1000pF microwave capacitors (0402)                                                        | Murata Electronics North America, Inc. |
| C15             | 1   | 82pF microwave capacitor (0402)                                                           | Murata Electronics North America, Inc. |
| C16             | 1   | Not installed for RF frequencies ranging from 3000MHz to 4000MHz                          | —                                      |
|                 |     | 0.3pF microwave capacitor (0402). Use for RF frequencies ranging from 2300MHz to 2900MHz. | Murata Electronics North America, Inc. |
| L1, L2          | 2   | 390nH wire-wound high-Q inductors* (0805)                                                 | Coilcraft, Inc.                        |
| L3              | 1   | 4.7nH wire-wound high-Q inductor (0603)                                                   | Coilcraft, Inc.                        |
| R1              | 1   | 698 $\Omega$ $\pm$ 1% resistor (0402). Use for <b>VCC = 5.0V</b> applications.            | Digi-Key Corp.                         |
|                 |     | 845 $\Omega$ $\pm$ 1% resistor (0402). Use for <b>VCC = 3.3V</b> applications.            |                                        |
| R2              | 1   | 604 $\Omega$ $\pm$ 1% resistor (0402). Use for <b>VCC = 5.0V</b> applications.            | Digi-Key Corp.                         |
|                 |     | 1.1k $\Omega$ $\pm$ 1% resistor (0402). Use for <b>VCC = 3.3V</b> applications.           |                                        |
| R3              | 1   | 0 $\Omega$ resistor (1206)                                                                | Digi-Key Corp.                         |
| T1              | 1   | 4:1 IF balun TC4-1W-17*                                                                   | Mini-Circuits                          |
| U1              | 1   | MAX19998 IC (20 Thin QFN-EP)                                                              | Maxim Integrated Products, Inc.        |

\*Use larger value inductors and a TC4-1W-7A 4:1 balun for IF frequencies below 200MHz.

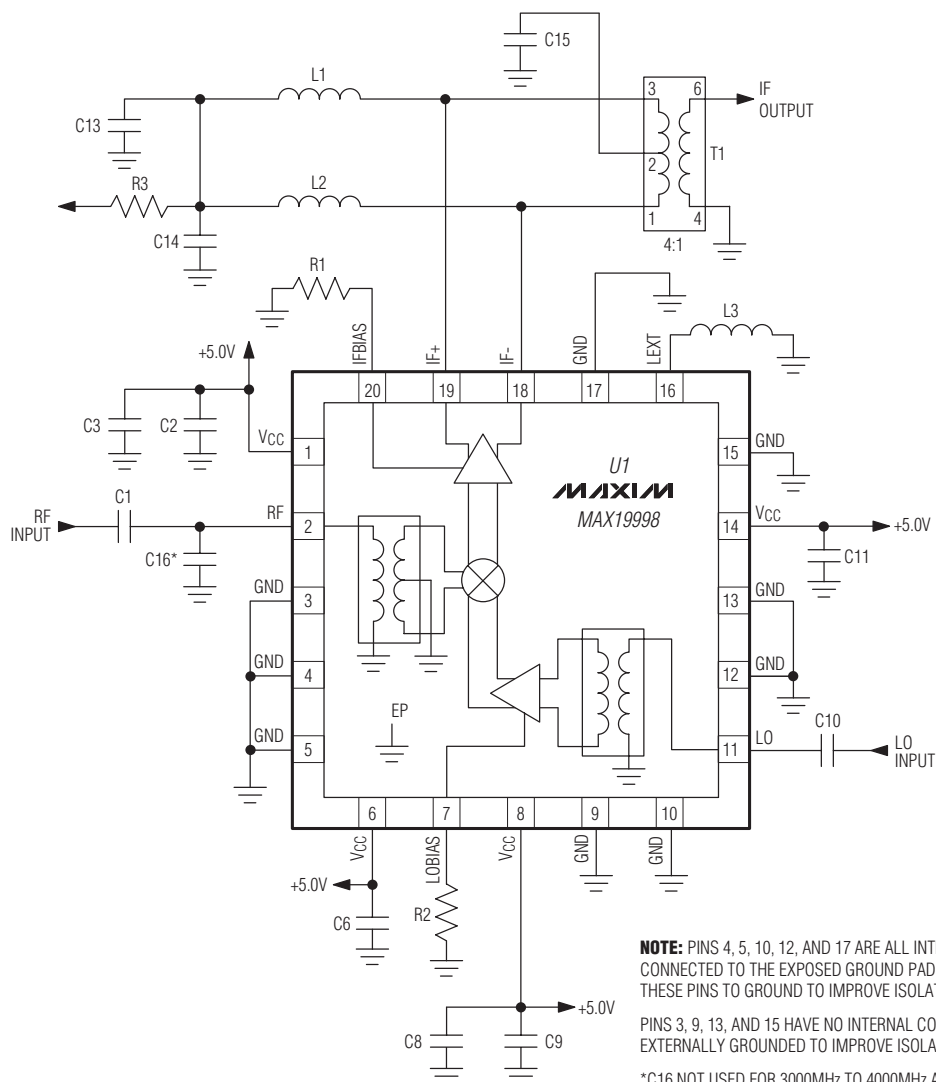
# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Exposed Pad RF/Thermal Considerations

The exposed pad (EP) of the MAX19998's 20-pin thin QFN-EP package provides a low thermal-resistance path to the die. It is important that the PCB on which the MAX19998 is mounted be designed to conduct

heat from the EP. In addition, provide the EP with a low-inductance path to electrical ground. The EP **MUST** be soldered to a ground plane on the PCB, either directly or through an array of plated via holes.

## Typical Application Circuit



# SiGe, High-Linearity, 2300MHz to 4000MHz Downconversion Mixer with LO Buffer

## Chip Information

PROCESS: SiGe BiCMOS

## Package Information

For the latest package outline information and land patterns, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE   | PACKAGE CODE | DOCUMENT NO.            |
|----------------|--------------|-------------------------|
| 20 Thin QFN-EP | T2055+3      | <a href="#">21-0140</a> |

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

28 **Maxim Integrated Products, 120 San Gabriel Drive, Sunnyvale, CA 94086 408-737-7600**

© 2009 Maxim Integrated Products

Maxim is a registered trademark of Maxim Integrated Products, Inc.