19-4177; Rev 0; 7/08

# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

MAX19996

## General Description

The MAX19996 single, high-linearity downconversion mixer provides 8.7dB conversion gain, +24.5dBm IIP3, and 9.6dB noise figure for 2000MHz to 3000MHz WCS, LTE, WiMAX™, and MMDS wireless infrastructure applications. With an 1800MHz to 2550MHz LO frequency range, this particular mixer is ideal for low-side LO injection receiver architectures. High-side LO injection is supported by the MAX19996A, which is pin-for-pin and functionally compatible with the MAX19996.

In addition to offering excellent linearity and noise performance, the MAX19996 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 MAX19996 requires a nominal LO drive of 0dBm, and supply current is typically 230mA at $V_{CC}$ = +5.0V or 149.5mA at $V_{CC}$ = +3.3V.

The MAX19996 is pin compatible with the MAX19996A 2300MHz to 3900MHz mixer. The device is also pin similar with the MAX9984/MAX9986 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 MAX19996 is available in a compact 5mm x 5mm, 20-pin thin QFN lead-free package with an exposed pad. Electrical performance is guaranteed over the extended -40°C to +85°C temperature range.

## Applications

2.3GHz WCS Base Stations

2.5GHz WiMAX and LTE Base Stations

2.7GHz MMDS Base Stations

Fixed Broadband Wireless Access

Wireless Local Loop

Private Mobile Radios

Military Systems

*WiMAX is a trademark of WiMAX Forum.*

## Features

- **2000MHz to 3000MHz RF Frequency Range**
- **1800MHz to 2550MHz LO Frequency Range**
- **50MHz to 500MHz IF Frequency Range**
- **8.7dB Typical Conversion Gain**
- **9.6dB Typical Noise Figure**
- **+24.5dBm Typical Input IP3**
- **+11dBm Typical Input 1dB Compression Point**
- **69dBc Typical 2RF-2LO Spurious Rejection at $P_{RF}$ = -10dBm**
- **Integrated LO Buffer**
- **Integrated RF and LO Baluns for Single-Ended Inputs**
- **Low -3dBm to +3dBm LO Drive**
- **Pin Compatible with the MAX19996A 2300MHz to 3900MHz Mixer**
- **Pin Similar with the MAX9993/MAX9994/MAX9996 1700MHz to 2200MHz Mixers and MAX9984/MAX9986 400MHz to 1000MHz 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 |
|---|---|---|
| MAX19996ETP+ | -40°C to +85°C | 20 Thin QFN-EP* |
| MAX19996ETP+T | -40°C to +85°C | 20 Thin QFN-EP* |

*+Denotes a lead-free/RoHS-compliant package.*
**EP = Exposed pad.*
*T = Tape and reel.*

***Pin Configuration appears at end of data sheet.***

# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$ to GND ..........................................................-0.3V to +5.5V
IF+, IF-, LOBIAS, LO, IFBIAS,
LEXT to GND ..........................................-0.3V to ($V_{CC}$ + 0.3V)
RF, LO Input Power .......................................................+12dBm
RF, LO Current
(RF and LO is DC shorted to GND through a balun)......50mA
Continuous Power Dissipation (Note 1) ..............................5.0W
$\theta_{JA}$ (Notes 2, 3).............................................................+38°C/W
$\theta_{JC}$ (Notes 1, 3)...............................................................13°C/W
Operating Case Temperature
Range (Note 4).......................................$T_C$ = -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**.
**Note 4:** $T_C$ is the temperature on the exposed pad of the package. $T_A$ 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*, $V_{CC}$ = +4.75V to +5.25V, no input AC signals. $T_C$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{CC}$ = +5.0V, $T_C$ = +25°C, all parameters are production tested.) (Note 6)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | | 4.75 | 5 | 5.25 | V |
| Supply Current | $I_{CC}$ | | | 230 | 245 | mA |

## +3.3V SUPPLY DC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit*, $V_{CC}$ = +3.0V to +3.6V, no input AC signals. $T_C$ = -40°C to +85°C, unless otherwise noted. Typical values are at $V_{CC}$ = +3.3V, $T_C$ = +25°C, parameters are guaranteed by design and not production tested, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | | 3.0 | 3.3 | 3.6 | V |
| Supply Current | $I_{CC}$ | Total supply current, $V_{CC}$ = +3.3V | | 149.5 | | mA |

## RECOMMENDED AC OPERATING CONDITIONS

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| RF Frequency | $f_{RF}$ | (Note 7) | 2000 | | 3000 | MHz |
| LO Frequency | $f_{LO}$ | (Note 7) | 1800 | | 2550 | MHz |
| IF Frequency | $f_{IF}$ | Using Mini-Circuits TC4-1W-17 4:1 transformer as defined in the *Typical Application Circuit*, IF matching components affect the IF frequency range (Note 7) | 100 | | 500 | MHz |
| | | Using alternative Mini-Circuits TC4-1W-7A 4:1 transformer, IF matching components affect the IF frequency range (Note 7) | 50 | | 250 | |
| LO Drive Level | $P_{LO}$ | | -3 | | +3 | dBm |

## +5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit*, $V_{CC}$ = +4.75V to +5.25V, RF and LO ports are driven from 50Ω sources, $P_{LO}$ = -3dBm to +3dBm, $P_{RF}$ = -5dBm, $f_{RF}$ = 2300MHz to 2800MHz, $f_{LO}$ = 2000MHz to 2500MHz, $f_{IF}$ = 300MHz, $f_{RF}$ > $f_{LO}$, $T_C$ = -40°C to +85°C. Typical values are at $V_{CC}$ = +5.0V, $P_{RF}$ = -5dBm, $P_{LO}$ = 0dBm, $f_{RF}$ = 2500MHz, $f_{LO}$ = 2200MHz, $f_{IF}$ = 300MHz, $T_C$ = +25°C, all parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 6)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Conversion Power Gain | $G_C$ | $T_C$ = +25°C (Note 5) | | 8.1 | 8.7 | 9.3 | dB |
| Conversion Power Gain Variation vs. Frequency | $\Delta G_C$ | $f_{RF}$ = 2300MHz to 2800MHz for any 100MHz band | | | 0.1 | | dB |
| Conversion Power Gain Temperature Coefficient | $TC_G$ | $T_C$ = -40°C to +85°C | | | -0.012 | | dB/°C |
| Input 1dB Compression Point | $IP_{1dB}$ | $T_C$ = +25°C (Note 8) | | 10 | 11 | | dBm |
| | | $f_{RF}$ = 2500MHz, $T_C$ = +25°C (Note 8) | | 10.4 | 11 | | dBm |
| Third-Order Input Intercept Point | IIP3 | $f_{RF1}$ - $f_{RF2}$ = 1MHz, $P_{RF1}$ = $P_{RF2}$ = -5dBm, $T_C$ = +25°C (Note 5) | | 22 | 24.5 | | dBm |
| Third-Order Input Intercept Point Variation Over Temperature | | $f_{RF}$ = 2300MHz to 2800MHz, $f_{IF}$ = 300MHz, $f_{RF1}$ - $f_{RF2}$ = 1MHz, $P_{RF1}$ = $P_{RF2}$ = -5dBm, $T_C$ = -40°C to +85°C | | | ±0.5 | | dB |
| Noise Figure | $NF_{SSB}$ | $f_{RF}$ = 2300MHz to 2700MHz, $f_{IF}$ = 300MHz, single sideband, no blockers present (Note 9) | | | 9.6 | 12 | dB |
| | | $f_{RF}$ = 2500MHz, $f_{IF}$ = 300MHz, $P_{LO}$ = 0dBm, $V_{CC}$ = +5.0V, $T_C$ = +25°C, single sideband, no blockers present (Note 9) | | | 9.6 | 10.5 | |
| Noise Figure Temperature Coefficient | $TC_{NF}$ | $f_{RF}$ = 2000MHz to 3000MHz, single sideband, no blockers present, $T_C$ = -40°C to +85°C (Note 9) | | | 0.0183 | | dB/°C |
| Noise Figure Under Blocking Condition | $NF_B$ | +8dBm blocker tone applied to RF port, $f_{RF}$ = 2300MHz, $f_{LO}$ = 2110MHz, $f_{BLOCKER}$ = 2400MHz, $P_{LO}$ = -3dBm, $V_{CC}$ = +5.0V, $T_C$ = +25°C (Note 9) | | | 20.8 | 25 | dB |
| 2RF-2LO Spur Rejection | 2 x 2 | $f_{RF}$ = 2300MHz to 2700MHz, $f_{LO}$ = 2000MHz to 2400MHz, $f_{SPUR}$ = $f_{LO}$ + 150MHz | $P_{RF}$ = -10dBm | 60 | 69 | | dBc |
| | | | $P_{RF}$ = -5dBm (Note 5) | 55 | 64 | | |
| 3RF-3LO Spur Rejection | 3 x 3 | $f_{RF}$ = 2300MHz to 2700MHz, $f_{LO}$ = 2000MHz to 2400MHz, $f_{SPUR}$ = $f_{LO}$ + 100MHz | $P_{RF}$ = -10dBm | 70 | 78 | | dBc |
| | | | $P_{RF}$ = -5dBm (Note 5) | 60 | 68 | | |
| RF Input Return Loss | | LO on and IF terminated into a matched impedance | | | 18 | | dB |
| LO Input Return Loss | | RF and IF terminated into a matched impedance | | | 20 | | dB |

# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

## +5.0V SUPPLY AC ELECTRICAL CHARACTERISTICS (continued)

(*Typical Application Circuit*, $V_{CC}$ = +4.75V to +5.25V, RF and LO ports are driven from 50Ω sources, $P_{LO}$ = -3dBm to +3dBm, $P_{RF}$ = -5dBm, $f_{RF}$ = 2300MHz to 2800MHz, $f_{LO}$ = 2000MHz to 2500MHz, $f_{IF}$ = 300MHz, $f_{RF} > f_{LO}$, $T_C$ = -40°C to +85°C. Typical values are at $V_{CC}$ = +5.0V, $P_{RF}$ = -5dBm, $P_{LO}$ = 0dBm, $f_{RF}$ = 2500MHz, $f_{LO}$ = 2200MHz, $f_{IF}$ = 300MHz, $T_C$ = +25°C, all parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 6)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| IF Output Impedance | $Z_{IF}$ | Nominal differential impedance at the IC's IF outputs | | | 200 | | Ω |
| IF Output Return Loss | | RF terminated into 50Ω, LO driven by 50Ω source, IF transformed to 50Ω using external components shown in the *Typical Application Circuit*. See the *IF Port Return Loss vs. IF Frequency* graph in the *Typical Operating Characteristics* 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 = 470nH | | 25 | | |
| Minimum RF-to-IF Isolation | | $f_{RF}$ = 2300MHz to 2700MHz, $P_{LO}$ = +3dBm (Note 5) | | | 34 | | dB |
| Maximum LO Leakage at RF Port | | $f_{LO}$ = 1900MHz to 2500MHz, $P_{LO}$ = +3dBm | | | -22.7 | | dBm |
| Maximum 2LO Leakage at RF Port | | $f_{LO}$ = 1900MHz to 2500MHz, $P_{LO}$ = +3dBm | | | -21 | | dBm |
| Maximum LO Leakage at IF Port | | $f_{LO}$ = 1900MHz to 2500MHz, $P_{LO}$ = +3dBm (Note 5) | | | -27.5 | | dBm |

## +3.3V SUPPLY AC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit*, RF and LO ports are driven from 50Ω sources, Typical values are at $V_{CC}$ = +3.3V, $P_{RF}$ = -5dBm, $P_{LO}$ = 0dBm, $f_{RF}$ = 2500MHz, $f_{LO}$ = 2200MHz, $f_{IF}$ = 300MHz, $T_C$ = +25°C, unless otherwise noted.) (Note 6)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Conversion Power Gain | $G_C$ | | | 8.6 | | dB |
| Conversion Power Gain Variation vs. Frequency | $\Delta G_C$ | $f_{RF}$ = 2300MHz to 2800MHz for any 100MHz band | | 0.1 | | dB |
| Gain Variation Over Temperature | $TC_G$ | $T_C$ = -40°C to +85°C | | -0.012 | | dB/°C |
| Input 1dB Compression Point | $IP_{1dB}$ | (Note 8) | | 7.5 | | dBm |
| Third-Order Input Intercept Point | IIP3 | $f_{RF1}$ = 2500MHz, $f_{RF2}$ = 2501MHz, $f_{LO}$ = 2200MHz, $P_{RF1}$ = $P_{RF2}$ = -5dBm | | 19.8 | | dBm |
| Third-Order Input Intercept Variation Over Temperature | | $f_{RF1}$ = 2500MHz, $f_{RF2}$ = 2501MHz, $f_{LO}$ = 2200MHz, $P_{RF1}$ = $P_{RF2}$ = -5dBm, $T_C$ = +25°C | | ±0.5 | | dB |
| Noise Figure | $NF_{SSB}$ | Single sideband, no blockers present (Note 9) | | 9.6 | | dB |
| Noise Figure Temperature Coefficient | $TC_{NF}$ | Single sideband, no blockers present, $T_C$ = -40°C to +85°C (Note 9) | | 0.017 | | dB/°C |
| 2RF-2LO Spur Rejection | 2 x 2 | $P_{RF}$ = -10dBm | | 65.9 | | dBc |
| | | $P_{RF}$ = -5dBm | | 60.9 | | |

## +3.3V SUPPLY AC ELECTRICAL CHARACTERISTICS (continued)

(*Typical Application Circuit*, RF and LO ports are driven from 50Ω sources, Typical values are at $V_{CC}$ = +3.3V, $P_{RF}$ = -5dBm, $P_{LO}$ = 0dBm, $f_{RF}$ = 2500MHz, $f_{LO}$ = 2200MHz, $f_{IF}$ = 300MHz, $T_C$ = +25°C, unless otherwise noted.) (Note 6)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| 3RF-3LO Spur Rejection | 3 x 3 | $P_{RF}$ = -10dBm | | | 67.9 | | dBc |
| | | $P_{RF}$ = -5dBm | | | 57.9 | | |
| RF Input Return Loss | | LO on and IF terminated into a matched impedance | | | 16 | | dB |
| LO Input Return Loss | | RF and IF terminated into a matched impedance | | | 16.7 | | dB |
| IF Output Impedance | $Z_{IF}$ | Nominal differential impedance at the IC's IF outputs | | | 200 | | Ω |
| IF Output Return Loss | | RF terminated into 50Ω, LO driven by 50Ω source, IF transformed to 50Ω using external components shown in the *Typical Application Circuit*. See the *IF Port Return Loss vs. IF Frequency* graph in the *Typical Operating Characteristics* for performance vs. inductor values. | $f_{IF}$ = 450MHz, L1 = L2 = 120nH | | 23 | | dB |
| | | | $f_{IF}$ = 350MHz, L1 = L2 = 270nH | | 23 | | |
| | | | $f_{IF}$ = 300MHz, L1 = L2 = 470nH | | 23 | | |
| Minimum RF-to-IF Isolation | | $f_{RF}$ = 2300MHz to 2700MHz, $P_{LO}$ = +3dBm | | | 33 | | dB |
| Maximum LO Leakage at RF Port | | $f_{LO}$ = 1900MHz to 2500MHz, $P_{LO}$ = +3dBm | | | -26.6 | | dBm |
| Maximum 2LO Leakage at RF Port | | $f_{LO}$ = 1900MHz to 2500MHz, $P_{LO}$ = +3dBm | | | -28.8 | | dBm |
| Maximum LO Leakage at IF Port | | $f_{LO}$ = 1900MHz to 2500MHz, $P_{LO}$ = +3dBm | | | -21.9 | | dBm |

**Note 5:** 100% production tested for functional performance.

**Note 6:** 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 7:** Not production tested. Operation outside this range is possible, but with degraded performance of some parameters. See the *Typical Operating Characteristics*.

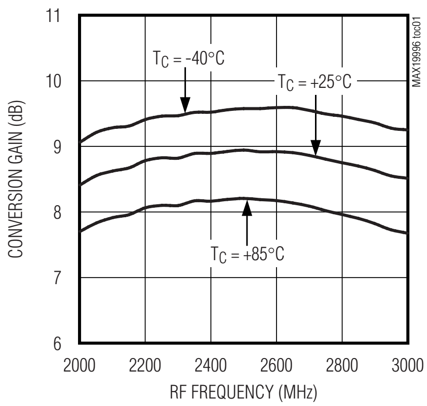
**Note 8:** Maximum reliable continuous input power applied to the RF or IF port of this device is +12dBm from a 50Ω source.

**Note 9:** 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*.

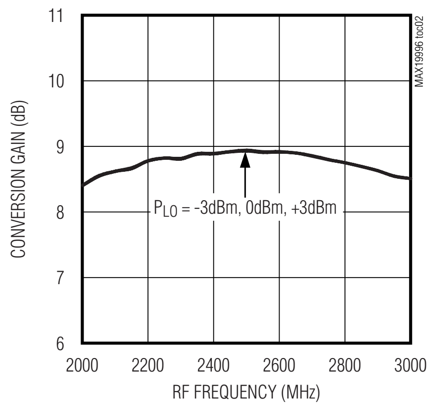
## Typical Operating Characteristics

(*Typical Application Circuit*, **$V_{CC}$ = +5.0V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

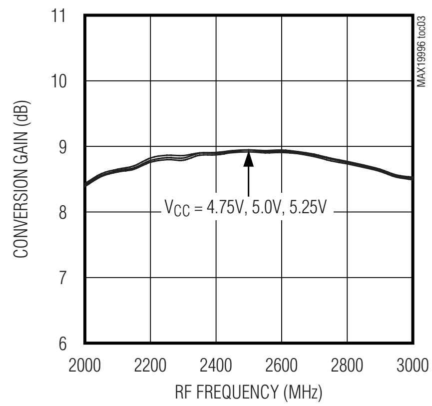
**CONVERSION GAIN vs. RF FREQUENCY**



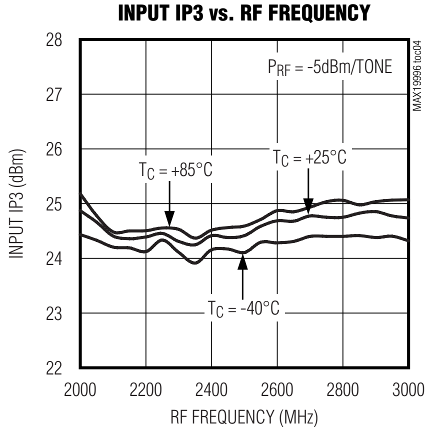

**CONVERSION GAIN vs. RF FREQUENCY**



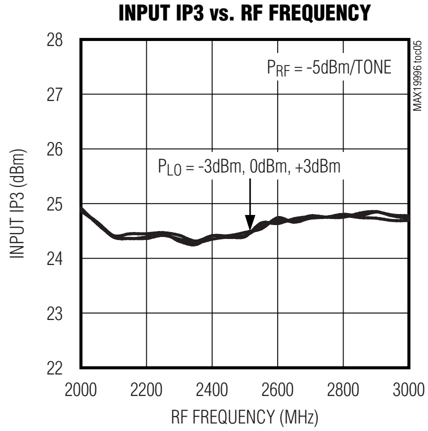

**CONVERSION GAIN vs. RF FREQUENCY**



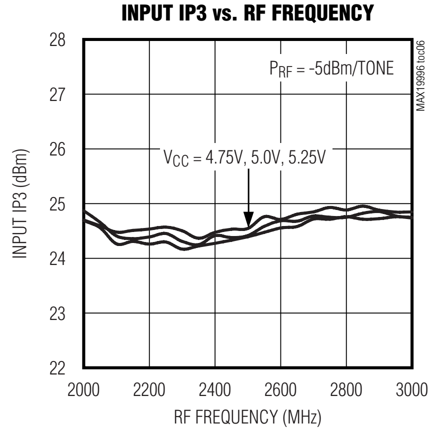

**INPUT IP3 vs. RF FREQUENCY**



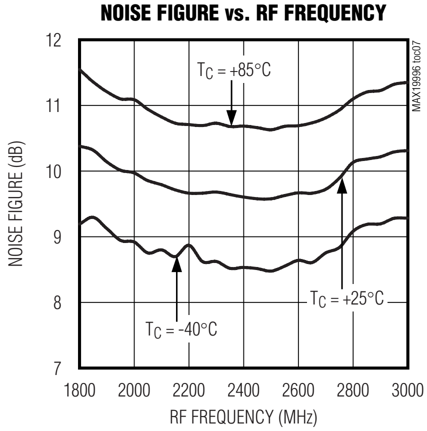

**INPUT IP3 vs. RF FREQUENCY**



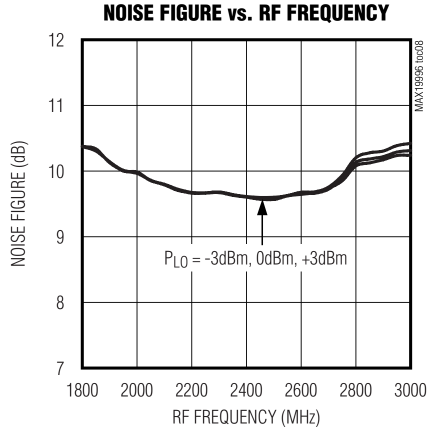

**INPUT IP3 vs. RF FREQUENCY**



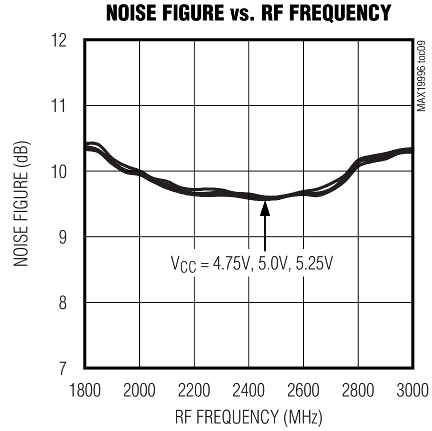

**NOISE FIGURE vs. RF FREQUENCY**




**NOISE FIGURE vs. RF FREQUENCY**



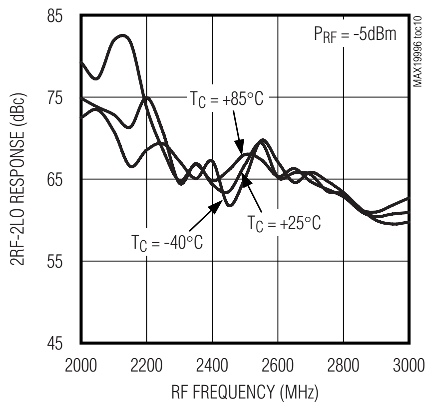

**NOISE FIGURE vs. RF FREQUENCY**



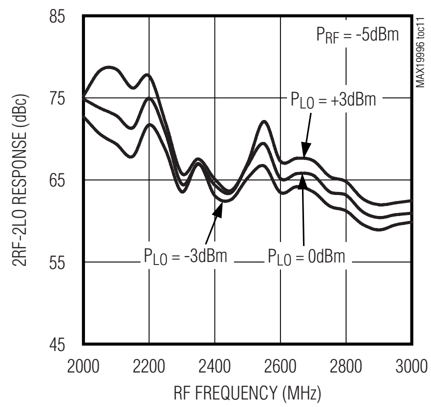
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +5.0V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

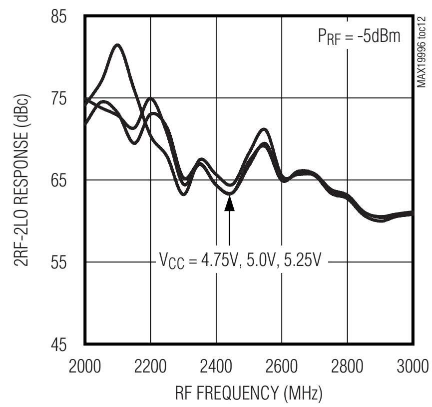
**2RF-2LO RESPONSE vs. RF FREQUENCY**



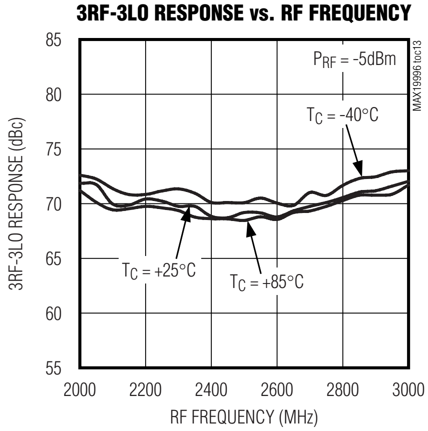

**2RF-2LO RESPONSE vs. RF FREQUENCY**



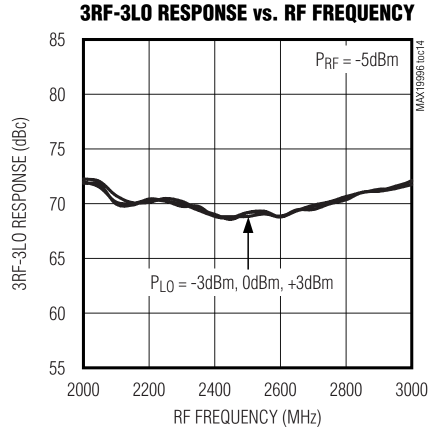

**2RF-2LO RESPONSE vs. RF FREQUENCY**



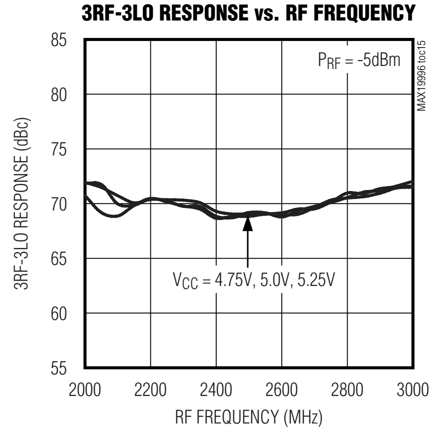

**3RF-3LO RESPONSE vs. RF FREQUENCY**



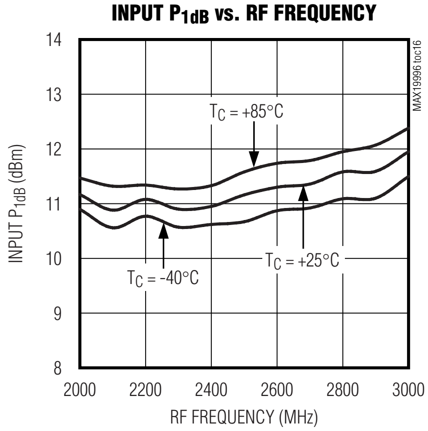

**3RF-3LO RESPONSE vs. RF FREQUENCY**



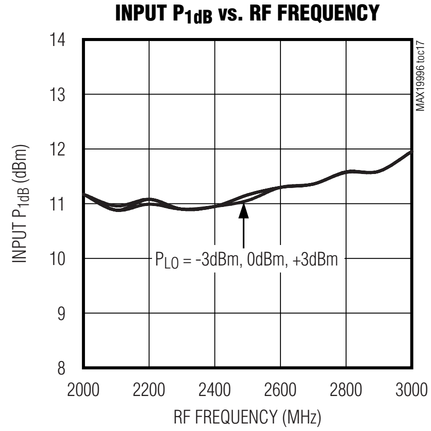

**3RF-3LO RESPONSE vs. RF FREQUENCY**



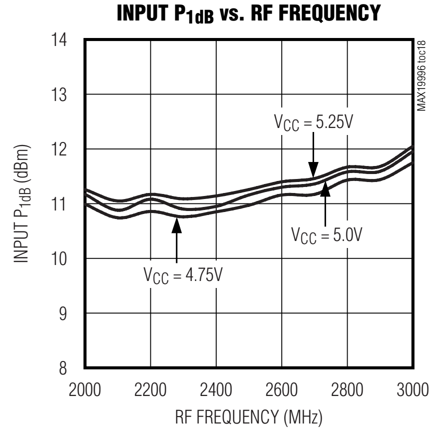

**INPUT $P_{1dB}$ vs. RF FREQUENCY**




**INPUT $P_{1dB}$ vs. RF FREQUENCY**




**INPUT $P_{1dB}$ vs. RF FREQUENCY**

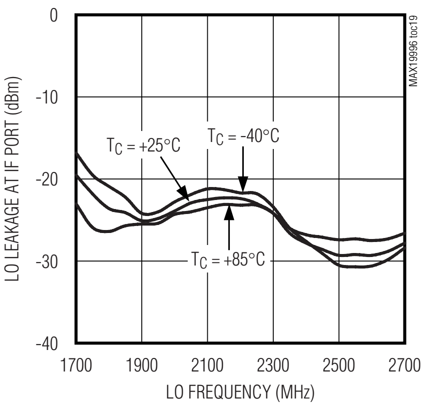


# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

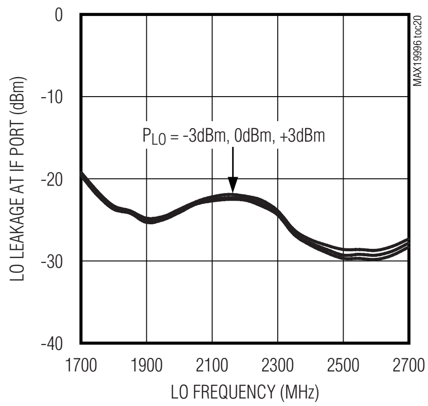
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +5.0V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

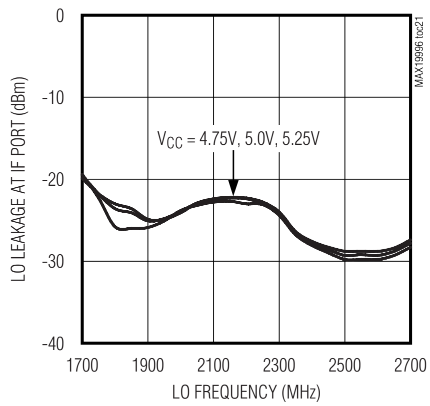
### LO LEAKAGE AT IF PORT vs. LO FREQUENCY



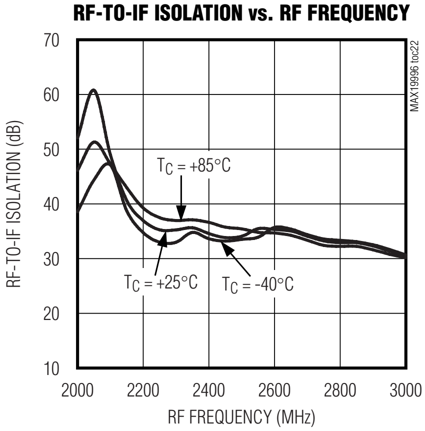

### LO LEAKAGE AT IF PORT vs. LO FREQUENCY



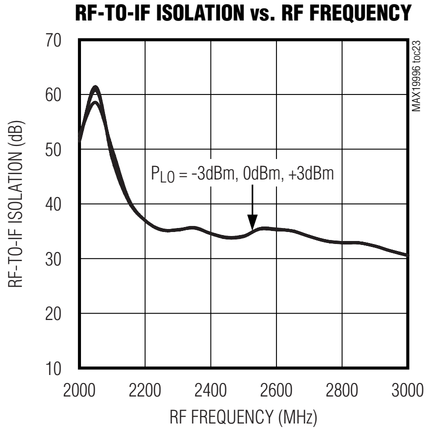

### LO LEAKAGE AT IF PORT vs. LO FREQUENCY




### RF-TO-IF ISOLATION vs. RF FREQUENCY




### RF-TO-IF ISOLATION vs. RF FREQUENCY

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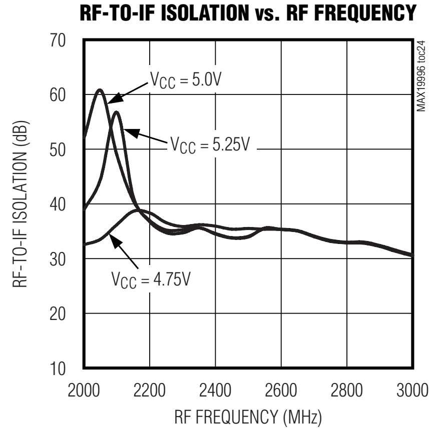
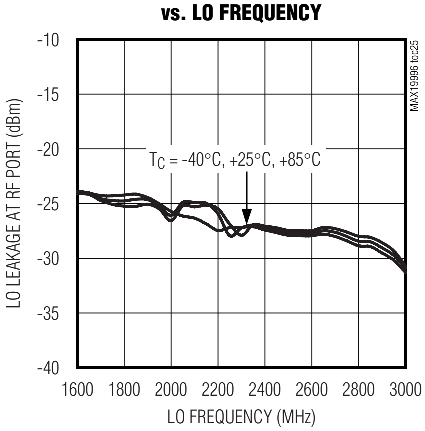
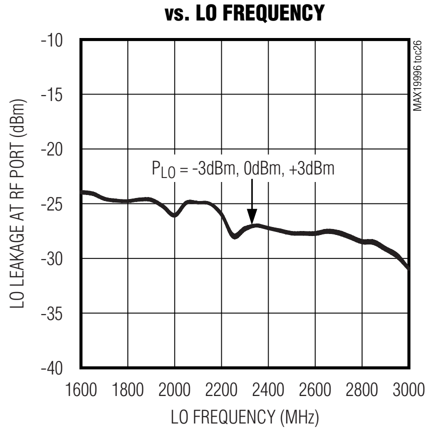


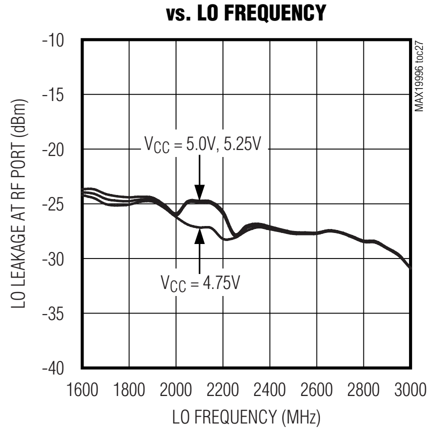

### LO LEAKAGE AT RF PORT vs. LO FREQUENCY




### LO LEAKAGE AT RF PORT vs. LO FREQUENCY



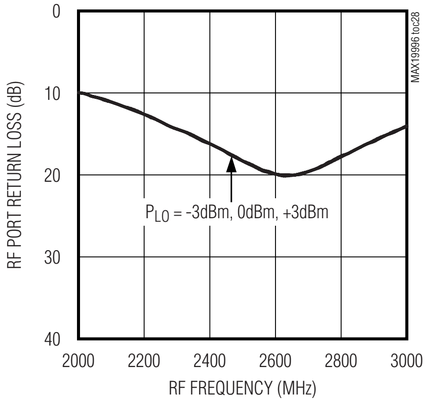

### LO LEAKAGE AT RF PORT vs. LO FREQUENCY



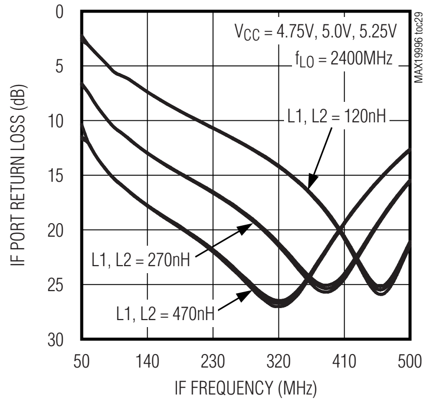
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +5.0V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

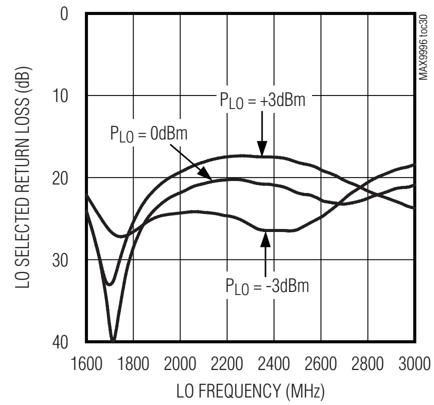
**RF PORT RETURN LOSS vs. RF FREQUENCY**



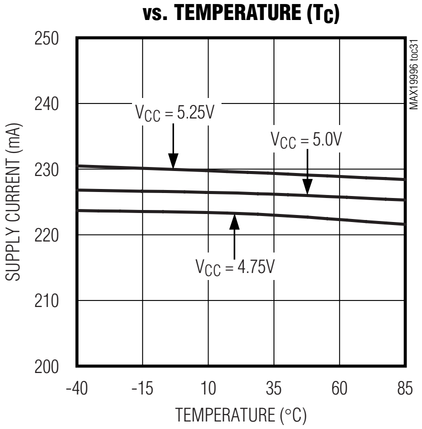

**IF PORT RETURN LOSS vs. IF FREQUENCY**



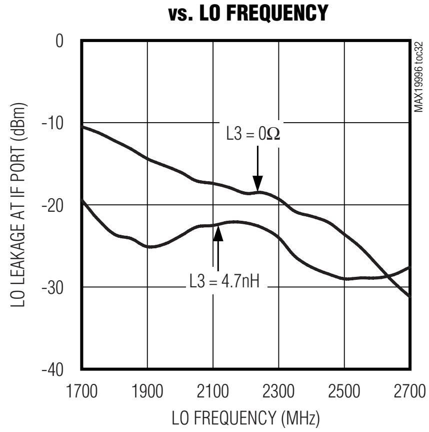

**LO SELECTED RETURN LOSS vs. LO FREQUENCY**



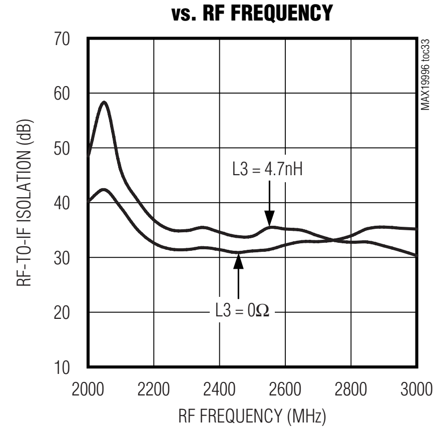

**SUPPLY CURRENT vs. TEMPERATURE ($T_C$)**




**LO LEAKAGE AT IF PORT vs. LO FREQUENCY**




**RF-TO-IF ISOLATION vs. RF FREQUENCY**

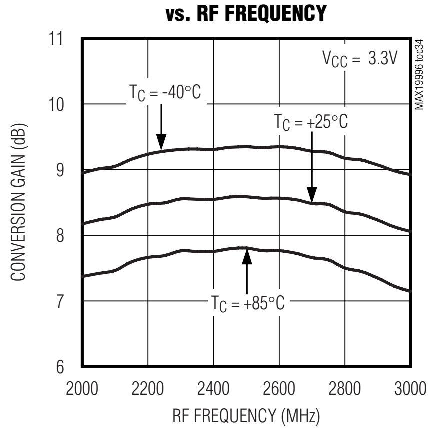


# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

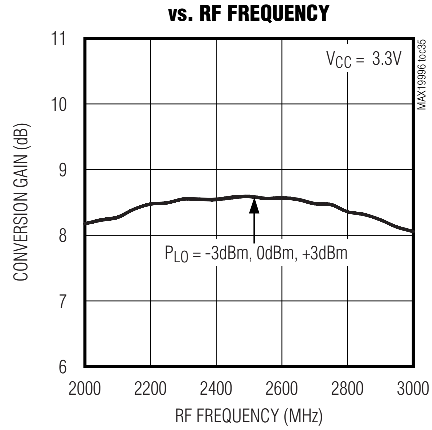
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +3.3V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

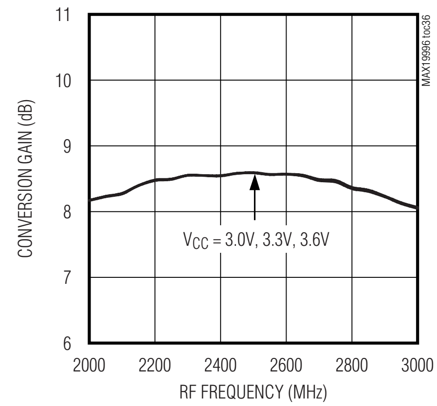
**CONVERSION GAIN vs. RF FREQUENCY**



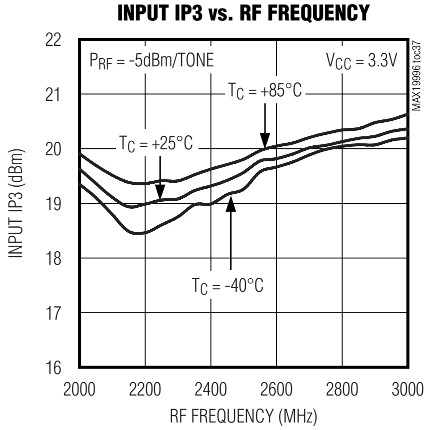

**CONVERSION GAIN vs. RF FREQUENCY**



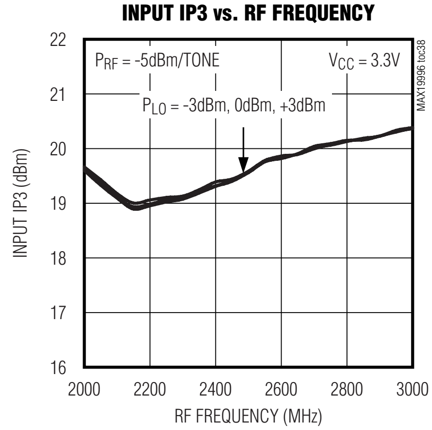

**CONVERSION GAIN vs. RF FREQUENCY**



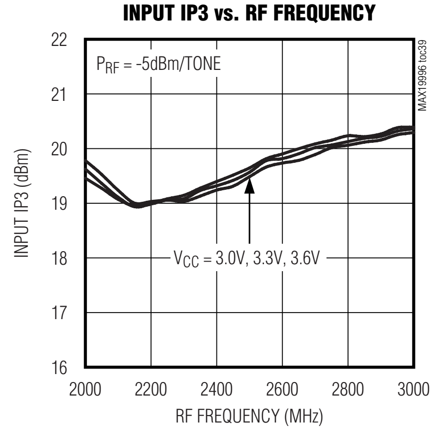

**INPUT IP3 vs. RF FREQUENCY**



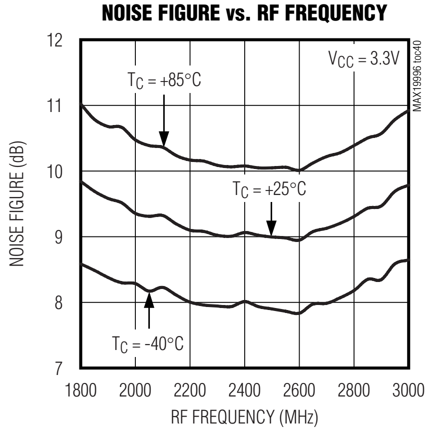

**INPUT IP3 vs. RF FREQUENCY**



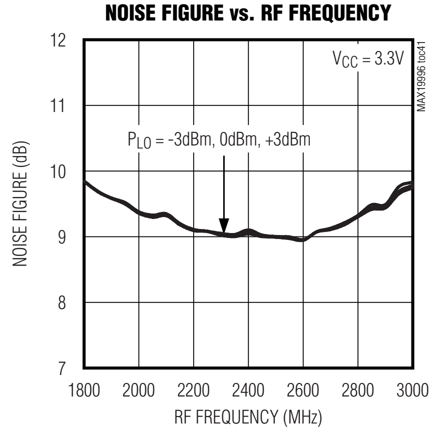

**INPUT IP3 vs. RF FREQUENCY**



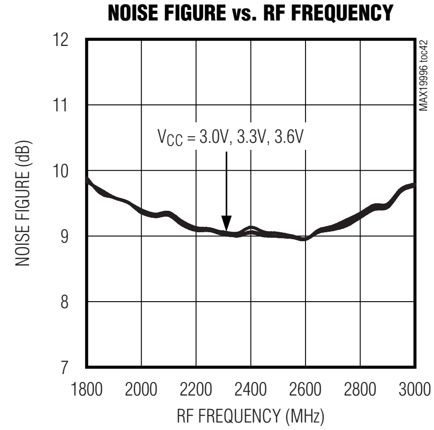

**NOISE FIGURE vs. RF FREQUENCY**




**NOISE FIGURE vs. RF FREQUENCY**



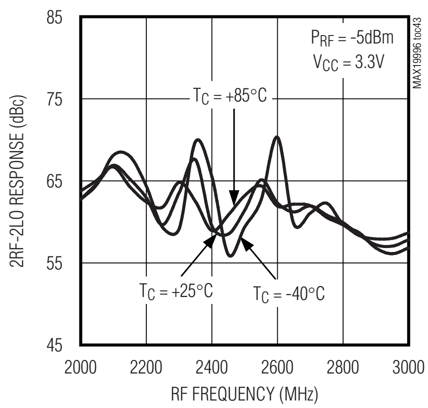

**NOISE FIGURE vs. RF FREQUENCY**



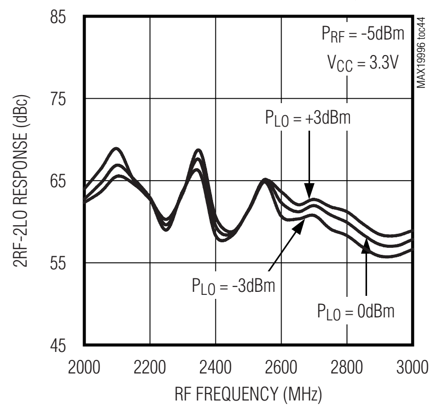
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +3.3V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

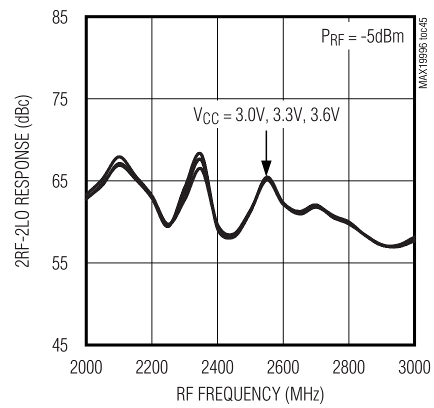
**2RF-2LO RESPONSE vs. RF FREQUENCY**



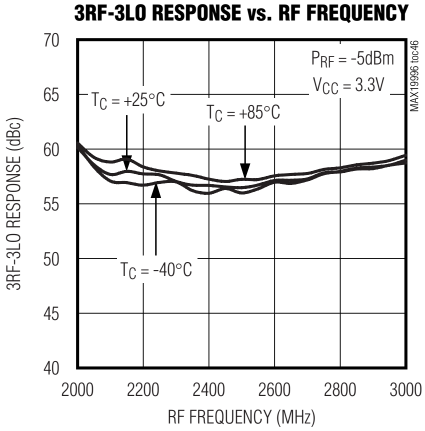

**2RF-2LO RESPONSE vs. RF FREQUENCY**



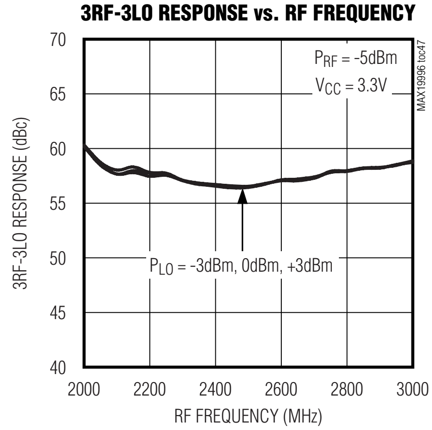

**2RF-2LO RESPONSE vs. RF FREQUENCY**



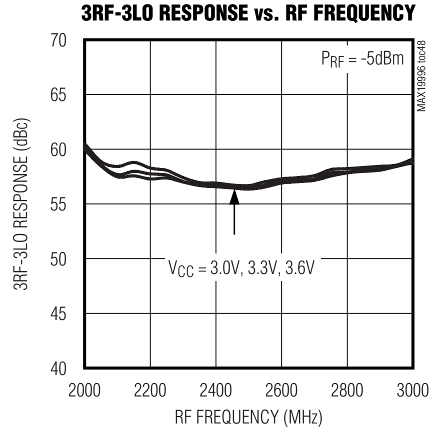

**3RF-3LO RESPONSE vs. RF FREQUENCY**



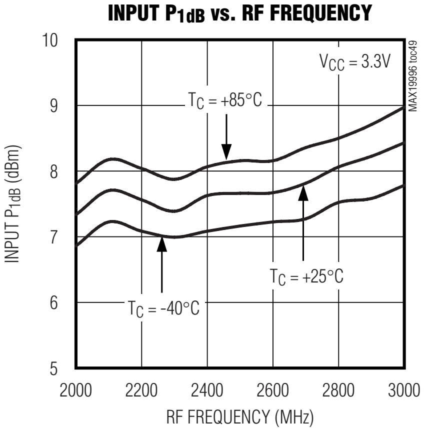

**3RF-3LO RESPONSE vs. RF FREQUENCY**



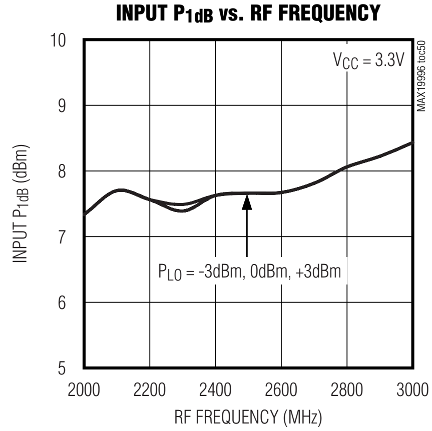

**3RF-3LO RESPONSE vs. RF FREQUENCY**



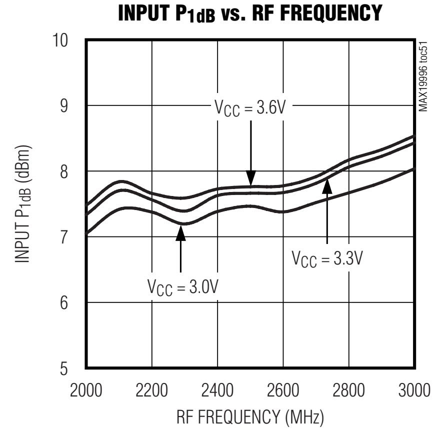

**INPUT $P_{1dB}$ vs. RF FREQUENCY**




**INPUT $P_{1dB}$ vs. RF FREQUENCY**



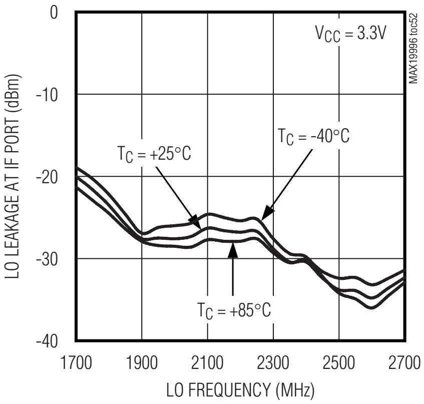

**INPUT $P_{1dB}$ vs. RF FREQUENCY**



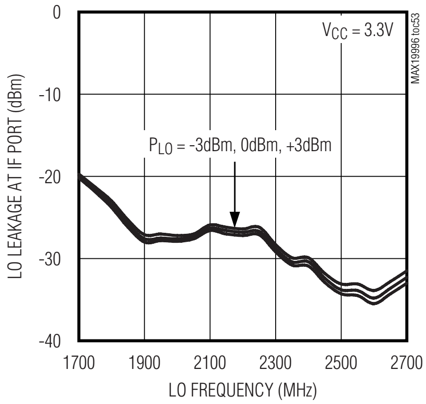
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +3.3V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

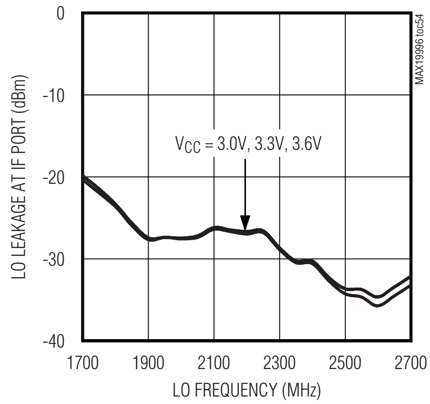
**LO LEAKAGE AT IF PORT vs. LO FREQUENCY**



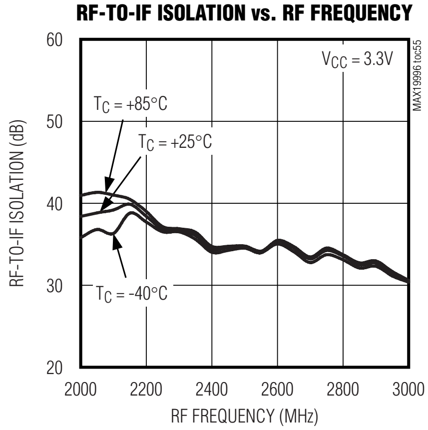

**LO LEAKAGE AT IF PORT vs. LO FREQUENCY**



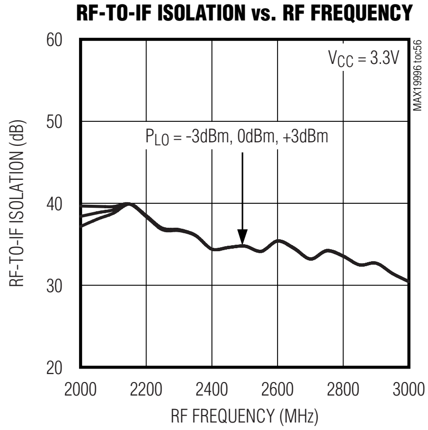

**LO LEAKAGE AT IF PORT vs. LO FREQUENCY**



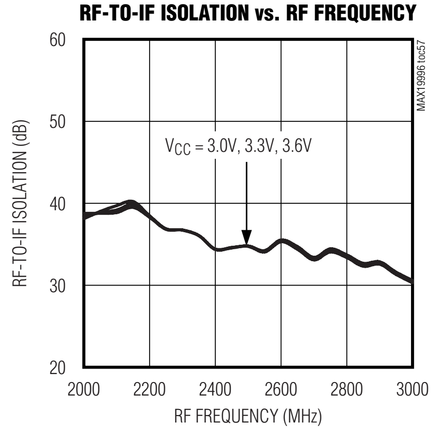

**RF-TO-IF ISOLATION vs. RF FREQUENCY**



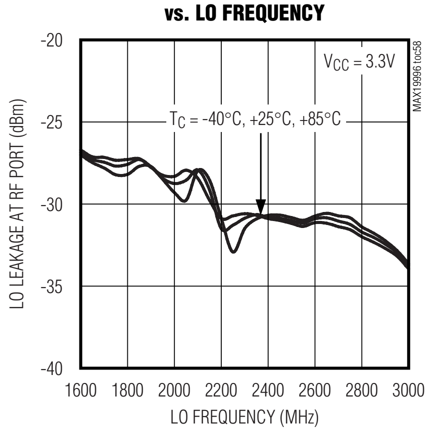

**RF-TO-IF ISOLATION vs. RF FREQUENCY**



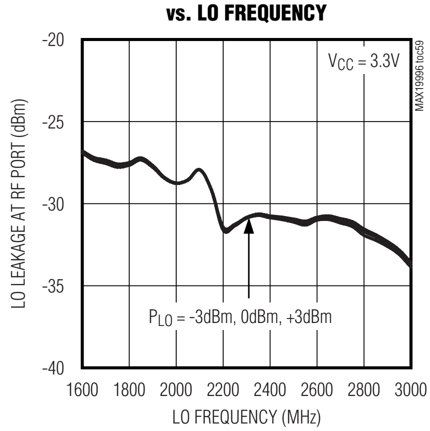

**RF-TO-IF ISOLATION vs. RF FREQUENCY**



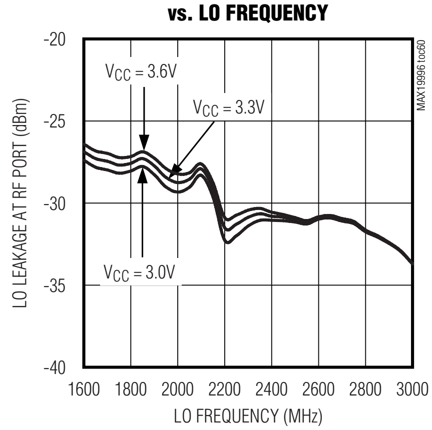

**LO LEAKAGE AT RF PORT vs. LO FREQUENCY**




**LO LEAKAGE AT RF PORT vs. LO FREQUENCY**



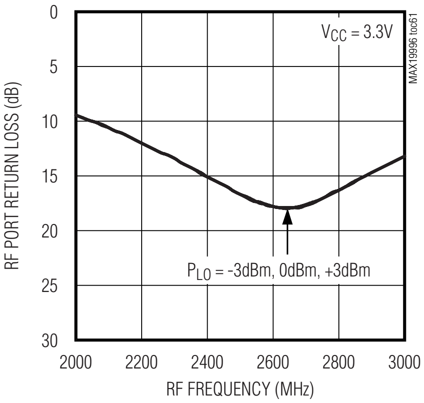

**LO LEAKAGE AT RF PORT vs. LO FREQUENCY**



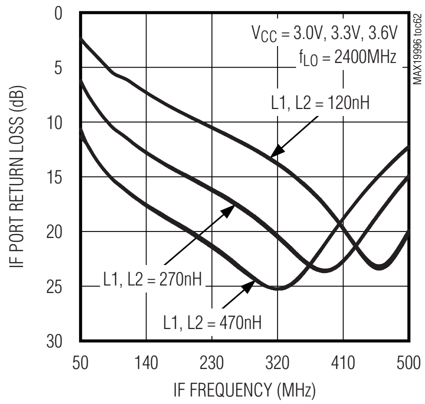
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +3.3V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)

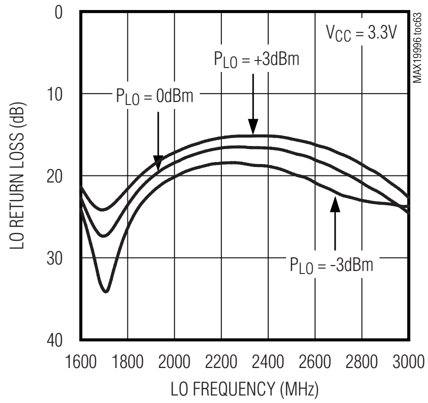
**RF PORT RETURN LOSS vs. RF FREQUENCY**



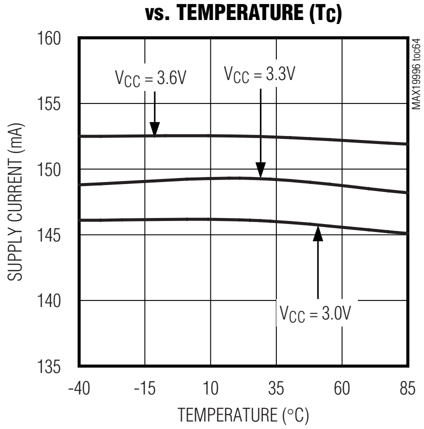

**IF PORT RETURN LOSS vs. IF FREQUENCY**



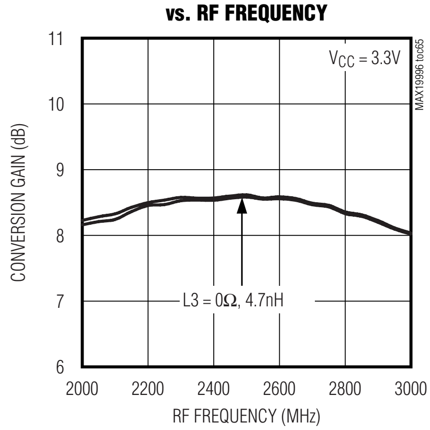

**LO RETURN LOSS vs. LO FREQUENCY**



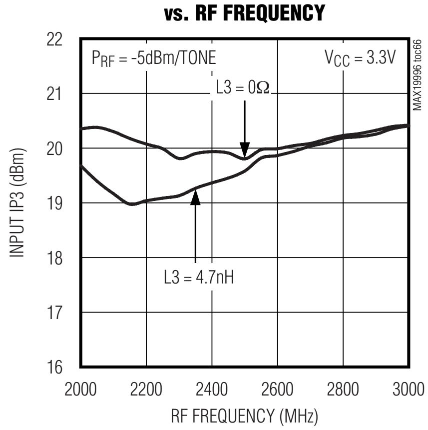

**SUPPLY CURRENT vs. TEMPERATURE ($T_C$)**




**CONVERSION GAIN vs. RF FREQUENCY**



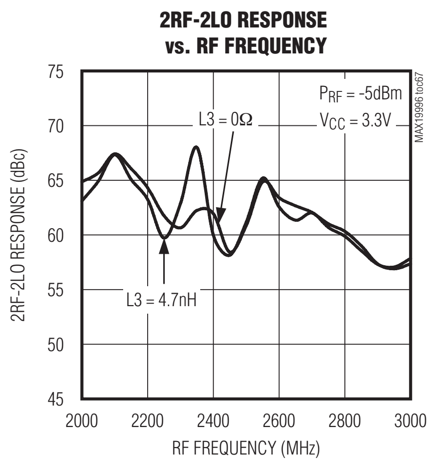

**INPUT IP3 vs. RF FREQUENCY**

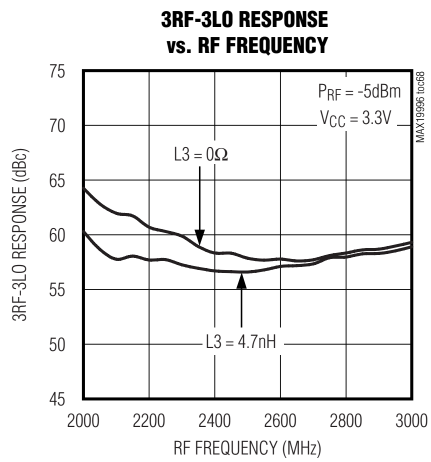


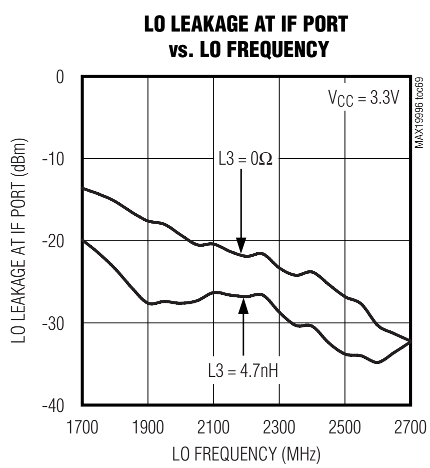
# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

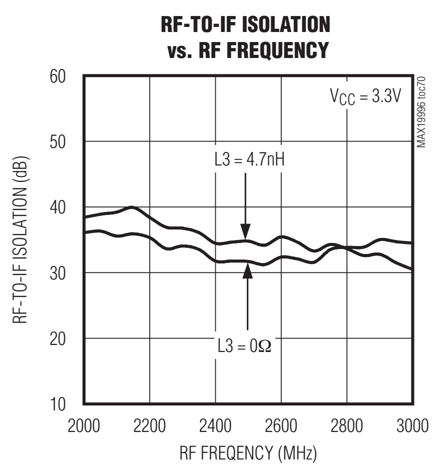
## Typical Operating Characteristics (continued)

(*Typical Application Circuit*, **$V_{CC}$ = +3.3V**, $P_{LO}$ = 0dBm, $P_{RF}$ = -5dBm, LO is low-side injected for a 300MHz IF, $T_C$ = +25°C, unless otherwise noted.)



## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1, 6, 8, 14 | $V_{CC}$ | Power Supply. Bypass to GND with 0.01µF capacitors as close as possible to the pin. |
| 2 | RF | Single-Ended 50Ω RF Input. Internally matched and DC shorted to GND through a balun. Requires an input DC-blocking capacitor. |
| 3, 4, 5, 10, 12, 13, 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 604Ω 1% resistor (230mA bias condition) from LOBIAS to ground. |
| 9, 15 | N.C. | Not internally connected. Pins can be grounded. |
| 11 | LO | Local Oscillator Input. This input is internally matched to 50Ω. Requires an input DC-blocking capacitor. |
| 16 | LEXT | External Inductor Connection. Connect an inductor from this pin to ground to increase the RF-to-IF and LO-to-IF isolation (see the *Typical Operating Characteristics* for typical performance vs. inductor value). |
| 18, 19 | IF-, IF+ | Mixer Differential IF Output. Connect pullup inductors from each of these pins to $V_{CC}$ (see the *Typical Application Circuit*). |
| 20 | IFBIAS | IF Amplifier Bias Control. IF bias resistor connection for the IF amplifier. Connect a 698Ω 1% resistor (230mA bias condition) from IFBIAS to GND. |
| — | EP | Exposed Pad. Internally connected to GND. Connect to a large ground plane using multiple vias to maximize thermal and RF performance. |

# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

## Detailed Description

The MAX19996 high-linearity downconversion mixer provides 8.7dB of conversion gain and +24.5dBm of IIP3, with a typical 9.6dB noise figure. The integrated baluns and matching circuitry allow for 50Ω single-ended interfaces to the RF and the LO port. The integrated LO buffer provides a high drive level to the mixer core, reducing the LO drive required at the MAX19996's input to a -3dBm to +3dBm range. The IF port incorporates a differential output, which is ideal for providing enhanced 2RF-2LO performance.

Specifications are guaranteed over broad frequency ranges to allow for use in WCS, LTE, WiMAX, and MMDS base stations. The MAX19996 is specified to operate over an RF input range of 2000MHz to 3000MHz, an LO range of 1800MHz to 2550MHz, and an IF range of 50MHz to 500MHz. The external IF components set the lower frequency range (see the *Typical Operating Characteristics* for details). Operation beyond these ranges is possible (see the *Typical Operating Characteristics* for additional information). Although this device is optimized for low-side LO injection applications, it can operate in high-side LO injection modes as well. However, performance degrades as $f_{LO}$ continues to increase. For increased high-side LO performance, refer to the MAX19996A data sheet.

### RF Port and Balun

The MAX19996 RF input provides a 50Ω match when combined with a series 8.2pF DC-blocking capacitor. This DC-blocking capacitor is required as the input is internally DC shorted to ground through the on-chip balun. The RF port input return loss is typically 15dB over the RF frequency range of 2300MHz to 2800MHz.

### LO Inputs, Buffer, and Balun

The MAX19996 is optimized for low-side LO injection applications with an 1800MHz to 2550MHz LO frequency range. The LO input is internally matched to 50Ω, 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 MAX19996 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 amplifiers, the performance of IIP3, 2RF-2LO rejection, and noise-figure is typically +24.5dBm, 69dBc, and 9.6dB, respectively.

### Differential IF Output Amplifier

The MAX19996 has an IF frequency range of 50MHz to 500MHz, where the low-end frequency depends on the frequency response of the external IF components. The MAX19996 mixer is tuned for a 450MHz IF using 120nH external pullup bias inductors. Lower IFs of 350MHz and 300MHz require higher inductor values of 270nH and 470nH, respectively. The differential, open-collector IF output ports require these inductors to be connected to $V_{CC}$.

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 200Ω differential IF impedance to a 50Ω 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 ports are designed to operate in a 50Ω system. Use DC blocks at the RF and LO inputs to isolate the ports from external DC while providing some reactive tuning. The IF output impedance is 200Ω (differential). For evaluation, an external low-loss 4:1 (impedance-ratio) balun transforms this impedance down to a 50Ω single-ended output (see the *Typical Application Circuit*).

### Externally Adjustable Bias

Bias currents for the LO buffer and the IF amplifier are optimized by fine-tuning resistors R1 and R2. The values for R1 and R2, as listed in Table 1, represent the nominal values which yield the highest level of linearity performance. Larger value resistors can be used to reduce power dissipation at the expense of some performance loss. Contact the factory for details concerning recommended power reduction vs. performance tradeoffs. If ±1% resistors are not readily available, ±5% resistors can be substituted.

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 up to 57%. 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 tradeoffs.

## Table 1. Component Values

| DESIGNATION | QTY | DESCRIPTION | COMPONENT SUPPLIER |
|---|---|---|---|
| C1 | 1 | 8.2pF microwave capacitor (0402) | Murata Electronics North America, Inc. |
| C2, C6, C8, C11 | 4 | 0.01µF 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. |
| L1, L2 | 2 | 120nH wire-wound high-Q inductors* (0805) (see the *Typical Operating Characteristics*) | Coilcraft, Inc. |
| L3 | 1 | 4.7nH wire-wound high-Q inductor (0603) | Coilcraft, Inc. |
| R1 | 1 | 698Ω ±1% resistor (0402). Use for **$V_{CC}$ = +5.0V** applications.<br>1.1kΩ ±1% resistor (0402). Use for **$V_{CC}$ = +3.3V** applications. | Digi-Key Corp. |
| R2 | 1 | 604Ω ±1% resistor (0402). Use for **$V_{CC}$ = +5.0V** applications.<br>845Ω ±1% resistor (0402). Use for **$V_{CC}$ = +3.3V** applications. | Digi-Key Corp. |
| R3 | 1 | 0Ω resistor (1206) | Digi-Key Corp. |
| T1 | 1 | 4:1 IF balun TC4-1W-17* | Mini-Circuits |
| U1 | 1 | MAX19996 IC (20 TQFN) | Maxim Integrated Products, Inc. |

**Use 470nH inductors and TC4-1W-7A 4:1 balun for IF frequencies below 200MHz.*

### LEXT Inductor

Short LEXT to ground using a 0Ω resistor. For applications requiring improved RF-to-IF and LO-to-IF isolation, a 4.7nH low-ESR inductor can be connected from LEXT to GND. 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 MAX19996 evaluation kit can be used as a reference for board layout. Gerber files are available upon request at **www.maxim-ic.com**.

### Power-Supply Bypassing

Proper voltage-supply bypassing is essential for high-frequency circuit stability. Bypass each $V_{CC}$ pin with the capacitors shown in the *Typical Application Circuit* and see Table 1.

### Exposed Pad RF/Thermal Considerations

The exposed pad (EP) of the MAX19996's 20-pin thin QFN package provides a low thermal-resistance path to the die. It is important that the PCB on which the MAX19996 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.

# SiGe High-Linearity, 2000MHz to 3000MHz Downconversion Mixer with LO Buffer

## Typical Application Circuit