



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

MAX19993

General Description

The MAX19993 dual-channel downconverter is designed to provide 6.4dB of conversion gain, +27dBm input IP3, 15.4dBm 1dB input compression point, and a noise figure of 9.8dB for 1200MHz to 1700MHz diversity receiver applications. With an optimized LO frequency range of 1000MHz to 1560MHz, this mixer is ideal for low-side LO injection architectures. High-side LO injection is supported by the MAX19993A, which is pin-pin and functionally compatible with the MAX19993.

In addition to offering excellent linearity and noise performance, the MAX19993 also yields a high level of component integration. This device includes two double-balanced passive mixer cores, two LO buffers, a dual-input LO selectable switch, and a pair of differential IF output amplifiers. Integrated on-chip baluns allow for single-ended RF and LO inputs. The device requires a nominal LO drive of 0dBm and a typical supply current of 337mA at $V_{CC} = +5.0V$ or 275mA at $V_{CC} = +3.3V$.

The MAX19993 is pin compatible with the MAX9985/MAX19985A/MAX9995/MAX19993A/MAX19994/MAX19994A/MAX19995/MAX19995A series of 700MHz to 2200MHz mixers and pin similar to the MAX19997A/MAX19999 series of 1850MHz to 4000MHz mixers, making this entire family of downconverters ideal for applications where a common PCB layout is used across multiple frequency bands.

The device is available in a 6mm x 6mm, 36-pin TQFN package with an exposed pad. Electrical performance is guaranteed over the extended temperature range, from $T_C = -40^{\circ}C$ to $+85^{\circ}C$.

Applications

WCDMA/LTE Base Stations
 Wireless Local Loop
 Fixed Broadband Wireless Access
 Private Mobile Radios
 Military Systems

Features

- ◆ 1200MHz to 1700MHz RF Frequency Range
- ◆ 1000MHz to 1560MHz LO Frequency Range
- ◆ 50MHz to 500MHz IF Frequency Range
- ◆ 6.4dB Typical Conversion Gain
- ◆ 9.8dB Typical Noise Figure
- ◆ +27dBm Typical Input IP3
- ◆ 15.4dBm Typical Input 1dB Compression Point
- ◆ 72dBc Typical 2RF - 2LO Spurious Rejection at PRF = -10dBm
- ◆ Dual Channels Ideal for Diversity Receiver Applications
- ◆ 47dB Typical Channel-to-Channel Isolation
- ◆ Low -6dBm to +3dBm LO Drive
- ◆ Integrated LO Buffer
- ◆ Internal RF and LO Baluns for Single-Ended Inputs
- ◆ Built-In SPDT LO Switch with 57dB LO-to-LO Isolation and 50ns Switching Time
- ◆ Pin Compatible with the MAX9985/MAX19985A/MAX9995/MAX19993A/MAX19994/MAX19994A/MAX19995/MAX19995A Series of 700MHz to 2200MHz Mixers
- ◆ Pin Similar to the MAX19997A/MAX19999 Series of 1850MHz to 4000MHz Mixers
- ◆ Single +5V 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 |
|---------------|----------------|-------------|
| MAX19993ETX+ | -40°C to +85°C | 36 TQFN-EP* |
| MAX19993ETX+T | -40°C to +85°C | 36 TQFN-EP* |

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

*EP = Exposed pad.

T = Tape and reel.

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ABSOLUTE MAXIMUM RATINGS

| | | | |
|--|-----------------------|--|-----------------|
| VCC to GND..... | -0.3V to +5.5V | Continuous Power Dissipation (Note 1) | 8.7W |
| LO1, LO2 to GND..... | ±0.3V | θJA (Notes 2, 3) | +38°C/W |
| LOSEL to GND | -0.3V to (VCC + 0.3V) | θJC (Notes 1, 3) | 7.4°C/W |
| RFMAIN, RFDIV, and LO_ Input Power | +15dBm | Operating Temperature Range (Note 4)... TC = | -40°C to +85°C |
| RFMAIN, RFDIV Current (RF is DC shorted to GND through a balun)..... | 50mA | Junction Temperature | +150°C |
| TAPMAIN, TAPDIV to GND | -0.3V to +2V | Storage Temperature Range..... | -65°C to +150°C |
| Any Other Pins to GND | -0.3V to (VCC + 0.3V) | Lead Temperature (soldering, 10s)..... | +300°C |
| | | Soldering Temperature (reflow) | +260°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. $T_C = -40^\circ C$ to $+85^\circ C$, $R1 = R4 = 681\Omega$, $R2 = R5 = 1.82k\Omega$. Typical values are at $V_{CC} = 5.0V$, $T_C = +25^\circ C$, unless otherwise noted. All parameters are production tested.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--------------------------|-----------------------|----------------------|------|-----|------|-------|
| Supply Voltage | V_{CC} | | 4.75 | 5 | 5.25 | V |
| Supply Current | I_{CC} | Total supply current | | 337 | 400 | mA |
| LOSEL Input High Voltage | V_{IH} | | 2 | | | V |
| LOSEL Input Low Voltage | V_{IL} | | | | 0.8 | V |
| LOSEL Input Current | I_{IH} and I_{IL} | | -10 | | +10 | μA |

3.3V SUPPLY DC ELECTRICAL CHARACTERISTICS

(Typical Application Circuit, $V_{CC} = 3.0V$ to $3.6V$, no input AC signals. $T_C = -40^\circ C$ to $+85^\circ C$, $R1 = R4 = 681\Omega$, $R2 = R5 = 1.43k\Omega$. Typical values are at $V_{CC} = 3.3V$, $T_C = +25^\circ C$, unless otherwise noted. Parameters are guaranteed by design and not production tested.)

| 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 (Note 5) | | 275 | | mA |
| LOSEL Input High Voltage | V_{IH} | | | 2 | | V |
| LOSEL Input Low Voltage | V_{IL} | | | 0.8 | | V |

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RECOMMENDED AC OPERATING CONDITIONS

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|----------------|----------|--|------|-----|------|-------|
| RF Frequency | f_{RF} | (Note 6) | 1200 | | 1700 | MHz |
| LO Frequency | f_{LO} | (Note 6) | 1000 | | 1560 | MHz |
| IF Frequency | f_{IF} | Using 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 (Note 6) | 100 | | 500 | MHz |
| | | Using 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 (Note 6) | 50 | | 250 | |
| LO Drive Level | P_{LO} | (Note 6) | -6 | | +3 | dBm |

5.0V SUPPLY, LOW-SIDE INJECTION AC ELECTRICAL CHARACTERISTICS

(*Typical Application Circuit* (see Table 1). $R1 = R4 = 681\Omega$, $R2 = R5 = 1.82k\Omega$, $V_{CC} = 4.75V$ to $5.25V$, RF and LO ports are driven from 50Ω sources, $P_{LO} = -6dBm$ to $+3dBm$, $P_{RF} = -5dBm$, $f_{RF} = 1200MHz$ to $1700MHz$, $f_{LO} = 1060MHz$ to $1560MHz$, $f_{IF} = 140MHz$, $f_{RF} > f_{LO}$, $T_C = -40^\circ C$ to $+85^\circ C$. Typical values are at $V_{CC} = +5.0V$, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $f_{RF} = 1450MHz$, $f_{LO} = 1310MHz$, $f_{IF} = 140MHz$, $T_C = +25^\circ C$. All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|--------------|--|------|------------|------|----------------|
| Conversion Gain (Note 5) | G_C | | 4.5 | 6.4 | 7.4 | dB |
| | | $T_C = +25^\circ C$ | 5.1 | 6.4 | 7.0 | |
| | | $T_C = +25^\circ C$, $f_{RF} = 1427MHz$ to $1463MHz$ | 5.2 | 6.4 | 6.9 | |
| Conversion Gain Flatness | ΔG_C | $f_{RF} = 1427MHz$ to $1463MHz$ | | ± 0.03 | | dB |
| Gain Variation Over Temperature | T_{CCG} | $T_C = -40^\circ C$ to $+85^\circ C$ | | -0.009 | | dB/ $^\circ C$ |
| Input Compression Point | IP_{1dB} | $f_{RF} = 1450MHz$ (Notes 5, 8) | 12.9 | 15.4 | | dBm |
| Input Third-Order Intercept Point | $IIP3$ | $f_{RF1} - f_{RF2} = 1MHz$, $P_{RF} = -5dBm$ per tone | 24.0 | 27.0 | | dBm |
| | | $f_{RF1} - f_{RF2} = 1MHz$, $P_{RF} = -5dBm$ per tone, $f_{RF} = 1427MHz$ to $1463MHz$, $T_C = +25^\circ C$ (Note 5) | 24.8 | 27.0 | | |
| | | $f_{RF1} - f_{RF2} = 1MHz$, $P_{RF} = -5dBm$ per tone, $f_{RF} = 1427MHz$ to $1463MHz$ (Note 5) | 24.4 | 27.0 | | |
| Input Third-Order Intercept Point Variation Over Temperature | TC_{IIP3} | $f_{RF1} - f_{RF2} = 1MHz$, $P_{RF} = -5dBm$ per tone, $T_C = -40^\circ C$ to $+85^\circ C$ | | ± 0.5 | | dBm |
| Noise Figure (Note 9) | NF_{SSB} | Single sideband, no blockers present | | 9.8 | 12.7 | dB |
| | | $f_{RF} = 1427MHz$ to $1463MHz$, $T_C = +25^\circ C$, $P_{LO} = 0dBm$, single sideband, no blockers present | | 9.8 | 11.0 | |
| | | $f_{RF} = 1427MHz$ to $1463MHz$, $P_{LO} = 0dBm$, single sideband, no blockers present | | 9.8 | 12.0 | |

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5.0V SUPPLY, LOW-SIDE INJECTION AC ELECTRICAL CHARACTERISTICS (continued)

(Typical Application Circuit (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.82kΩ, V_{CC} = 4.75V to 5.25V, RF and LO ports are driven from 50Ω sources, P_{LO} = -6dBm to +3dBm, P_{RF} = -5dBm, f_{RF} = 1200MHz to 1700MHz, f_{LO} = 1060MHz to 1560MHz, f_{IF} = 140MHz, 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} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C. All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|--------------------------------------|------------------|--|--------------------------|-----|-------|------|-------|
| Noise Figure Temperature Coefficient | TC _{NF} | Single sideband, no blockers present, T _C = -40°C to +85°C | | | 0.016 | | dB/°C |
| Noise Figure with Blocker | NFB | PBLOCKER = +8dBm, f _{RF} = 1450MHz, f _{LO} = 1310MHz, f _{BLOCKER} = 1550MHz, P _{LO} = 0dBm, V _{CC} = 5.0V, T _C = +25°C (Notes 9, 10) | | | 21.0 | 22.8 | dB |
| 2RF - 2LO Spur Rejection (Note 9) | 2x2 | f _{RF} = 1450MHz, f _{LO} = 1310MHz, f _{SPUR} = 1380MHz | P _{RF} = -10dBm | 58 | 72 | | dBc |
| | | | P _{RF} = -5dBm | 53 | 67 | | |
| | | f _{RF} = 1450MHz, f _{LO} = 1310MHz, f _{SPUR} = 1380MHz, P _{LO} = 0dBm, V _{CC} = 5.0V, T _C = +25°C | P _{RF} = -10dBm | 61 | 72 | | dBc |
| | | | P _{RF} = -5dBm | 56 | 67 | | |
| 3RF - 3LO Spur Rejection (Note 9) | 3x3 | f _{RF} = 1450MHz, f _{LO} = 1310MHz, f _{SPUR} = 1356.67MHz | P _{RF} = -10dBm | 77 | 93 | | dBc |
| | | | P _{RF} = -5dBm | 67 | 83 | | |
| | | f _{RF} = 1450MHz, f _{LO} = 1310MHz, f _{SPUR} = 1356.67MHz, P _{LO} = 0dBm, V _{CC} = 5.0V, T _C = +25°C | P _{RF} = -10dBm | 82 | 93 | | dBc |
| | | | P _{RF} = -5dBm | 72 | 83 | | |
| RF Input Return Loss | | LO and IF terminated into matched impedance, LO on | | | 21 | | dB |
| LO Input Return Loss | | LO port selected, RF and IF terminated into matched impedance | | | 24 | | dB |
| | | LO port unselected, RF and IF terminated into matched impedance | | | 27 | | |
| IF Output Impedance | Z _{IF} | Nominal differential impedance of the 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 <i>Typical Application Circuit</i> | | | 15 | | dB |
| RF-to-IF Isolation | | (Note 5) | | | 33 | | dB |
| LO Leakage at RF Port | | | | | -38 | | dBm |
| 2LO Leakage at RF Port | | | | | -27 | | dBm |

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5.0V SUPPLY, LOW-SIDE INJECTION AC ELECTRICAL CHARACTERISTICS (continued)

(Typical Application Circuit (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.82kΩ, V_{CC} = 4.75V to 5.25V, RF and LO ports are driven from 50Ω sources, P_{LO} = -6dBm to +3dBm, P_{RF} = -5dBm, f_{RF} = 1200MHz to 1700MHz, f_{LO} = 1060MHz to 1560MHz, f_{IF} = 140MHz, 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} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C. All parameters are guaranteed by design and characterization, unless otherwise noted.) (Note 7)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|----------------------------|--------|---|-----|-----|-----|-------|
| LO Leakage at IF Port | | (Note 5) | | -18 | | dBm |
| Channel Isolation (Note 5) | | RFMAIN converted power measured at IFDIV relative to IFMAIN, all unused ports terminated to 50Ω | 43 | 47 | | dB |
| | | RFDIV converted power measured at IFMAIN relative to IFDIV, all unused ports terminated to 50Ω | 43 | 47 | | |
| LO-to-LO Isolation | | P _{LO1} = +3dBm, P _{LO2} = +3dBm, f _{LO1} = 1310MHz, f _{LO2} = 1311MHz (Note 5) | 47 | 57 | | dB |
| LO Switching Time | | 50% of LOSEL to IF settled within 2 degrees | | 50 | | ns |

3.3V SUPPLY, LOW SIDE INJECTION AC ELECTRICAL CHARACTERISTICS

(Typical Application Circuit (see Table 1). R1 = R4 = 681Ω, R2 = R5 = 1.43kΩ. Typical values are at V_{CC} = 3.3V, P_{RF} = -5dBm, P_{LO} = 0dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C, unless otherwise noted.) (Note 7)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|--|--------------------|---|-----|--------|-----|-------|
| Conversion Gain | G _C | (Note 5) | | 6.2 | | dB |
| Conversion Gain Flatness | ΔG _C | f _{RF} = 1427MHz to 1463MHz | | ±0.05 | | dB |
| Gain Variation Over Temperature | T _{CCG} | T _C = -40°C to +85°C | | -0.009 | | dB/°C |
| Input Compression Point | IP _{1dB} | (Note 8) | | 12.8 | | dBm |
| Input Third-Order Intercept Point | IIP ₃ | f _{RF1} - f _{RF2} = 1MHz | | 24.4 | | dBm |
| Input Third-Order Intercept Point Variation Over Temperature | TC _{IIP3} | f _{RF1} - f _{RF2} = 1MHz, P _{RF} = -5dBm per tone, T _C = -40°C to +85°C | | ±0.8 | | dBm |
| Noise Figure | N _{FSSB} | Single sideband, no blockers present | | 9.8 | | dB |
| Noise Figure Temperature Coefficient | T _{CNF} | Single sideband, no blockers present, T _C = -40°C to +85°C | | 0.016 | | dB/°C |
| 2RF - 2LO Spur Rejection | 2 x 2 | P _{RF} = -10dBm | | 73 | | dBc |
| | | P _{RF} = -5dBm | | 68 | | |
| 3RF - 3LO Spur Rejection | 3 x 3 | P _{RF} = -10dBm | | 80 | | dBc |
| | | P _{RF} = -5dBm | | 70 | | |
| RF Input Return Loss | | LO and IF terminated into matched impedance, LO on | | 21 | | dB |
| LO Input Return Loss | | LO port selected, RF and IF terminated into matched impedance | | 24 | | dB |
| | | LO port unselected, RF and IF terminated into matched impedance | | 27 | | |

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3.3V SUPPLY, LOW SIDE INJECTION AC ELECTRICAL CHARACTERISTICS (continued)

(*Typical Application Circuit* (see Table 1). R1 = R4 = 681 Ω , R2 = R5 = 1.43k Ω . Typical values are at V_{CC} = 3.3V, PRF = -5dBm, P_{LO} = 0dBm, f_{RF} = 1450MHz, f_{LO} = 1310MHz, f_{IF} = 140MHz, T_C = +25°C, unless otherwise noted.) (Note 7)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|------------------------|--------|---|-----|-----|-----|-------|
| IF Output Return Loss | | RF terminated into 50 Ω , LO driven by 50 Ω source, IF transformed to 50 Ω using external components shown in the <i>Typical Application Circuit</i> | | 15 | | dB |
| RF-to-IF Isolation | | | | 33 | | dB |
| LO Leakage at RF Port | | | | -45 | | dBm |
| 2LO Leakage at RF Port | | | | -27 | | dBm |
| LO Leakage at IF Port | | | | -22 | | dBm |
| Channel Isolation | | RFMAIN converted power measured at IFDIV relative to IFMAIN, all unused ports terminated to 50 Ω | | 47 | | dB |
| | | RFDIV converted power measured at IFMAIN relative to IFDIV, all unused ports terminated to 50 Ω | | 47 | | |
| LO-to-LO Isolation | | P _{LO1} = +3dBm, P _{LO2} = +3dBm, f _{LO1} = 1310MHz, f _{LO2} = 1311MHz | | 57 | | dB |
| LO Switching Time | | 50% of LOSEL to IF settled within 2 degrees | | 50 | | ns |

Note 5: 100% production tested for functionality.

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

Note 7: All limits reflect losses of external components, including a 0.5dB loss at f_{IF} = 140MHz due to the 4:1 transformer. Output measurements were taken at IF outputs of the *Typical Application Circuit*.

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

Note 9: Not production tested.

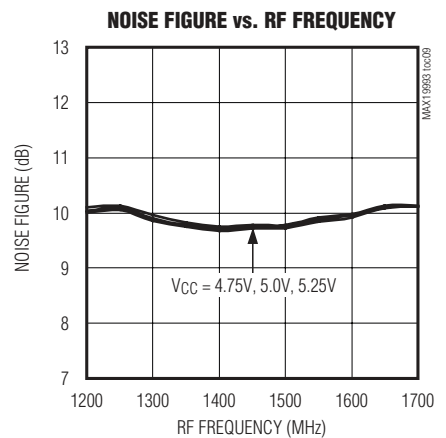
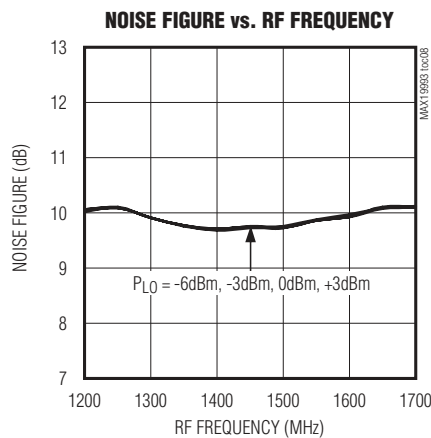
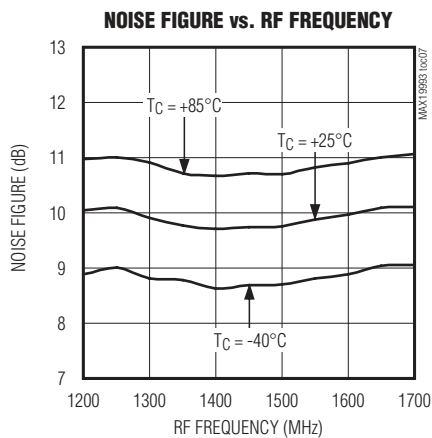
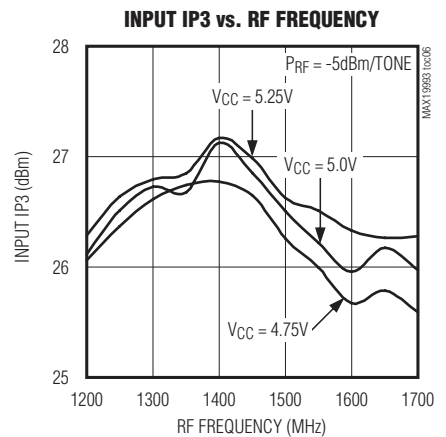
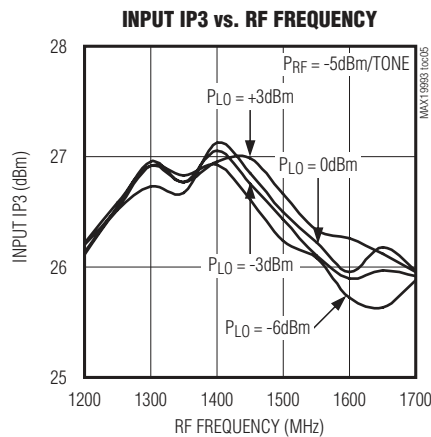
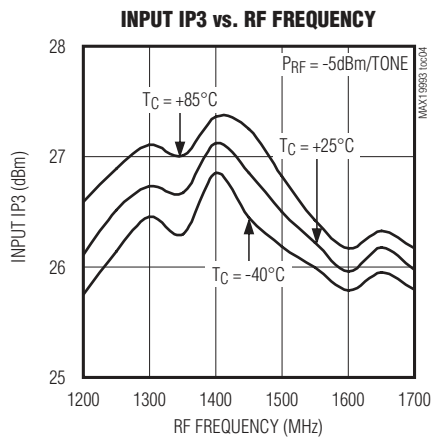
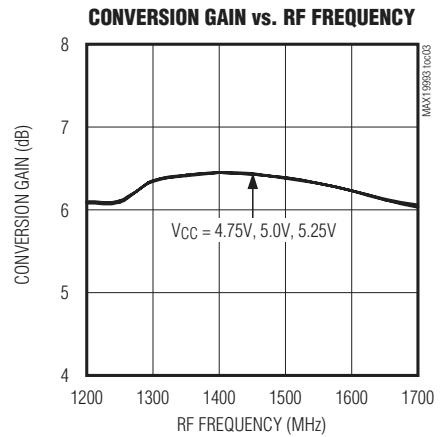
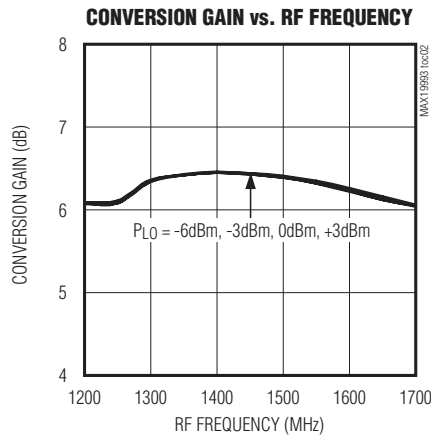
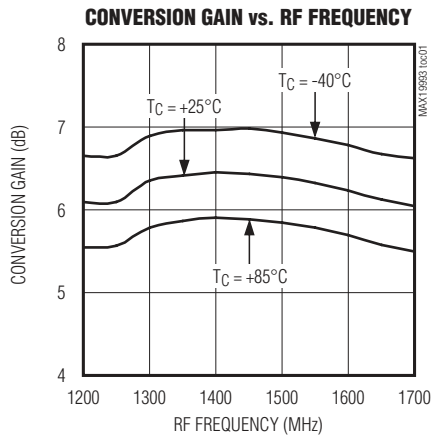
Note 10: Measured with external LO source noise filtered so the noise floor is -174dBm/Hz. This specification reflects the effects of all SNR degradations in the mixer, including the LO noise as defined in Application Note 2021: *Specifications and Measurement of Local Oscillator Noise in Integrated Circuit Base Station Mixers*.

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Typical Operating Characteristics

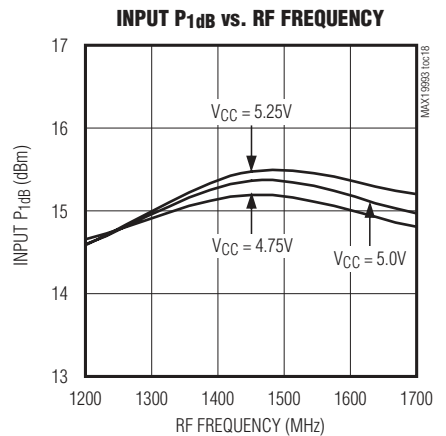
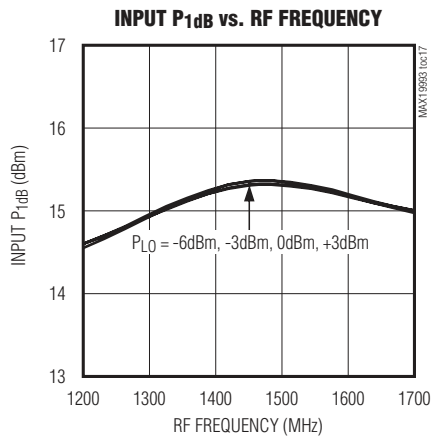
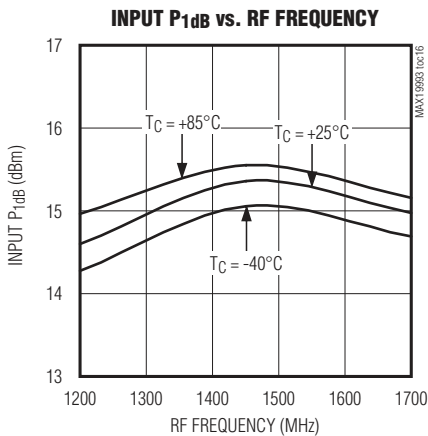
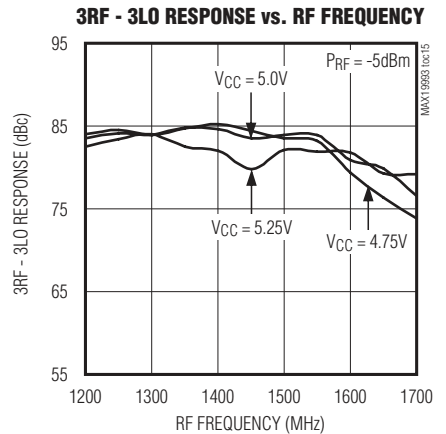
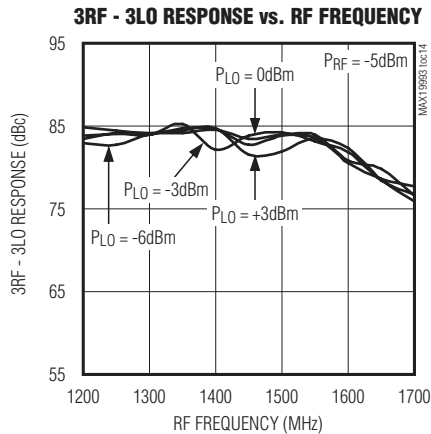
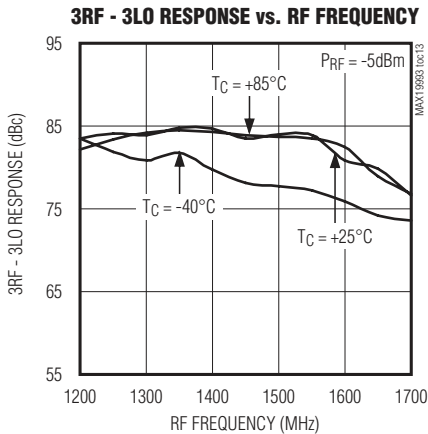
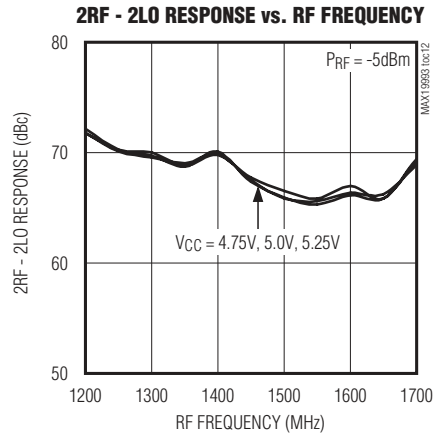
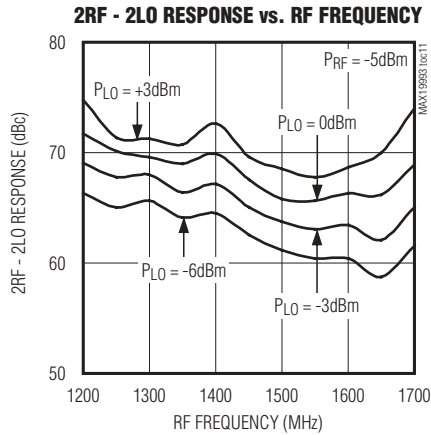
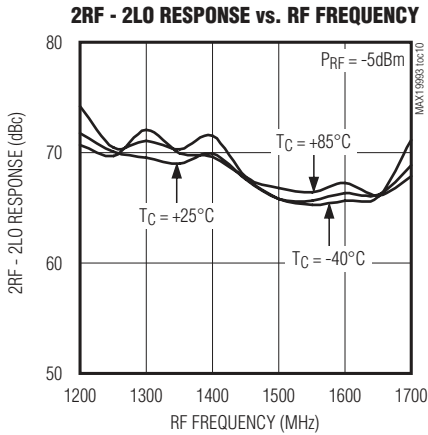
(Typical Application Circuit (see Table 1). $V_{CC} = 5.0V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

(Typical Application Circuit (see Table 1). $V_{CC} = 5.0V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)

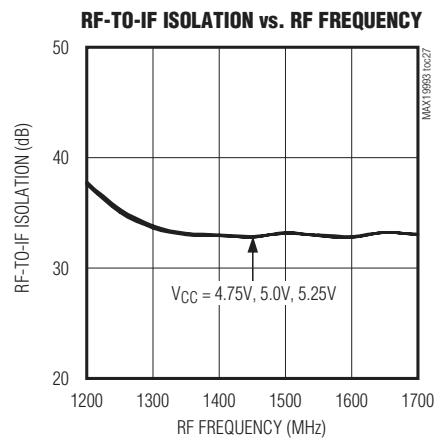
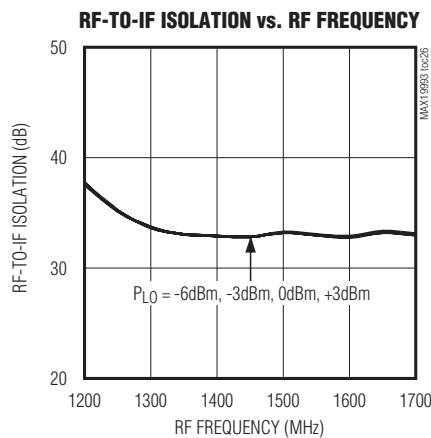
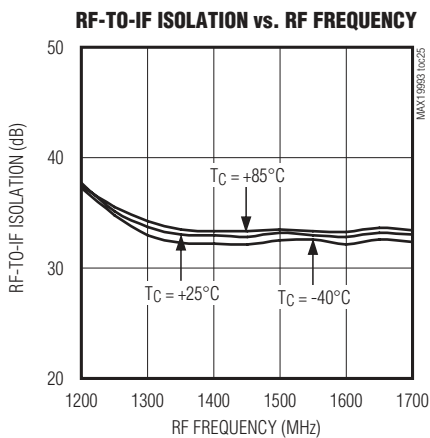
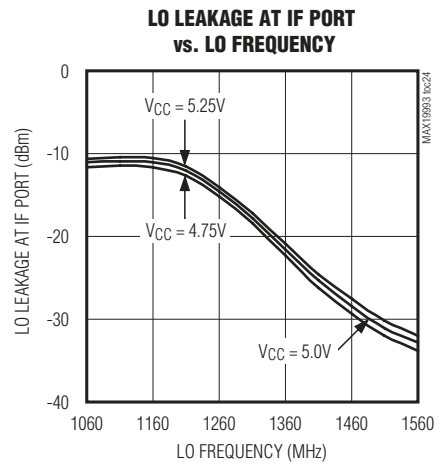
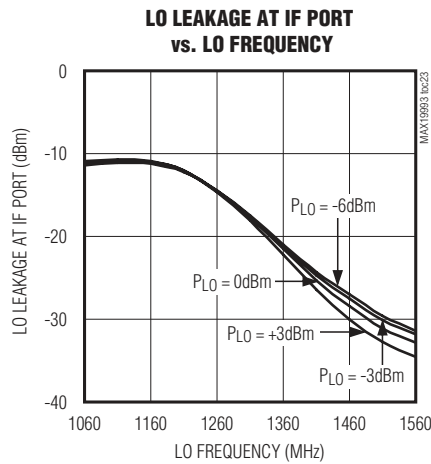
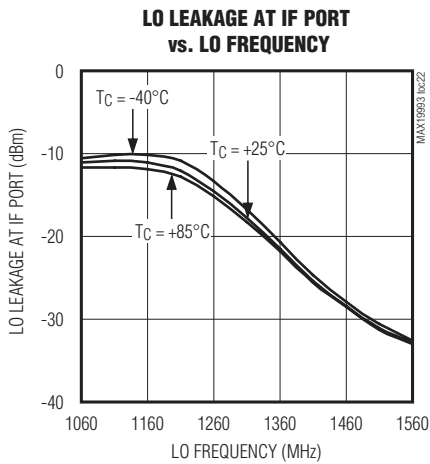
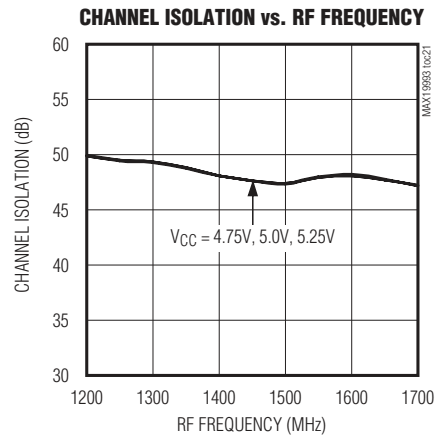
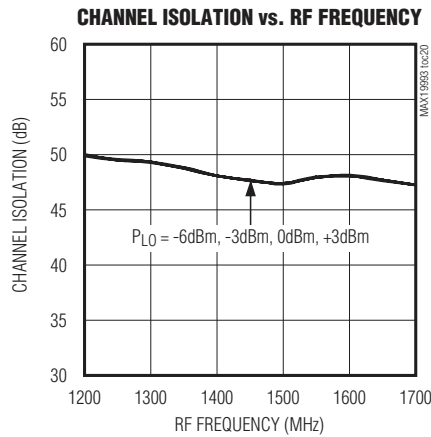
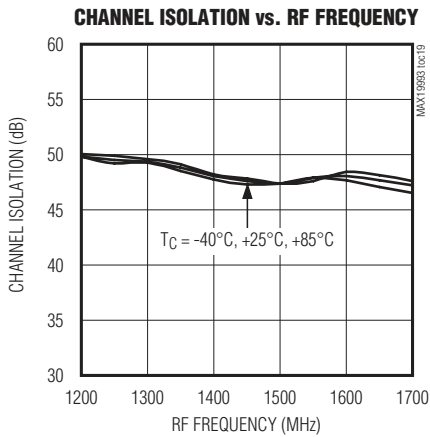


Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

MAX19993

Typical Operating Characteristics (continued)

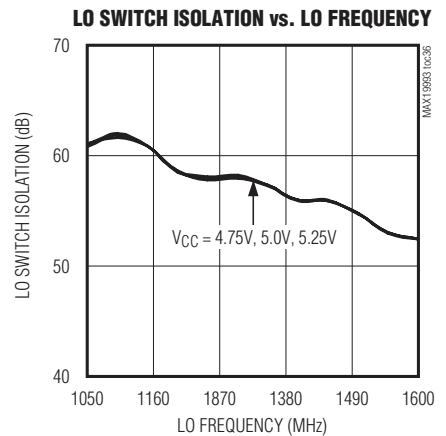
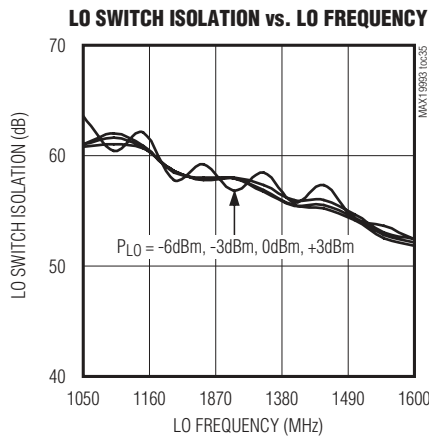
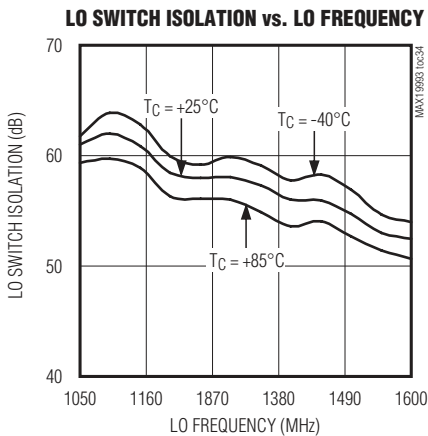
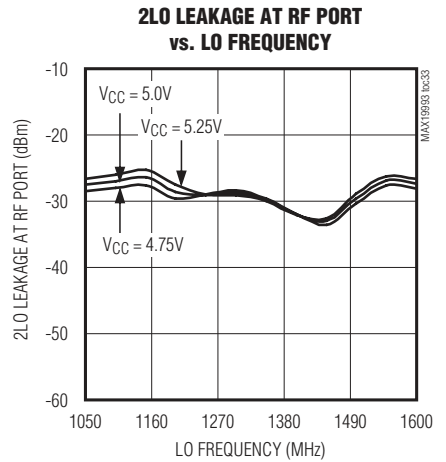
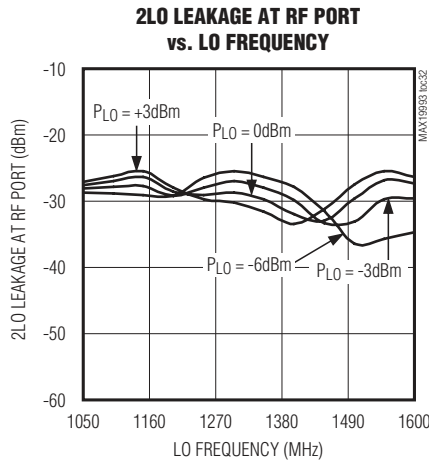
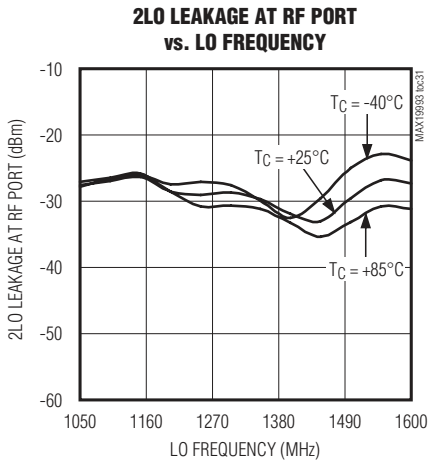
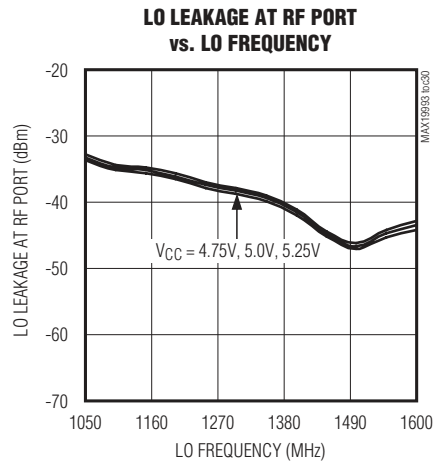
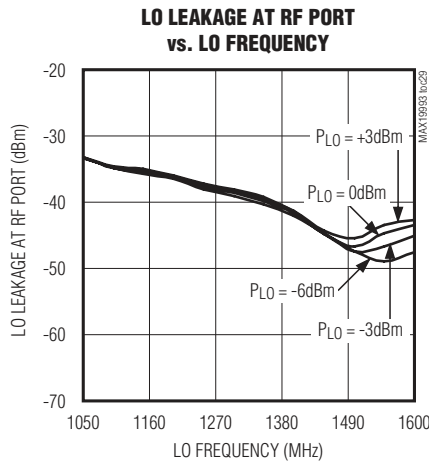
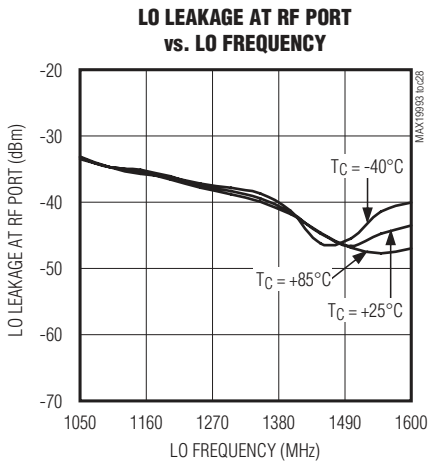
(Typical Application Circuit (see Table 1). $V_{CC} = 5.0V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

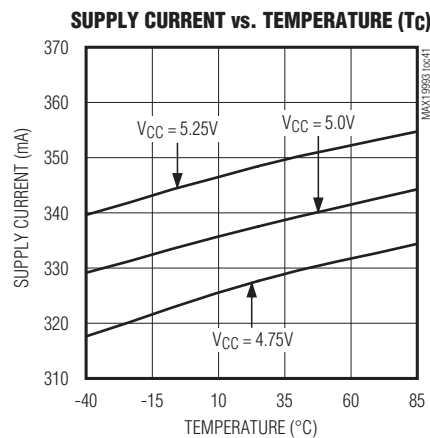
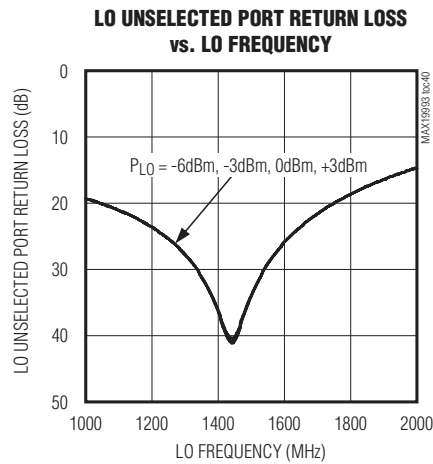
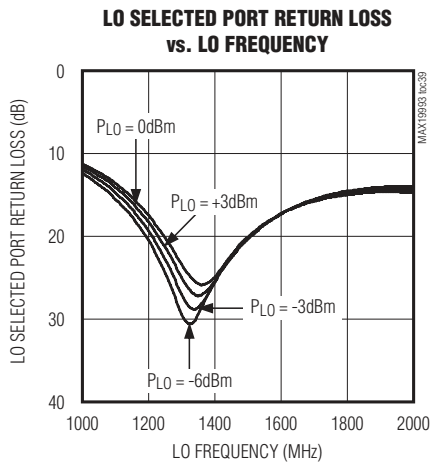
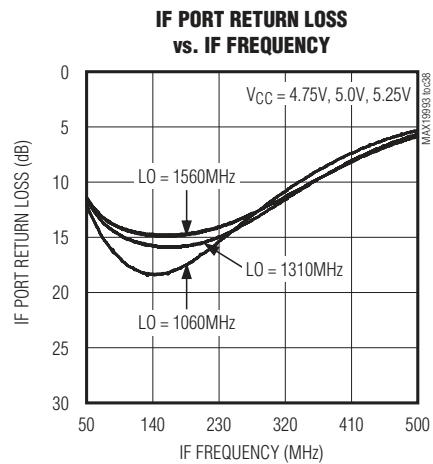
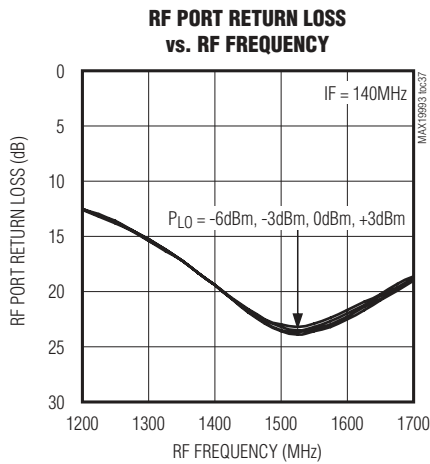
(Typical Application Circuit (see Table 1). $V_{CC} = 5.0V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

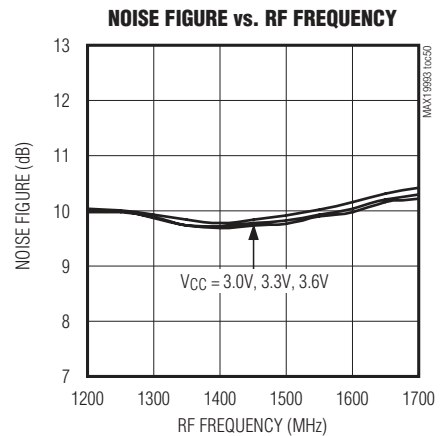
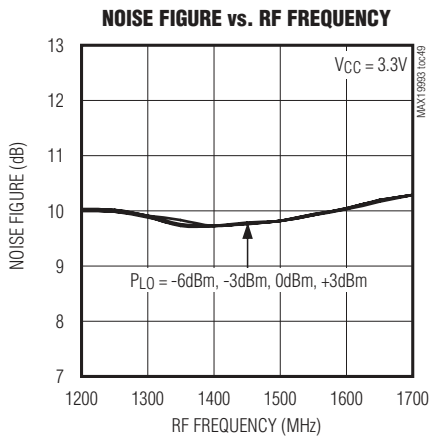
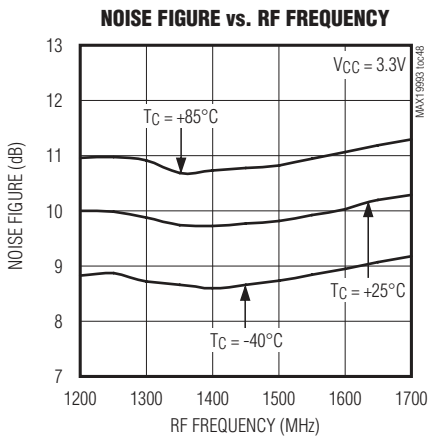
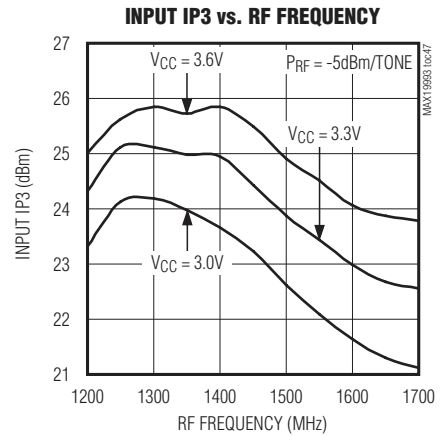
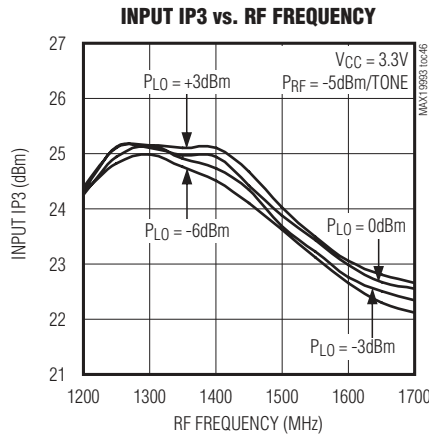
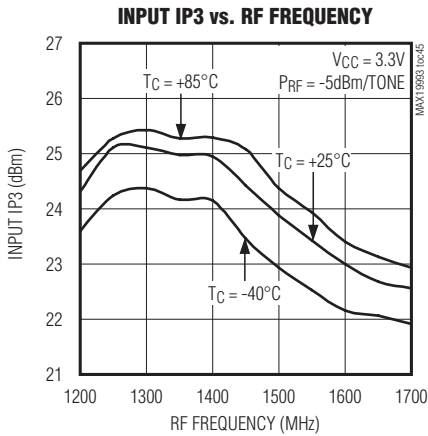
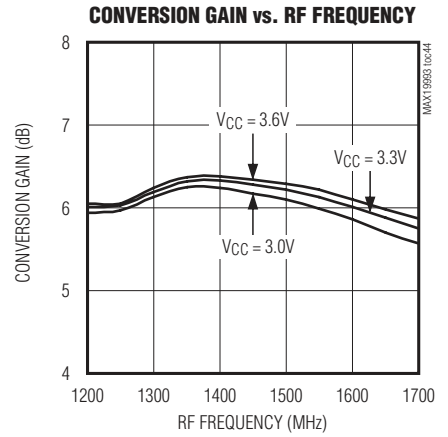
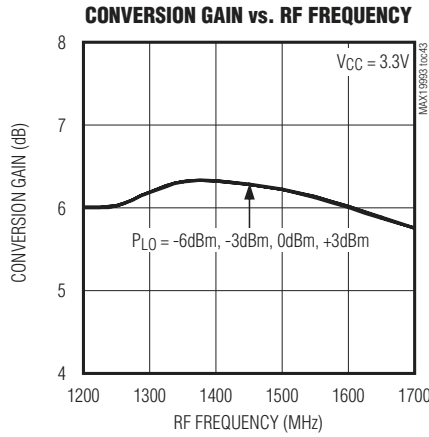
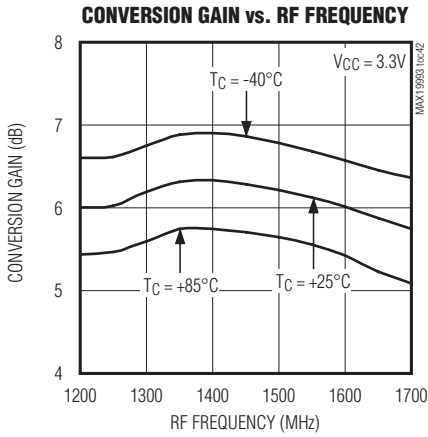
(Typical Application Circuit (see Table 1). $V_{CC} = 5.0V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

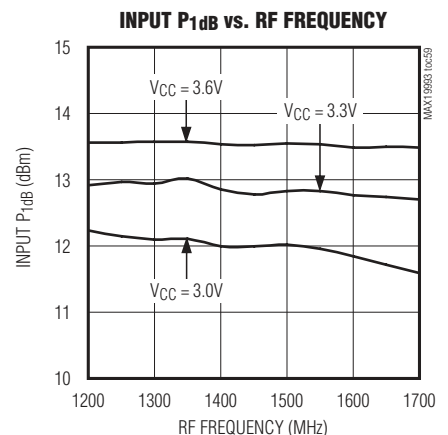
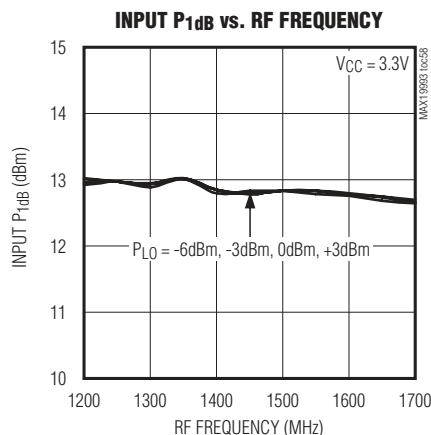
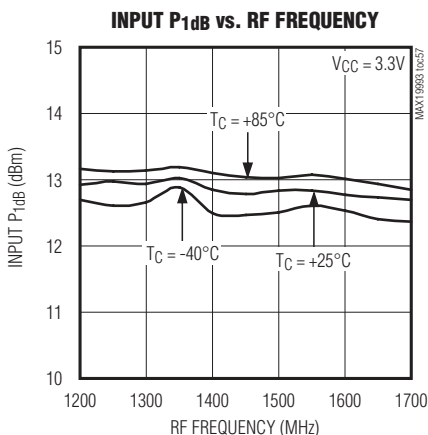
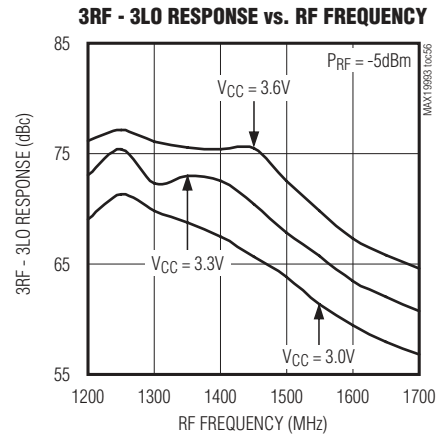
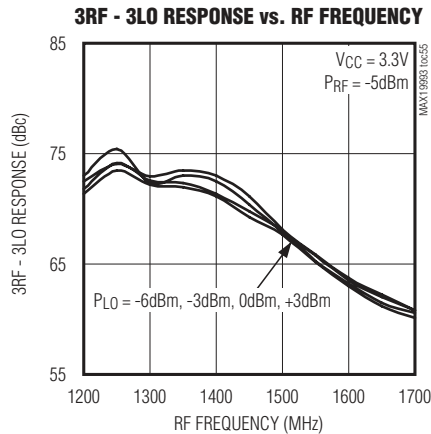
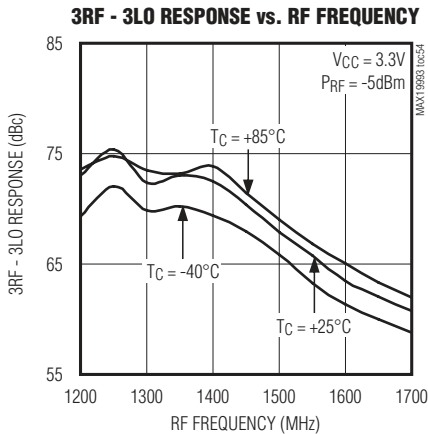
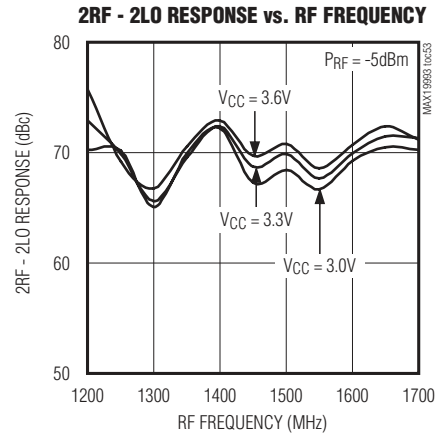
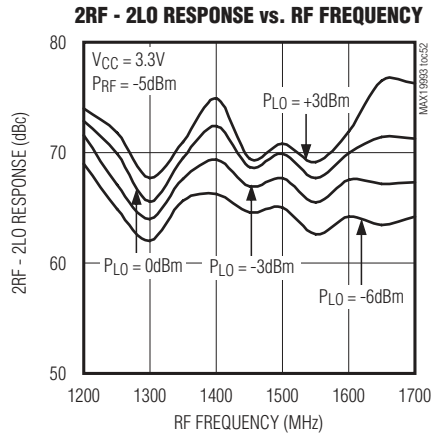
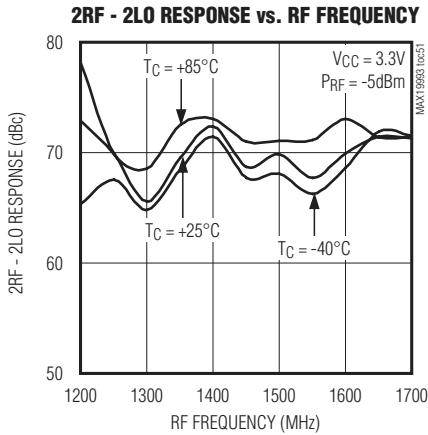
(Typical Application Circuit (see Table 1). $V_{CC} = 3.3V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

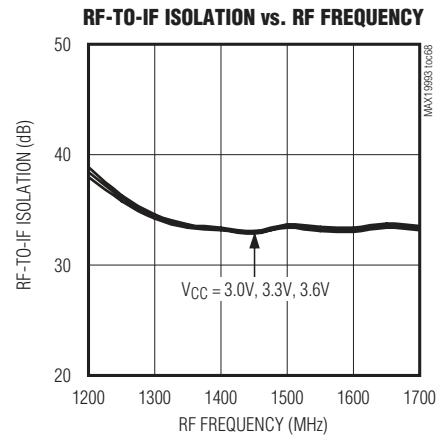
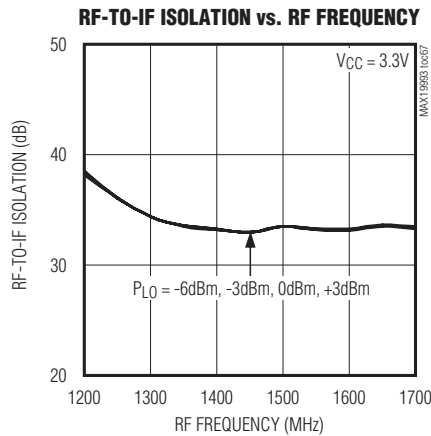
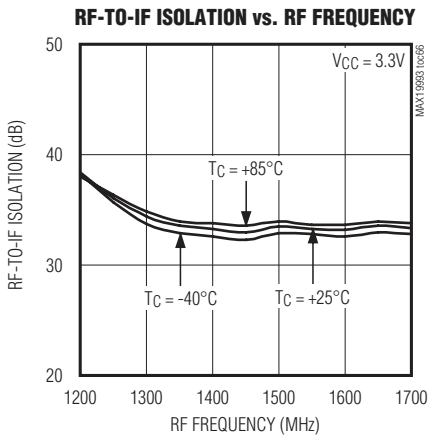
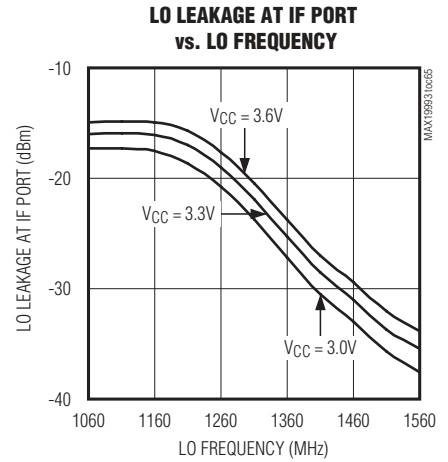
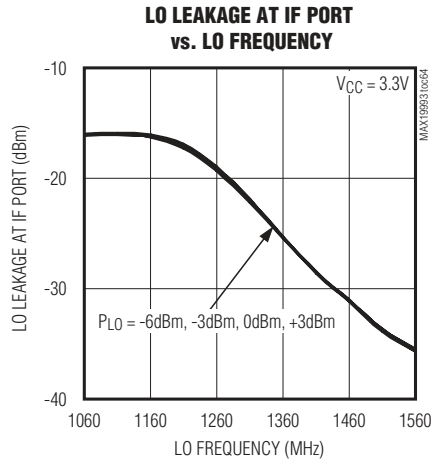
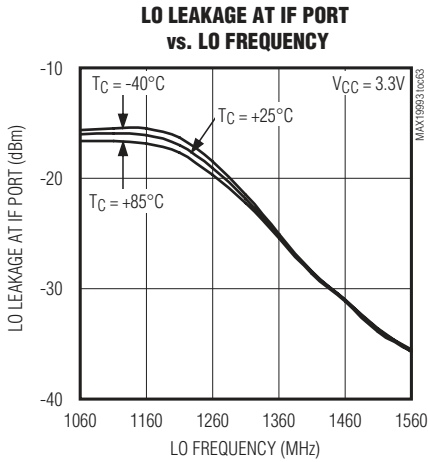
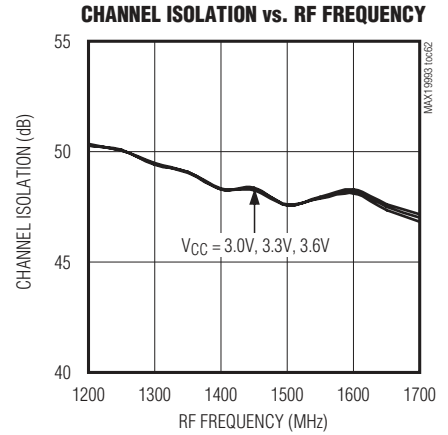
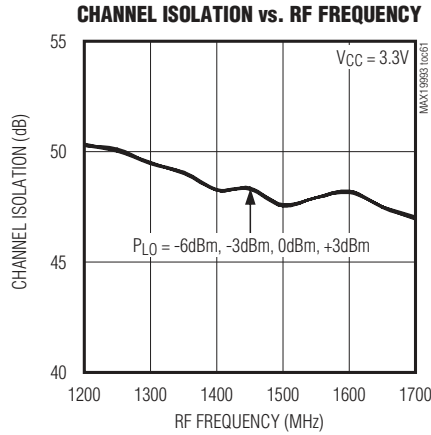
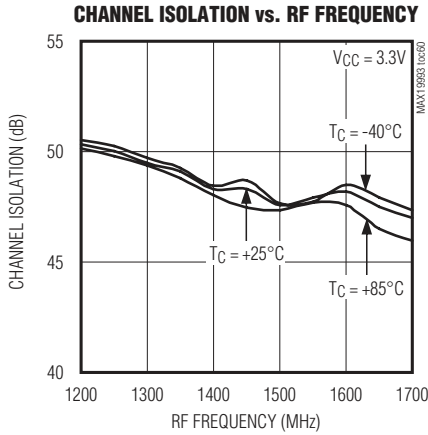
(Typical Application Circuit (see Table 1). $V_{CC} = 3.3V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

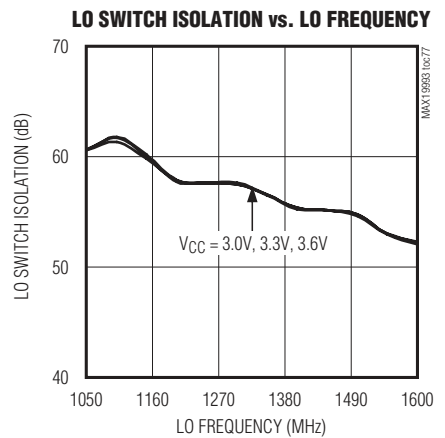
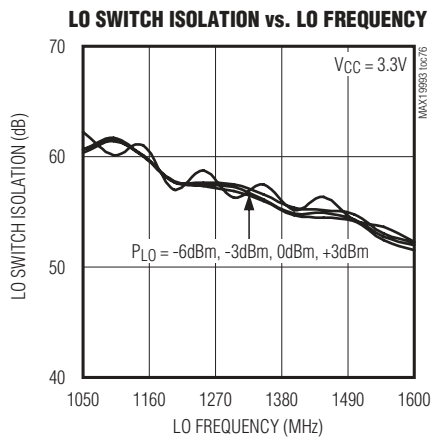
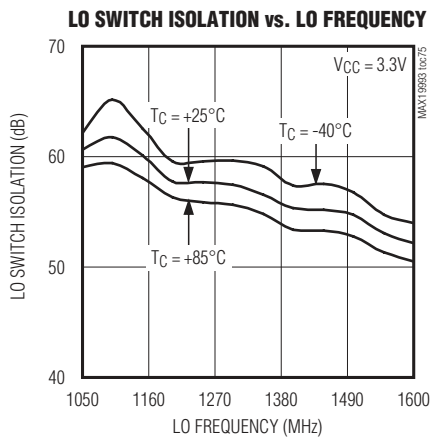
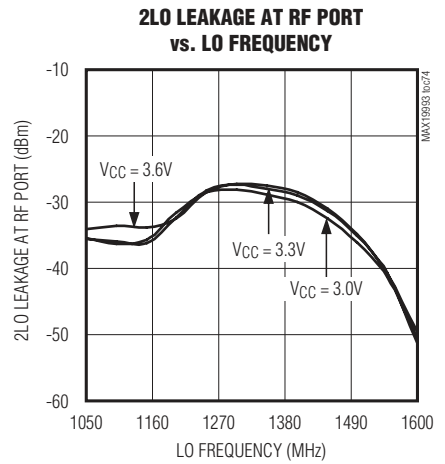
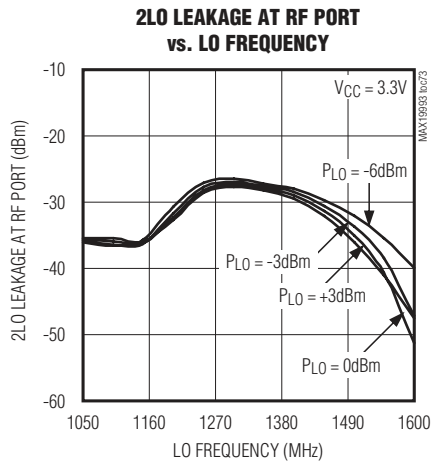
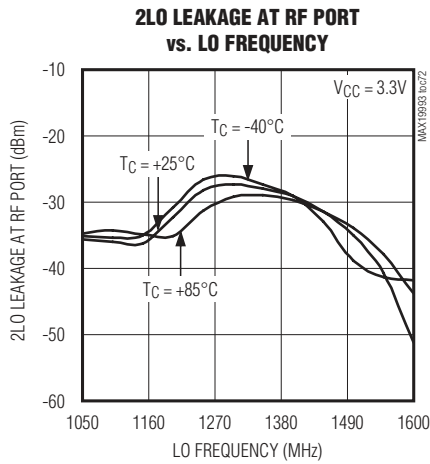
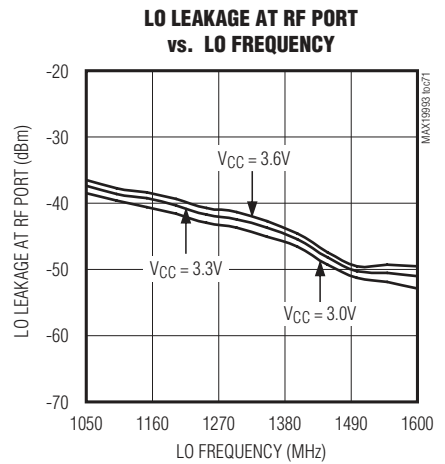
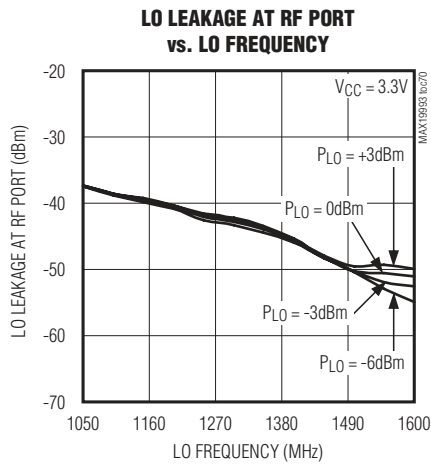
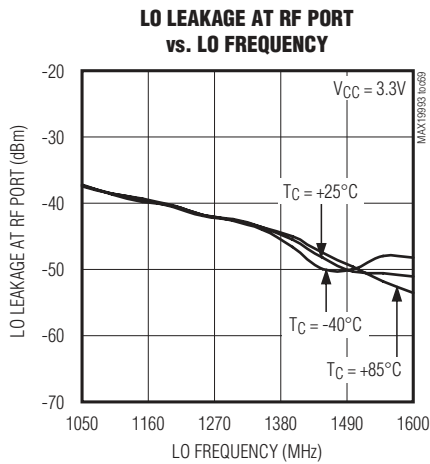
(Typical Application Circuit (see Table 1). $V_{CC} = 3.3V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

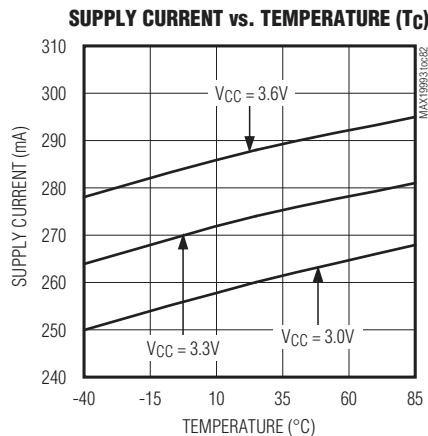
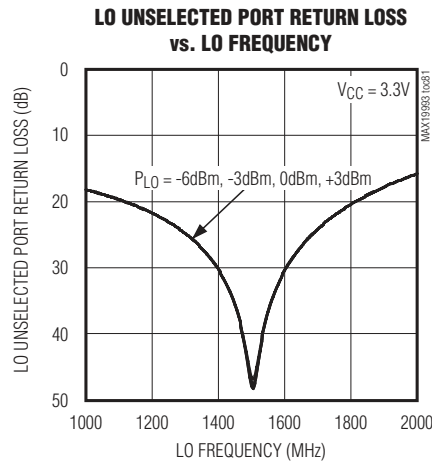
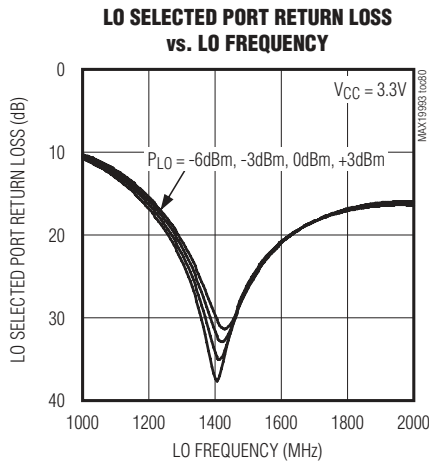
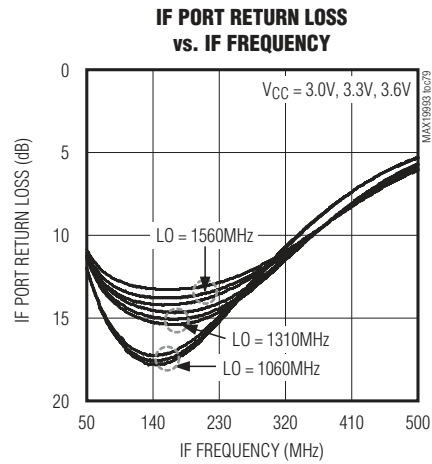
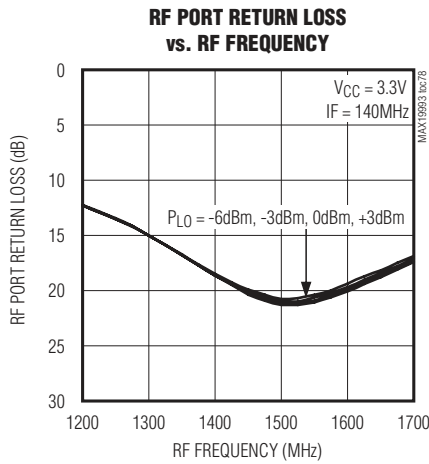
(Typical Application Circuit (see Table 1). $V_{CC} = 3.3V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C = +25^\circ C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Operating Characteristics (continued)

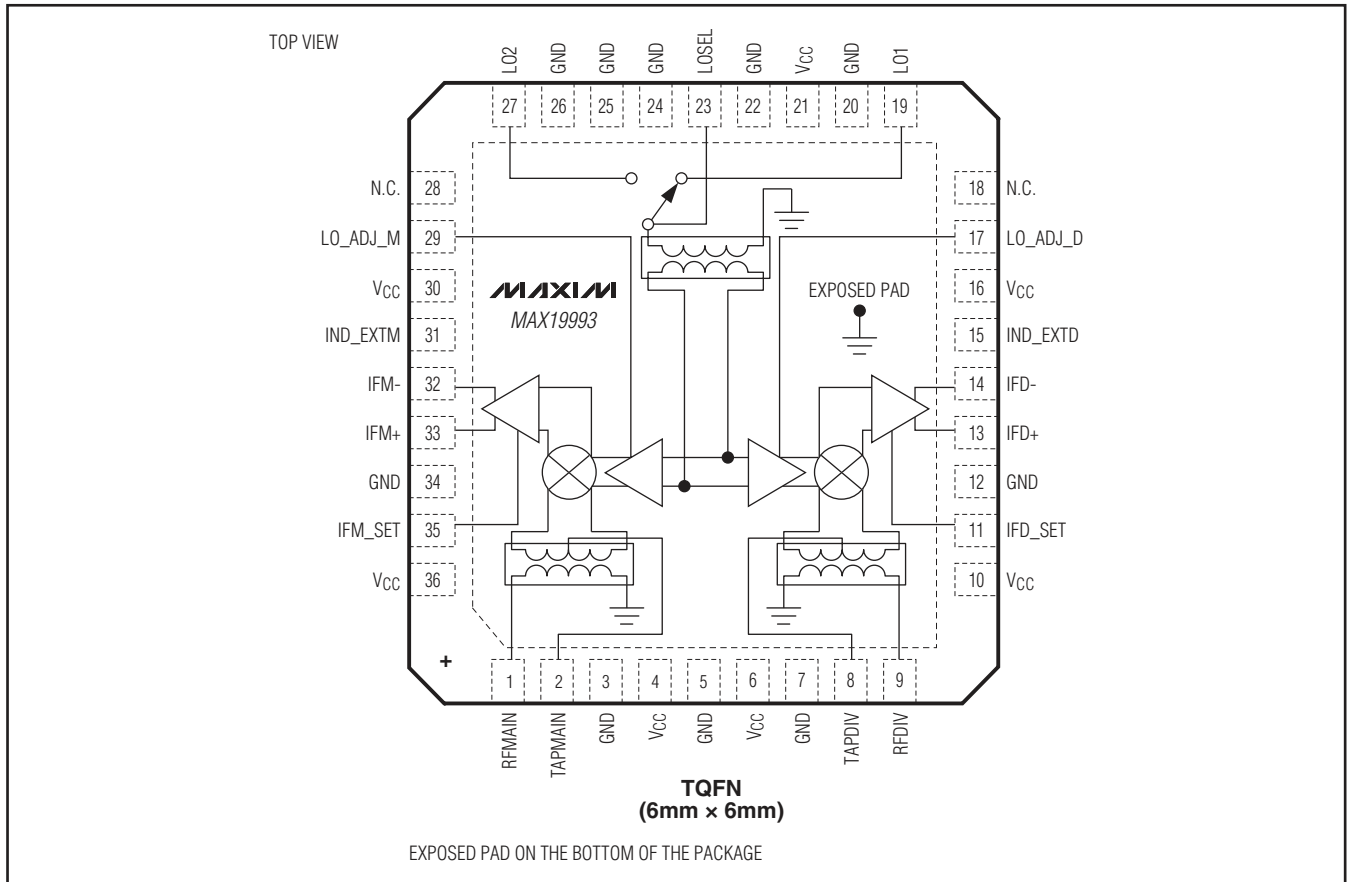
(Typical Application Circuit (see Table 1). $V_{CC} = 3.3V$, $f_{RF} > f_{LO}$ for a 140MHz IF, $P_{RF} = -5dBm$, $P_{LO} = 0dBm$, $T_C +25^{\circ}C$, unless otherwise noted.)



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Pin Configuration

MAX19993



Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Pin Description

| PIN | NAME | FUNCTION |
|-------------------------------------|------------|--|
| 1 | RFMAIN | Main Channel RF Input. Internally matched to 50Ω. Requires an input DC-blocking capacitor. |
| 2 | TAPMAIN | Main Channel Balun Center Tap. Bypass to GND with 39pF and 0.033μF capacitors as close as possible to the pin with the smaller value capacitor closer to the part. |
| 3, 5, 7, 12, 20, 22, 24, 25, 26, 34 | GND | Ground |
| 4, 6, 10, 16, 21, 30, 36 | VCC | Power Supply. Bypass to GND with capacitors as close as possible to the pin, as shown in the <i>Typical Application Circuit</i> . |
| 8 | TAPDIV | Diversity Channel Balun Center Tap. Bypass to GND with 39pF and 0.033μF capacitors as close as possible to the pin with the smaller value capacitor closer to the part. |
| 9 | RFDIV | Diversity Channel RF Input. Internally matched to 50Ω. Requires an input DC-blocking capacitor. |
| 11 | IFD_SET | IF Diversity Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the diversity IF amplifier. See the <i>Typical Application Circuit</i> . |
| 13, 14 | IFD+, IFD- | Diversity Mixer Differential IF Output +/- . Connect pullup inductors from each of these pins to VCC. See the <i>Typical Application Circuit</i> . |
| 15 | IND_EXTD | Diversity External Inductor Connection. Connect to ground through a 0Ω resistor (0603) as close as possible to the pin. For improved RF-to-IF and LO-to-IF isolation, contact the factory for details. |
| 17 | LO_ADJ_D | LO Diversity Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the diversity LO amplifier. See the <i>Typical Application Circuit</i> . |
| 18, 28 | N.C. | No Connection. Not internally connected. |
| 19 | LO1 | Local Oscillator 1 Input. This input is internally matched to 50Ω. Requires an input DC-blocking capacitor. |
| 23 | LOSEL | Local Oscillator Select. Set this pin to high to select LO1. Set to low to select LO2. |
| 27 | LO2 | Local Oscillator 2 Input. This input is internally matched to 50Ω. Requires an input DC-blocking capacitor. |
| 29 | LO_ADJ_M | LO Main Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the main LO amplifier. See the <i>Typical Application Circuit</i> . |
| 31 | IND_EXTM | Main External Inductor Connection. Connect to ground through a 0Ω resistor (0603) as close as possible to the pin. For improved RF-to-IF and LO-to-IF isolation, contact the factory for details. |
| 32, 33 | IFM-, IFM+ | Main Mixer Differential IF Output -/+ . Connect pullup inductors from each of these pins to VCC. See the <i>Typical Application Circuit</i> . |
| 35 | IFM_SET | IF Main Amplifier Bias Control. Connect a resistor from this pin to ground to set the bias current for the main IF amplifier. See the <i>Typical Application Circuit</i> . |
| — | 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 ground vias are also required to achieve the noted RF performance. |

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Detailed Description

The MAX19993 is a dual-channel downconverter designed to provide up to 6.4dB of conversion gain, +27dBm input IP3, 15.4dBm 1dB input compression point, and a noise figure of 9.8dB.

In addition to its high-linearity performance, the device achieves a high level of component integration. It integrates two double-balanced mixers for two-channel downconversion. Both the main and diversity channels include a balun and matching circuitry to allow 50 Ω single-ended interfaces to the RF ports and the two LO ports. An integrated single-pole/double-throw (SPDT) switch provides 50ns switching time between the two LO inputs with 57dB of LO-to-LO isolation and -38dBm of LO leakage at the RF port. Furthermore, the integrated LO buffers provide a high drive level to each mixer core, reducing the LO drive required at the device's inputs to a range of -6dBm to +3dBm. The IF ports for both channels incorporate differential outputs for downconversion, which is ideal for providing enhanced 2RF - 2LO performance.

The device is specified to operate over an RF input range of 1200MHz to 1700MHz, an LO range of 1000MHz to 1560MHz, and an IF range of 50MHz to 500MHz. The external IF components set the lower frequency range. See the *Typical Operating Characteristics* section for details. Operation beyond these ranges is possible; see the *Typical Operating Characteristics* section 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. Contact the factory for a variant with increased high-side LO performance.

RF Port and Balun

The RF input ports of both the main and diversity channels are internally matched to 50 Ω , requiring no external matching components. A 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 better than 19dB over the 1400MHz to 1700MHz RF frequency range.

LO Inputs, Buffer, and Balun

The device is optimized for a 1000MHz to 1560MHz LO frequency range. As an added feature, the device includes an internal LO SPDT switch for use in frequency-hopping applications. The switch selects one of the two single-ended LO ports, allowing the external oscillator to settle on a particular frequency before it is switched in. LO switching time is typically 50ns, which is more than adequate for typical GSM applications. If frequency hopping is not employed, simply set the switch to either of the LO inputs. The switch is controlled by a digital input (LOSEL), where logic-high selects LO1 and logic-low selects LO2. LO1 and LO2 inputs are internally matched to 50 Ω , requiring only 39pF DC-blocking capacitors.

If LOSEL is connected directly to a logic source, then voltage **MUST** be applied to VCC before digital logic is applied to LOSEL to avoid damaging the part. Alternatively, a 1k Ω resistor can be placed in series at the LOSEL to limit the input current in applications where LOSEL is applied before VCC.

The main and diversity channels incorporate a two-stage LO buffer that allows for a wide-input power range for the LO drive. The on-chip low-loss baluns, along with LO buffers, drive the double-balanced mixers. All interfacing and matching components from the LO inputs to the IF outputs are integrated on-chip.

High-Linearity Mixer

The core of the device's dual-channel downconverter consists of two double-balanced, high-performance passive mixers. Exceptional linearity is provided by the large LO swing from the on-chip LO buffers. When combined with the integrated IF amplifiers, the cascaded IIP3, 2RF - 2LO rejection, and noise-figure performance are typically +27dBm, 72dBc, and 9.8dB, respectively.

Differential IF

The device has a 50MHz to 500MHz IF frequency range, where the low-end frequency depends on the frequency response of the external IF components. Note that these differential ports are ideal for providing enhanced IIP2 performance. Single-ended IF applications require a 4:1 (impedance ratio) balun to transform the 200 Ω differential IF impedance to a 50 Ω single-ended system. After the balun, the return loss is typically 15dB. The user can use a differential IF amplifier on the mixer IF ports, but a DC block is required on both IFD+/IFD- and IFM+/IFM- ports to keep external DC from entering the IF ports of the mixer.

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Applications Information

Input and Output Matching

The RF and LO inputs are internally matched to 50Ω. No matching components are required. The RF port input return loss is typically better than 19dB over the 1400MHz to 1700MHz RF frequency range and return loss at the LO ports are typically better than 15dB over the entire LO range. RF and LO inputs require only DC-blocking capacitors for interfacing.

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

Reduced-Power Mode

Each channel of the device has two pins (LO_ADJ_D/LO_ADJ_M, IFD_SET/IFM_SET) that allow external resistors to set the internal bias currents. Nominal values for these resistors are given in Table 1. Larger value resistors can be used to reduce power dissipation at the expense of some performance loss. If ±1% resistors are not readily available, substitute with ±5% resistors.

Significant reductions in power consumption can also be realized by operating the mixer with an optional 3.3V supply voltage. Doing so reduces the overall power consumption by approximately 46%. See the *3.3V Supply DC Electrical Characteristics* table and the relevant 3.3V curves in the *Typical Operating Characteristics* section.

IND_EXT_ Inductors

The default application circuit calls for connecting IND_EXT_ (pins 15 and 31) to ground through a 0Ω resistor (0603) as close as possible to the pin. For improved RF-to-IF and LO-to-IF isolation, contact the factory for details.

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 MAX19993 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 VCC pin and TAPMAIN/TAPDIV with the capacitors shown in the *Typical Application Circuit*. See Table 1 for component values. Place the TAPMAIN/TAPDIV bypass capacitors to ground within 100 mils of the pin.

Exposed Pad RF/Thermal Considerations

The exposed pad (EP) of the MAX19993's 36-pin TQFN-EP package provides a low thermal-resistance path to the die. It is important that the PCB on which the device 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.

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Typical Application Circuit

MAX19993

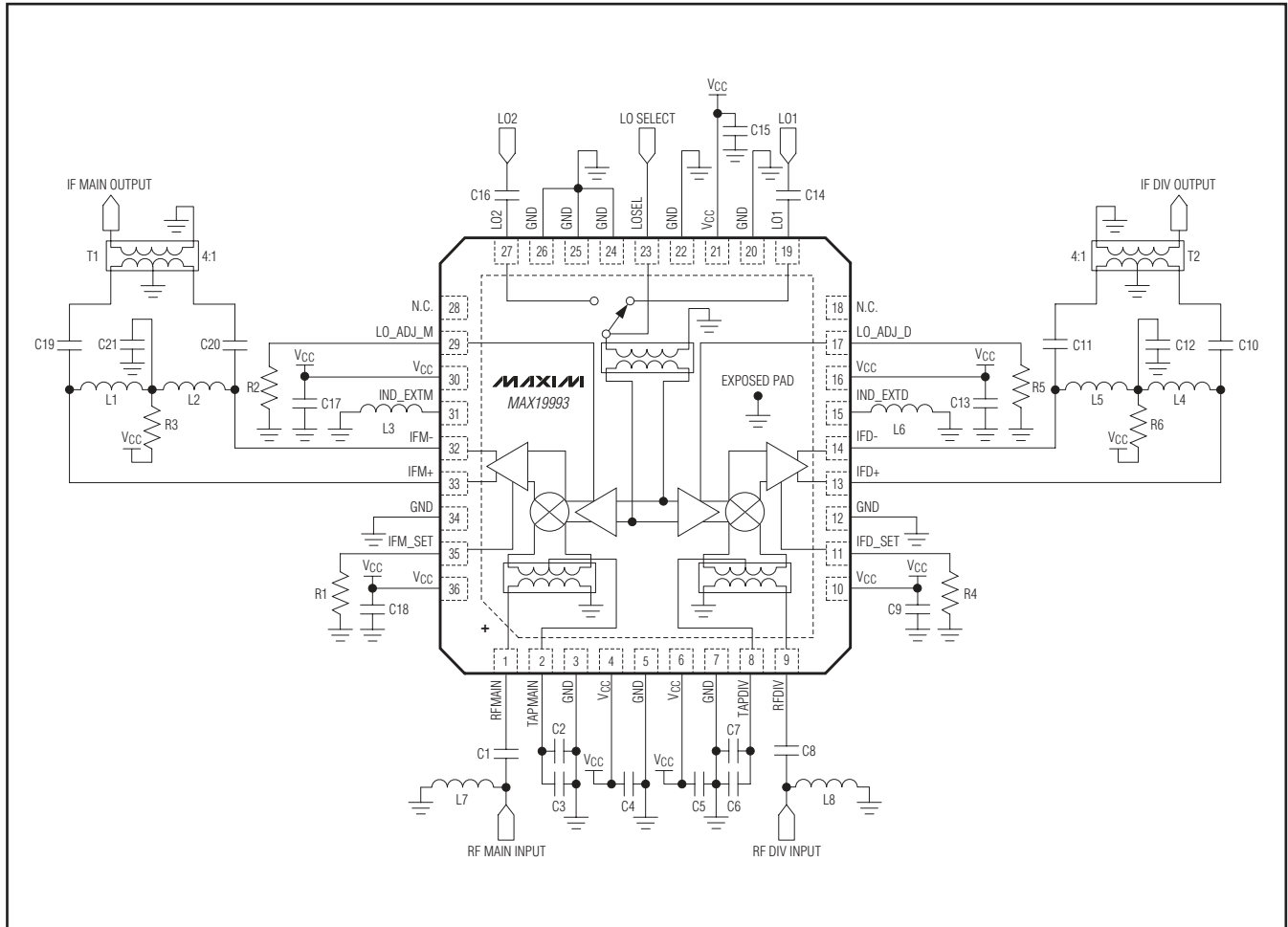


Table 1. Component Values

| DESIGNATION | QTY | DESCRIPTION | COMPONENT SUPPLIER |
|--------------------------|-----|-------------------------------------|--|
| C1, C2, C7, C8, C14, C16 | 6 | 39pF microwave capacitors (0402) | Murata Electronics North America, Inc. |
| C3, C6 | 2 | 0.033μF microwave capacitors (0603) | Murata Electronics North America, Inc. |
| C4, C5 | 2 | 0402, not used | — |
| C9, C13, C15, C17, C18 | 5 | 0.01μF microwave capacitors (0402) | Murata Electronics North America, Inc. |

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Table 1. Component Values (continued)

| DESIGNATION | QTY | DESCRIPTION | COMPONENT SUPPLIER |
|------------------------------|-----|--|--|
| C10, C11, C12, C19, C20, C21 | 6 | 150pF microwave capacitors (0603) | Murata Electronics North America, Inc. |
| L1, L2, L4, L5 | 4 | 330nH wire-wound high-Q inductors (0805) | Coilcraft, Inc. |
| L3, L6 | 2 | 0 Ω resistors (0603). For improved RF-to-IF and LO-to-IF isolation, contact factory for details. | Digi-Key Corp. |
| L7, L8 | 2 | Additional tuning elements (0402, not used) | — |
| R1, R4 | 2 | 681 Ω \pm 1% resistors (0402). Used for V_{CC} = 5.0V applications. Larger values can be used to reduce power at the expense of some performance loss. | Digi-Key Corp. |
| | | 681 Ω \pm 1% resistors (0402). Used for V_{CC} = 3.3V applications. | |
| R2, R5 | 2 | 1.82k Ω \pm 1% resistors (0402). Used for V_{CC} = 5.0V applications. Larger values can be used to reduce power at the expense of some performance loss. | Digi-Key Corp. |
| | | 1.43k Ω \pm 1% resistors (0402). Used for V_{CC} = 3.3V applications. | |
| R3, R6 | 2 | 0 Ω resistors (1206) | Digi-Key Corp. |
| T1, T2 | 2 | 4:1 transformers (200:50) TC4-1W-7A | Mini-Circuits |
| U1 | 1 | MAX19993 IC (36 TQFN-EP) | Maxim Integrated Products, Inc. |

Chip Information

PROCESS: SiGe BiCMOS

Package Information

For the latest package outline information and land patterns, go to 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 | OUTLINE NO. | LAND PATTERN NO. |
|----------------|--------------|-------------------------|-------------------------|
| 36 Thin QFN-EP | T3666+2 | 21-0141 | 90-0049 |

Dual, SiGe, High-Linearity, 1200MHz to 1700MHz Downconversion Mixer with LO Buffer/Switch

Revision History

| REVISION NUMBER | REVISION DATE | DESCRIPTION | PAGES CHANGED |
|-----------------|---------------|-----------------|---------------|
| 0 | 6/10 | Initial release | — |

MAX19993

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