19-2596; Rev 0; 10/02

# High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch



## General Description

The MAX9993 high-linearity down-conversion mixer provides 8.5dB of gain, +23.5dBm IIP3, and 9.5dB NF for UMTS, DCS, and PCS base-station applications.

The MAX9993 integrates baluns in the RF and LO ports, a dual-input LO selectable switch, an LO buffer, a double-balanced mixer, and a differential IF output amplifier. The MAX9993 requires a typical LO drive of +3dBm, and supply current is guaranteed to below 230mA.

The MAX9993 is available in a compact 20-pin thin QFN package (5mm × 5mm) with an exposed pad. Electrical performance is guaranteed over the extended -40°C to +85°C temperature range.

The MAX9993 EV kit is available; contact the factory for more information.

## Features

- ♦ **+23.5dBm Input IIP3**
- ♦ **1700MHz to 2200MHz RF Frequency Range**
- ♦ **40MHz to 350MHz IF Frequency Range**
- ♦ **1400MHz to 2000MHz LO Frequency Range**
- ♦ **8.5dB Conversion Gain**
- ♦ **9.5dB Noise Figure**
- ♦ **Integrated LO Buffer**
- ♦ **Switch-Selectable (SPDT), Two LO Inputs**
- ♦ **Low 0 to +6dBm LO Drive**
- ♦ **40dB LO1-to-LO2 Isolation**

## Applications

UMTS and 3G Base Stations

DCS1800 and EDGE Base Stations

PCS1900 Base Stations

Point-to-Point Microwave Systems

Wireless Local Loop

Private Mobile Radio

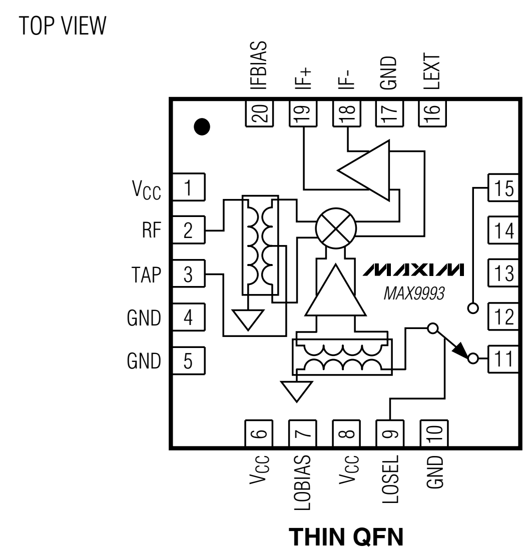
Military Systems

## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| MAX9993ETP-T | -40°C to 85°C | 20 Thin QFN-EP* |

*EP = Exposed pad.

## Pin Configuration/Functional Diagram



# High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$ ....................-0.3V to 5.5V
RF (RF is DC shorted to GND through balun)....................50mA
LO1, LO2 to GND ....................±0.3V
TAP, IF+, IF- to GND ....................-0.3V to ($V_{CC}$ + 0.3V)
LOSEL to GND ....................-0.3V to ($V_{CC}$ (pin 8) + 0.3V)
LOBIAS, IFBIAS, LEXT to GND ....................-0.3V to ($V_{CC}$ + 0.3V)
RF and LO Input Power ....................+22dBm
Continuous Power Dissipation ($T_A$ = +70°C)
20-Lead Thin QFN
(derate 30.3mW/°C above $T_A$ = +70°C) ....................2200mW
$\theta_{JA}$....................33°C/W
Operating Temperature Range ....................-40°C to +85°C
Storage Temperature Range ....................-65°C to +150°C
Lead Temperature (soldering, 10s) ....................+300°C

*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.*

## DC ELECTRICAL CHARACTERISTICS

(*Typical Operating Circuit* as shown, no input RF or LO signals applied. $V_{CC}$ = 4.75V to 5.25V, $T_A$ = -40°C to +85°C. Typical values are at $V_{CC}$ = 5.0V and $T_A$ = +25°C, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Supply Voltage | $V_{CC}$ | | 4.75 | 5.00 | 5.25 | V |
| Supply Current | $I_{CC}$ | Total supply current | | 202 | 230 | mA |
| | | $V_{CC}$ (pin 8) | | 87 | 105 | |
| | | IF+/IF- (total of both) | | 103 | 133 | |
| LOSEL Input High Voltage | $V_{IH}$ | | 2.0 | | | V |
| LOSEL Input Low Voltage | $V_{IL}$ | | | | 0.8 | V |
| LOSEL Input Current | $I_{IL}$ and $I_{IH}$ | | -5 | | +5 | µA |

## AC ELECTRICAL CHARACTERISTICS

(*Typical Operating Circuit*, 4.75V < $V_{CC}$ < 5.75V, -40°C < $T_A$ < +85°, RF and LO ports are driven from 50Ω sources, 0dBm < $P_{LO}$ < +6dBm, $P_{RF}$ = -5dBm, 1700MHz < $f_{RF}$ < 2200MHz, 1400MHz < $f_{LO}$ < 2000MHz, $f_{IF}$ = 200MHz. Typical values are for $T_A$ = +25°C $V_{CC}$ = 5.0V, $P_{LO}$ = +3dBm, $f_{RF}$ = 1900MHz, $f_{LO}$ = 1700MHz, 200MHz IF.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| RF Frequency | $f_{RF}$ | | 1700 | | 2200 | MHz |
| LO Frequency | $f_{LO}$ | (Note 6) | 1400 | | 2000 | MHz |
| IF Frequency | $f_{IF}$ | | 50 | | 350 | MHz |
| Conversion Gain | $G_C$ | (Note 3) | | 8.5 | | dB |
| Gain Variation Over Temperature | | $T_A$ = -40°C to +85°C | | 0.0012 | | dB/°C |
| Gain Variation from Nominal (3σ) | | | | 0.45 | | dB |
| Input Compression Point | $P_{1dB}$ | | | 12.6 | | dBm |
| Input Third-Order Intercept Point (Note 3) | IIP3 | Two RF tones: -5dBm each at 1950MHz and 1951MHz, LO: +3dBm at 1750MHz | | 24 | | dBm |
| | | Two RF tones: -5dBm each at 2200MHz and 2201MHz, LO: +3dBm at 2000MHz | | 23 | | |

## AC ELECTRICAL CHARACTERISTICS (continued)

(*Typical Operating Circuit*, 4.75V < $V_{CC}$ < 5.75V, -40°C < $T_A$ < +85°, RF and LO ports are driven from 50Ω sources, 0dBm < $P_{LO}$ < +6dBm, $P_{RF}$ = -5dBm, 1700MHz < $f_{RF}$ < 2200MHz, 1400MHz < $f_{LO}$ < 2000MHz, $f_{IF}$ = 200MHz. Typical values are for $T_A$ = +25°C $V_{CC}$ = 5.0V, $P_{LO}$ = +3dBm, $f_{RF}$ = 1900MHz, $f_{LO}$ = 1700MHz, 200MHz IF.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| IIP3 Variation Over Temperature | | $T_A$ = -40°C to +85°C | | | ±0.5 | | dB |
| Noise Figure | NF | $f_{RF}$ = 1950MHz, $f_{LO}$ = 1750MHz, measured single-side band | | | 9.5 | | dB |
| Required LO Drive | $P_{LO}$ | | | 0 | 3 | 6 | dBm |
| Spurious Response at IF | 2 × 2 | 2 RF - 2 LO<br>$P_{RF}$ = -5dBm<br>$f_{RF}$ = 1950MHz<br>$f_{LO}$ = 1750MHz<br>$f_{SPUR}$ = 1850MHz | $P_{LO}$ = +3dBm | | 65 | | dBc |
| | | | $P_{LO}$ = +6dBm | | 70 | | |
| | 3 × 3 | 3 RF - 3 LO<br>$P_{RF}$ = -5dBm<br>$f_{RF}$ = 1950MHz<br>$f_{LO}$ = 1750MHz<br>$f_{SPUR}$ = 1816.66MHz | $P_{LO}$ = +3dBm | | 67 | | |
| | | | $P_{LO}$ = +6dBm | | 68 | | |
| Maximum LO-to-RF Leakage | | $P_{LO}$ = 0dBm to +6dBm, $f_{LO}$ = 1400MHz to 2000MHz | | | -19 | | dBm |
| Maximum LO-to-IF Leakage | | $P_{LO}$ = 0dBm to +6dBm, $f_{LO}$ = 1400MHz to 2000MHz | | | -21 | | dBm |
| Minimum RF-to-IF Isolation | | $f_{RF}$ = 1700MHz to 2200MHz | | | 37 | | dB |
| Conversion Loss, LO to IF | | $P_{LO}$ = +0dBm, inject -20dBm at 200MHz into LO port, measure 200MHz at IF | | | 28 | | dB |
| LO Switching Time | | 50% of LOSEL to IF settled to within 2 degrees | | | <50 | | ns |
| LO1-to-LO2 Isolation | | (Note 4) | | | 40 | | dB |
| RF Return Loss | | | | | 19 | | dB |
| LO Return Loss | | LO port selected | | | 15 | | dB |
| | | LO port unselected | | | 14 | | |
| IF Return Loss | | RF terminated, $P_{LO}$ = +3dBm (Note 5) | | | 15 | | dB |

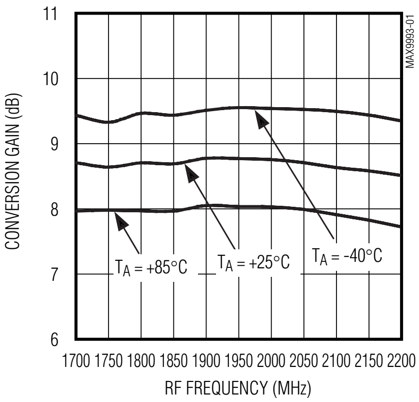
**Note 1:** Guaranteed by design and characterization.
**Note 2:** All limits reflect losses of external components. Output measurements taken at IFOUT of the *Typical Application Circuit*.
**Note 3:** Production tested.
**Note 4:** Measured at IF port at IF frequency. $f_{LO1}$ and $f_{LO2}$ are offset by 1MHz, $P_{LO1}$ = $P_{LO2}$ = +3dBm.
**Note 5:** IF return loss can be optimized by external matching components.
**Note 6:** Operation outside this range is possible, but with degraded performance of some specifications.

# High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch

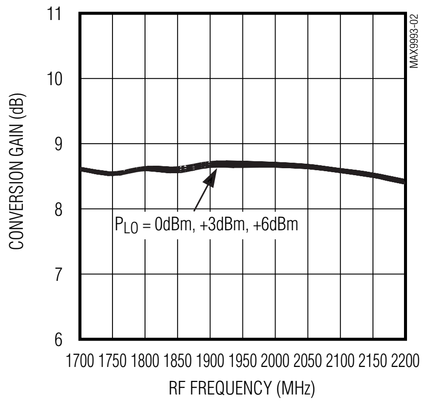
## Typical Operating Characteristics

(MAX9993 EV Kit, $V_{CC}$ = 5.0V, $P_{RF}$ = -5dBm, $P_{LO}$ = +3dBm, LO is low-side injected for a 200MHz IF, $T_A$ = +25°C. For high-side LO injection curves, LO frequency is beyond maximum specified range, and is shown for completeness.)

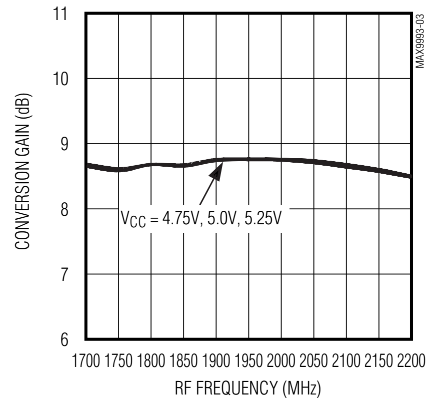
**CONVERSION GAIN vs. RF FREQUENCY LOW-SIDE INJECTION**



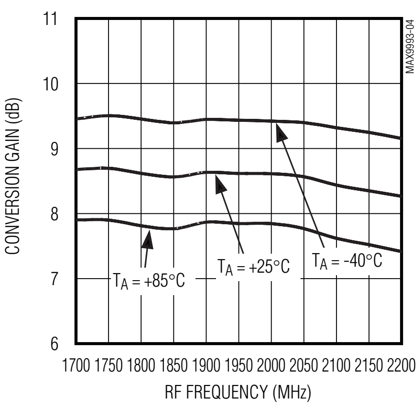

**CONVERSION GAIN vs. RF FREQUENCY LOW-SIDE INJECTION**



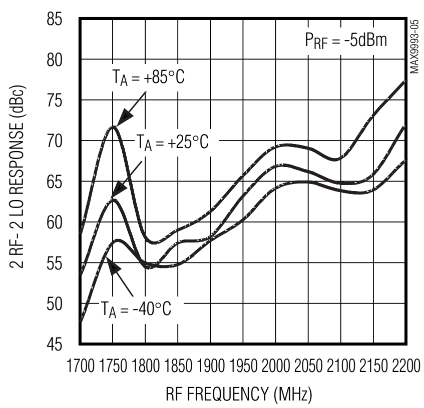

**CONVERSION GAIN vs. RF FREQUENCY LOW-SIDE INJECTION**



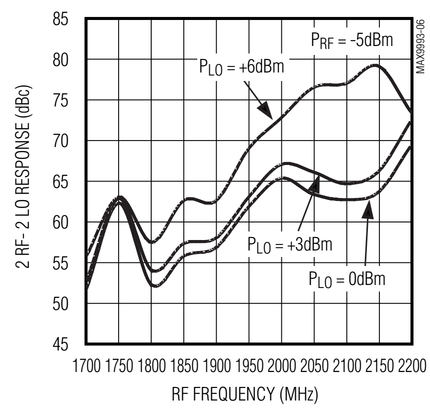

**CONVERSION GAIN vs. RF FREQUENCY HIGH-SIDE INJECTION**



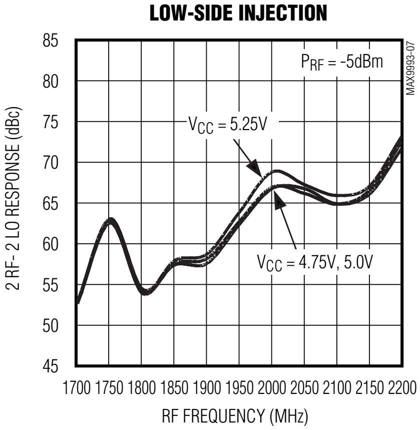

**2 RF - 2 LO RESPONSE vs. RF FREQUENCY LOW-SIDE INJECTION**



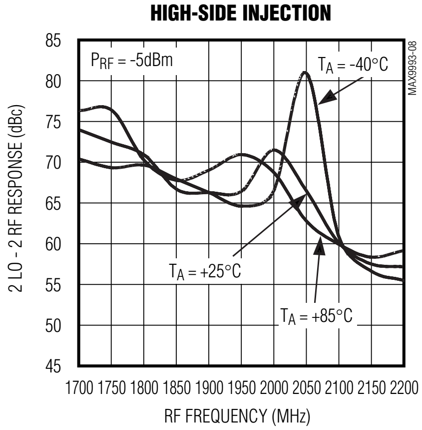

**2 RF - 2 LO RESPONSE vs. RF FREQUENCY LOW-SIDE INJECTION**



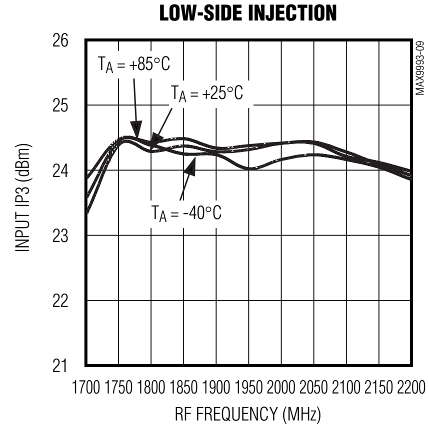

**2 RF - 2 LO RESPONSE vs. RF FREQUENCY LOW-SIDE INJECTION**




**2 LO - 2 RF RESPONSE vs. RF FREQUENCY HIGH-SIDE INJECTION**




**INPUT IP3 vs. RF FREQUENCY LOW-SIDE INJECTION**



## Typical Operating Characteristics (continued)

(MAX9993 EV Kit, $V_{CC}$ = 5.0V, $P_{RF}$ = -5dBm, $P_{LO}$ = +3dBm, LO is low-side injected for a 200MHz IF, $T_A$ = +25°C. For high-side LO injection curves, LO frequency is beyond maximum specified range, and is shown for completeness.)

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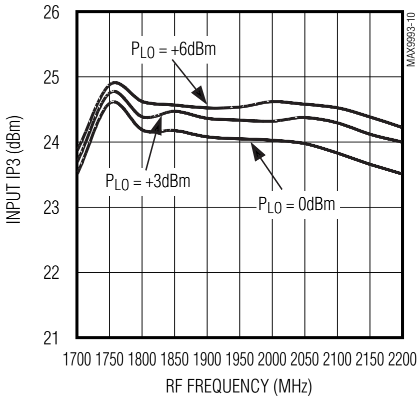
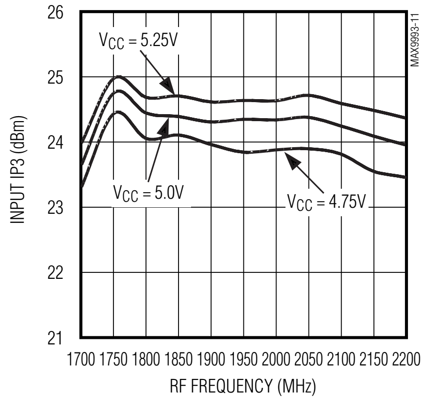
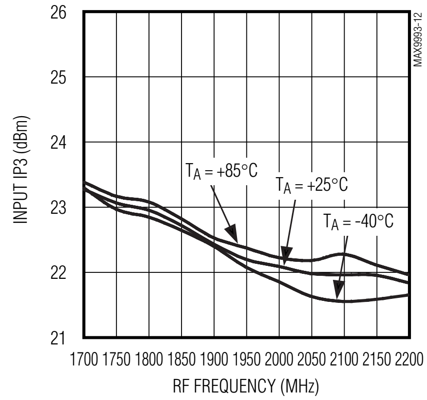


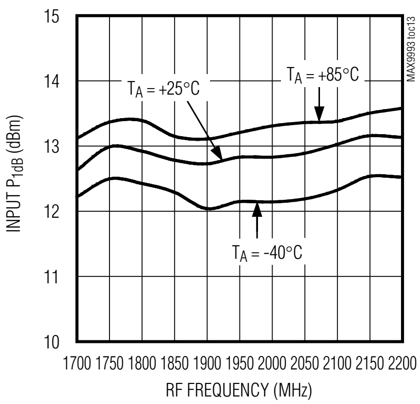

**INPUT IP3 vs. RF FREQUENCY LOW-SIDE INJECTION**



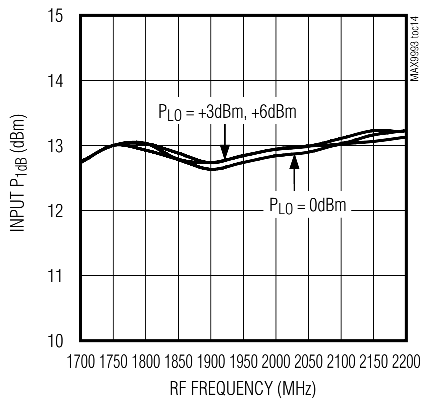

**INPUT IP3 vs. RF FREQUENCY HIGH-SIDE INJECTION**



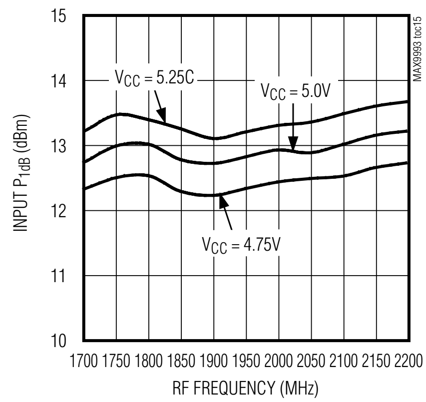

**INPUT $P_{1dB}$ vs. RF REQUENCY LOW-SIDE INJECTION**



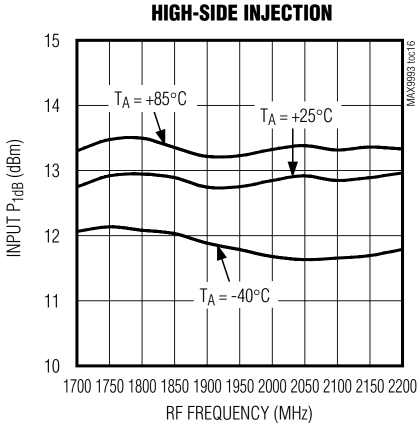

**INPUT $P_{1dB}$ vs. RF FREQUENCY LOW-SIDE INJECTION**



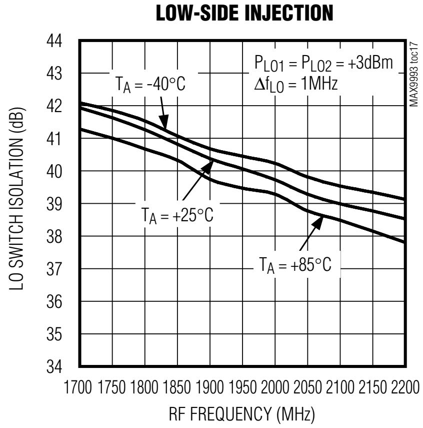

**INPUT $P_{1dB}$ vs. RF FREQUENCY LOW-SIDE INJECTION**



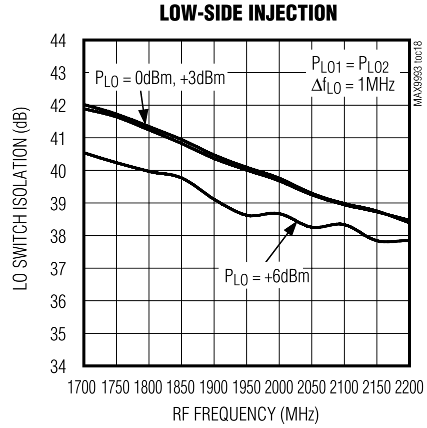

**INPUT $P_{1dB}$ vs. RF FREQUENCY HIGH-SIDE INJECTION**




**LO SWITCH ISOLATION vs. RF FREQUENCY LOW-SIDE INJECTION**




**LO SWITCH ISOLATION vs. RF FREQUENCY LOW-SIDE INJECTION**

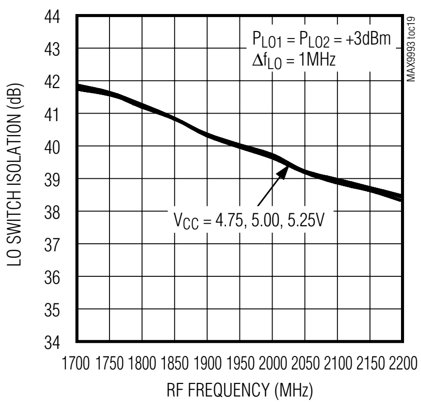


# High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch

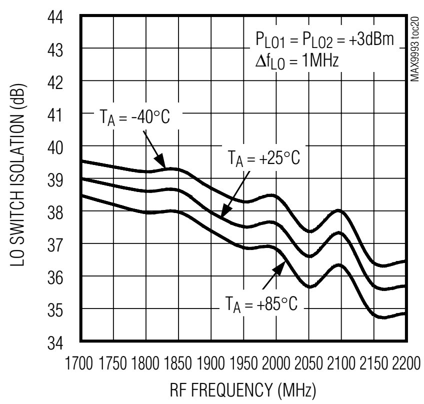
## Typical Operating Characteristics (continued)

(MAX9993 EV Kit, $V_{CC}$ = 5.0V, $P_{RF}$ = -5dBm, $P_{LO}$ = +3dBm, LO is low-side injected for a 200MHz IF, $T_A$ = +25°C. For high-side LO injection curves, LO frequency is beyond maximum specified range, and is shown for completeness.)

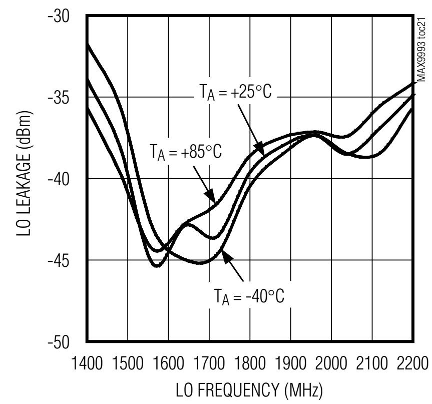
**LO SWITCH ISOLATION vs. RF FREQUENCY LOW-SIDE INJECTION**




**LO SWITCH ISOLATION vs. RF FREQUENCY HIGH-SIDE INJECTION**




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

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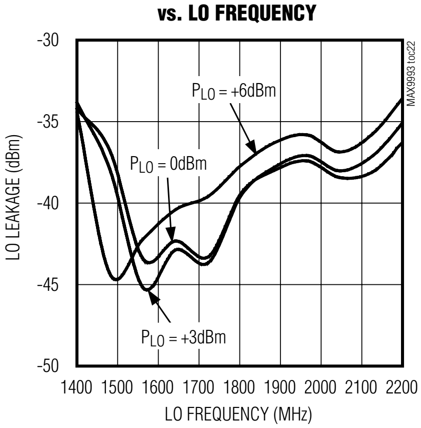


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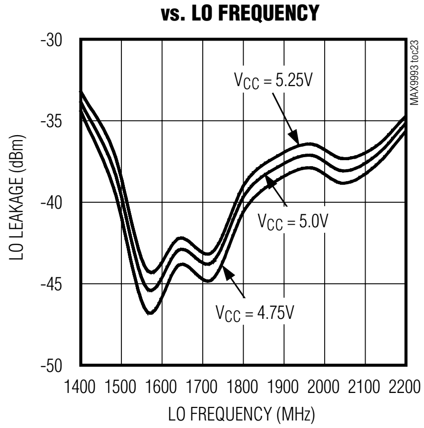
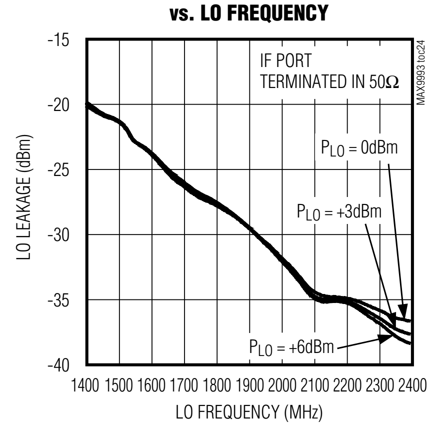
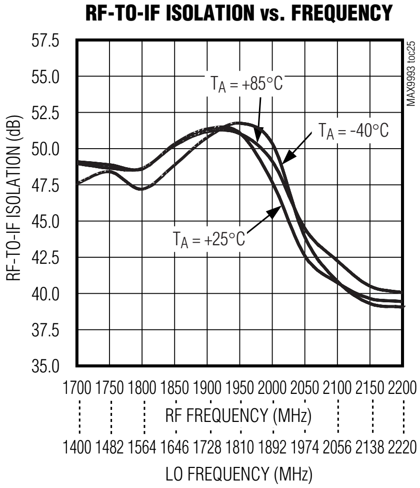



**LO LEAKAGE AT RF PORT vs. LO FREQUENCY**




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

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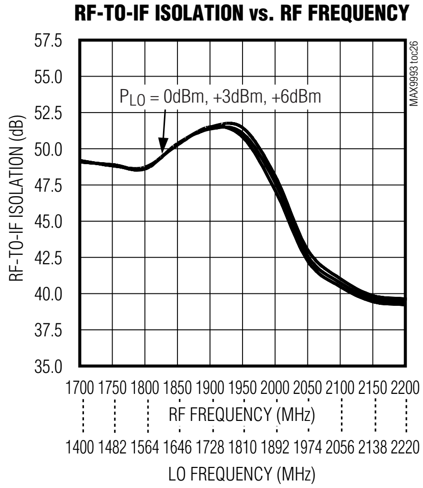
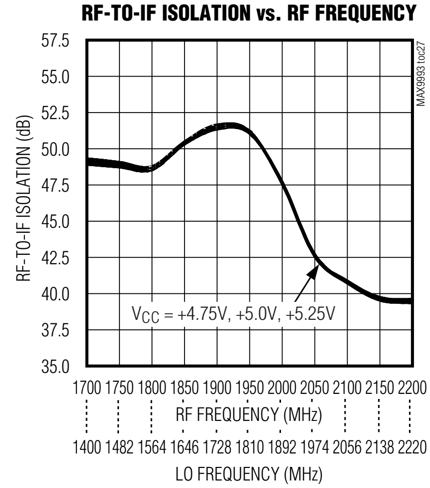


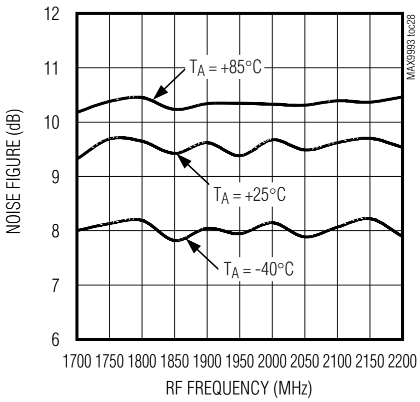

**RF-TO-IF ISOLATION vs. RF FREQUENCY**



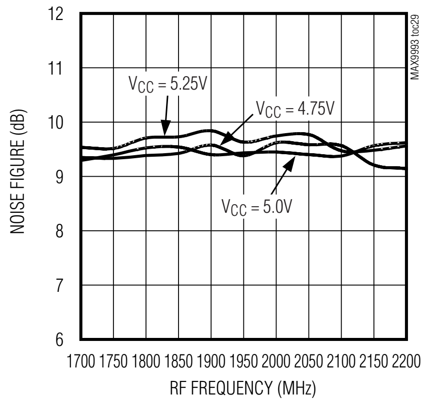
## Typical Operating Characteristics (continued)

(MAX9993 EV Kit, $V_{CC}$ = 5.0V, $P_{RF}$ = -5dBm, $P_{LO}$ = +3dBm, LO is low-side injected for a 200MHz IF, $T_A$ = +25°C. For high-side LO injection curves, LO frequency is beyond maximum specified range, and is shown for completeness.)

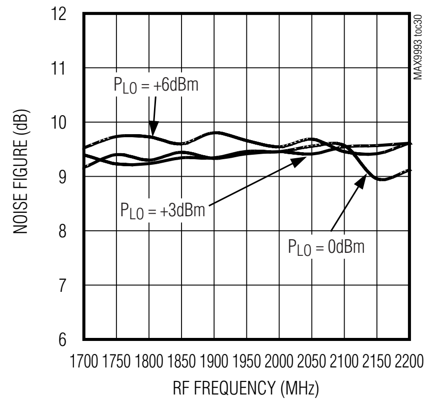
**NOISE FIGURE vs. RF FREQUENCY LOW-SIDE INJECTION**



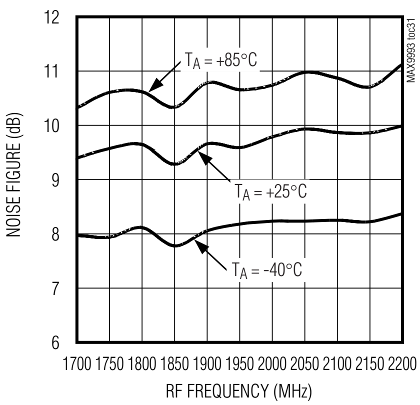

**NOISE FIGURE vs. RF FREQUENCY LOW-SIDE INJECTION**



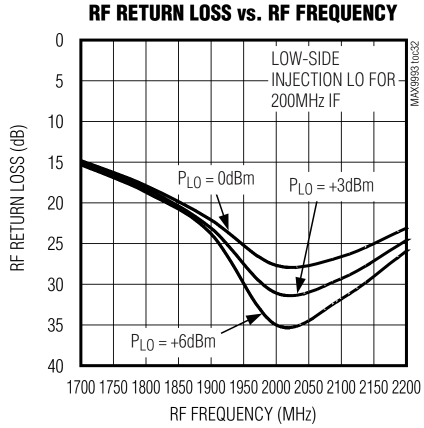

**NOISE FIGURE vs. RF FREQUENCY LOW-SIDE INJECTION**



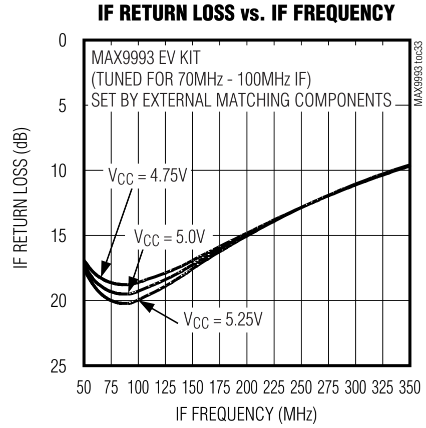

**NOISE FIGURE vs. RF FREQUENCY HIGH-SIDE INJECTION**



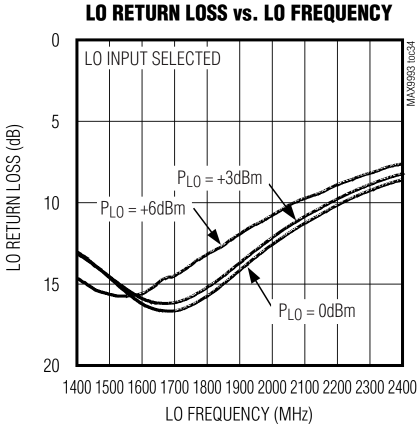

**RF RETURN LOSS vs. RF FREQUENCY**



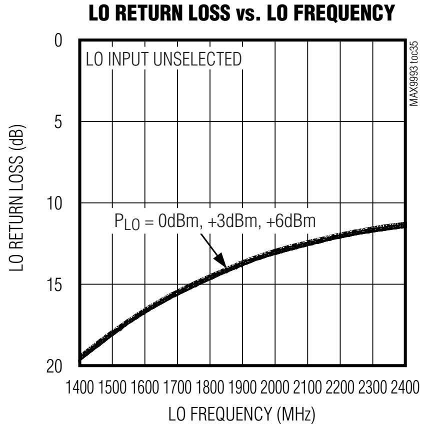

**IF RETURN LOSS vs. IF FREQUENCY**



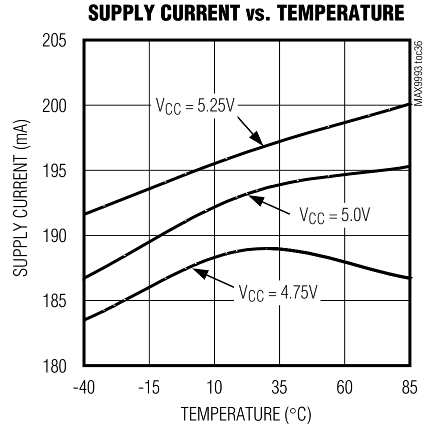

**LO RETURN LOSS vs. LO FREQUENCY**




**LO RETURN LOSS vs. LO FREQUENCY**




**SUPPLY CURRENT vs. TEMPERATURE**



# High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch

## Pin Description

| PIN | NAME | FUNCTION |
|---|---|---|
| 1, 6, 8 | $V_{CC}$ | Power Supply Connections. See the *Typical Application Circuit*. |
| 2 | RF | Single-Ended 50Ω RF Input. This port is internally matched and DC shorted to GND through a balun. Provide a DC-blocking capacitor if required. |
| 3 | TAP | Center Tap of the Internal RF Balun. Bypass with capacitors close to the IC, as shown in the *Typical Application Circuit*. |
| 4, 5, 10, 12, 13, 14, 17, EP | GND | Ground. Connect to supply ground. Provide multiple vias in the PC board to create a low-inductance connection between the exposed paddle (EP) and the PC board ground. |
| 7 | LOBIAS | LO Output Bias Resistor for LO Buffer. Connect a 383Ω (±1%) from LOBIAS to GND. |
| 9 | LOSEL | LO Select. Logic control input for selecting LO1 or LO2. |
| 11 | LO1 | Local Oscillator Input. LO1 selected when LOSEL is low. |
| 15 | LO2 | Local Oscillator Input. LO2 selected when LOSEL is high. |
| 16 | LEXT | External Inductor Connection. Connect a low-ESR 10nH inductor from LEXT to GND. This inductor carries approximately 100mA DC current. |
| 18 | IF- | Noninverting IF Output. Requires external bias to $V_{CC}$ through an RF choke (see the *Typical Application Circuit*). |
| 19 | IF+ | Inverting IF Output. Requires external bias to $V_{CC}$ through an RF choke (see the *Typical Application Circuit*). |
| 20 | IFBIAS | IF Bias Resistor Connection for IF Amplifier. Connect a 523Ω (±1%) from IFBIAS to GND. |

## Detailed Description

The MAX9993 high-linearity down-conversion mixer provides 8.5dB of gain and +23.5dBm IIP3, with a 9.5dB noise figure (typ). Integrated baluns and matching circuitry allow 50Ω single-ended interfaces to the RF and LO ports. A single-pole, double-throw (SPDT) LO switch provides 50ns switching time between LO inputs, with typically 40dB LO-to-LO isolation. Furthermore, the integrated LO buffer provides a high drive level to the mixer core, reducing the LO drive required at the MAX9993's inputs to 0dBm to +6dBm range. The IF port incorporates a differential output, which is ideal for providing enhanced IIP2 performance.

Specifications are guaranteed over broad frequency ranges to allow for use in UMTS and 2G/2.5G/3G DCS1800 and PCS1900 base stations. The MAX9993 is specified to operate over an RF input range of 1700MHz to 2200MHz, an LO range of 1400MHz to 2000MHz, and an IF range of 40MHz to 350MHz. This device can operate in high-side LO injection applications with an extended LO range, but performance degrades gently as $f_{LO}$ continues to increase. See the *Typical Operating Characteristics* for measurements taken with $f_{LO}$ up to 2400MHz. This device is available in a compact 5mm × 5mm 20-pin thin QFN package with an exposed pad.

### RF Input and Balun

The MAX9993 has one input (RF) that is internally matched to 50Ω, requiring no external matching components. A DC-blocking capacitor is required, because the input is internally DC shorted to ground through the on-chip balun. Input return loss is better than 15dB over the entire RF frequency range of 1700MHz to 2200MHz.

### LO Input, Switch, Buffer, and Balun

The mixer can be used for either high-side or low-side injection applications with an LO frequency range of 1400MHz to 2000MHz. An internal LO SPDT switch selects one of two single-ended LO ports. This allows the external oscillator to settle on a particular frequency before it is switched in. LO switching time is guaranteed to be less than 50ns. This switch is controlled by a digital input (LOSEL): logic low selects LO1, logic high selects LO2. LO1 and LO2 inputs are internally matched to 50Ω, requiring only a 22pF DC-blocking capacitor.

A two-stage internal LO buffer allows a wide input power range for the LO drive. All guaranteed specifications are for an LO signal power from 0dBm to +6dBm. A low-loss balun along with an LO buffer drives the double-balanced mixer. All interfacing and matching from the LO inputs to the IF outputs are integrated on-chip.

## Table 1. Component List

| COMPONENT | VALUE | SIZE | DESCRIPTION |
|---|---|---|---|
| C1 | 4pF | 0603 | Microwave capacitor |
| C2, C6, C7, C9, C10 | 22pF | 0603 | Microwave capacitors |
| C3, C5, C8 | 0.01µF | 0603 | Capacitors |
| C4 | 10pF | 0603 | Microwave capacitor |
| C11, C12, C13 | 150pF | 0603 | Microwave capacitors |
| L1, L2 | 470nH | 1008 | Wire-wound high-Q inductors |
| L3 | 10nH | 0805 | Wire-wound high-Q inductor |
| R1 | 523Ω | 0603 | ±1% resistor |
| R2 | 383Ω | 0603 | ±1% resistor |
| R3, R4 | 7.2Ω | 1206 | ±1% resistors |
| R5 | 200Ω | 0603 | ±5% resistor |
| T1 | 4:1 (200:50) | — | IF balun |

### High-Linearity Mixer

The core of the MAX9993 is a double-balanced, high-performance passive mixer. Exceptional linearity is provided by the large LO swing from the on-chip LO buffer; IIP3 is typically +23.5dBm, IIP2 is typically +60dBm, and total cascaded NF is 9.5dB.

### Differential IF Output Amplifier

The MAX9993 mixer has an IF frequency range of 40MHz to 350MHz. The differential, open-collector IF output ports require external pullup inductors to $V_{CC}$. Single-ended IF applications require a 4:1 balun to transform the 200Ω differential output impedance to a 50Ω single-ended output. After the balun, VSWR is typically 1.5:1.

## Applications Information

### Input and Output Matching

The RF and LO inputs are internally matched to 50Ω. No matching components are required. Return loss at the RF port is better than 15dB over the entire input range, 1700MHz to 2200MHz, and return loss at LO1 and LO2 is better than 10dB from 1400MHz to 2000MHz. RF and LO inputs require only DC-blocking capacitors for interfacing. These DC-blocking capacitors can be part of the matching circuit.

The IF output impedance is 200Ω differential out of the IC. An external low-loss 4:1 balun brings this impedance down to a 50Ω single-ended output (see the *Typical Application Circuit*).

### Bias Resistors

Bias currents for the LO buffer and the IF amplifier were optimized by fine-tuning the resistors at LOBIAS and IFBIAS during characterization at the factory. These currents should not be adjusted. If the 383Ω (±1%) and/or 523Ω (±1%) resistor values are not readily available, substitute standard ±5% values: 390Ω and 520Ω, respectively.

### Layout Considerations

A properly designed PC board is an essential part of any RF/microwave circuit. Keep RF signal lines as short as possible to reduce losses, radiation, and inductance. For best performance, route the ground pin traces directly to the exposed pad underneath the package. This pad should be connected to the ground plane of the board by using multiple vias under the device to provide the best RF/thermal conduction path. Solder the exposed pad on the bottom of the device package to a PC board exposed pad.

### Power Supply Bypassing

Proper voltage supply bypassing is essential for high-frequency circuit stability. Bypass each $V_{CC}$ pin and TAP with the capacitors shown in the typical application circuit. Place the TAP bypass capacitor to ground within 100 mils of the TAP pin.

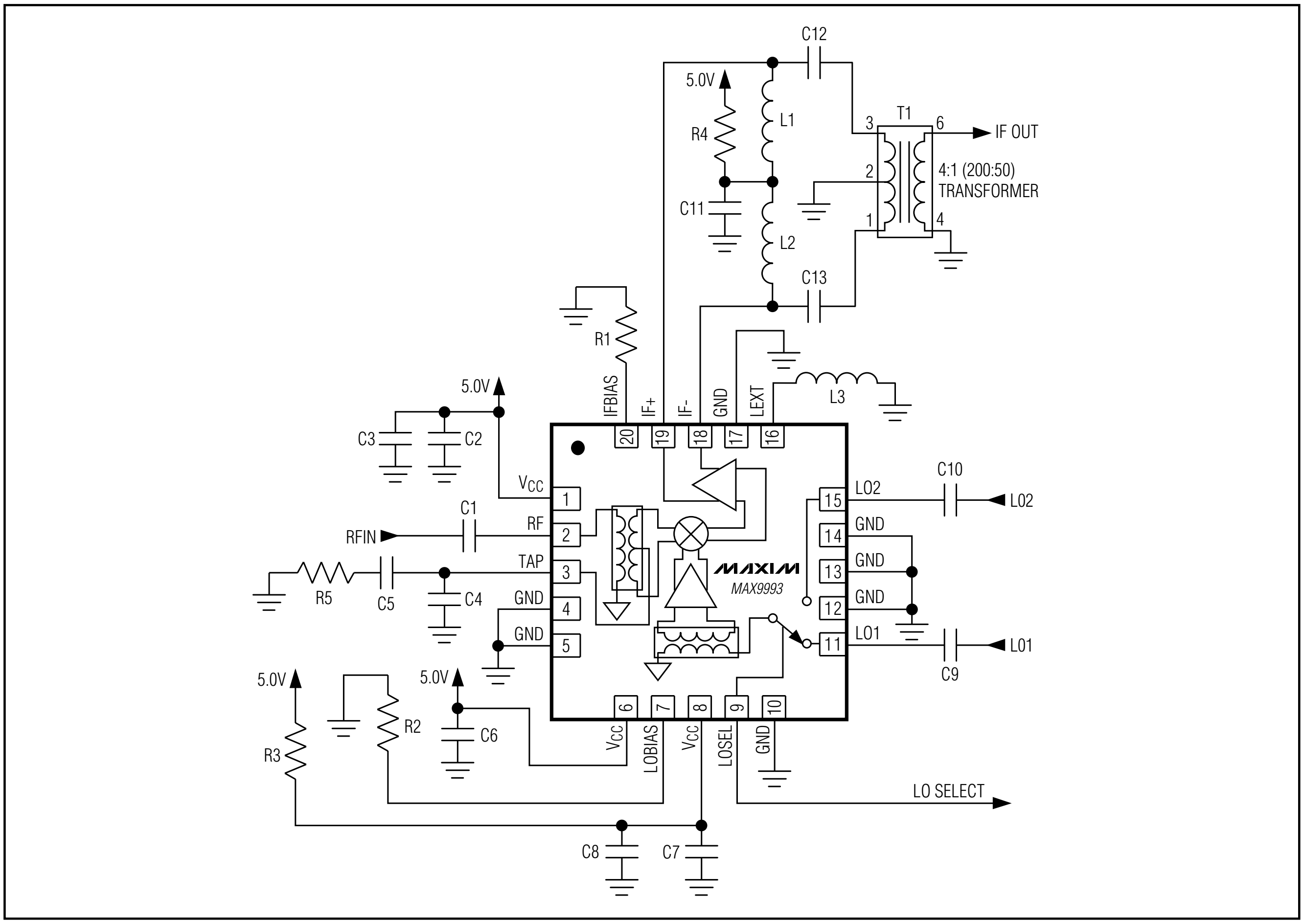
## Chip Information

TRANSISTOR COUNT: 989

PROCESS: SiGe BiCMOS

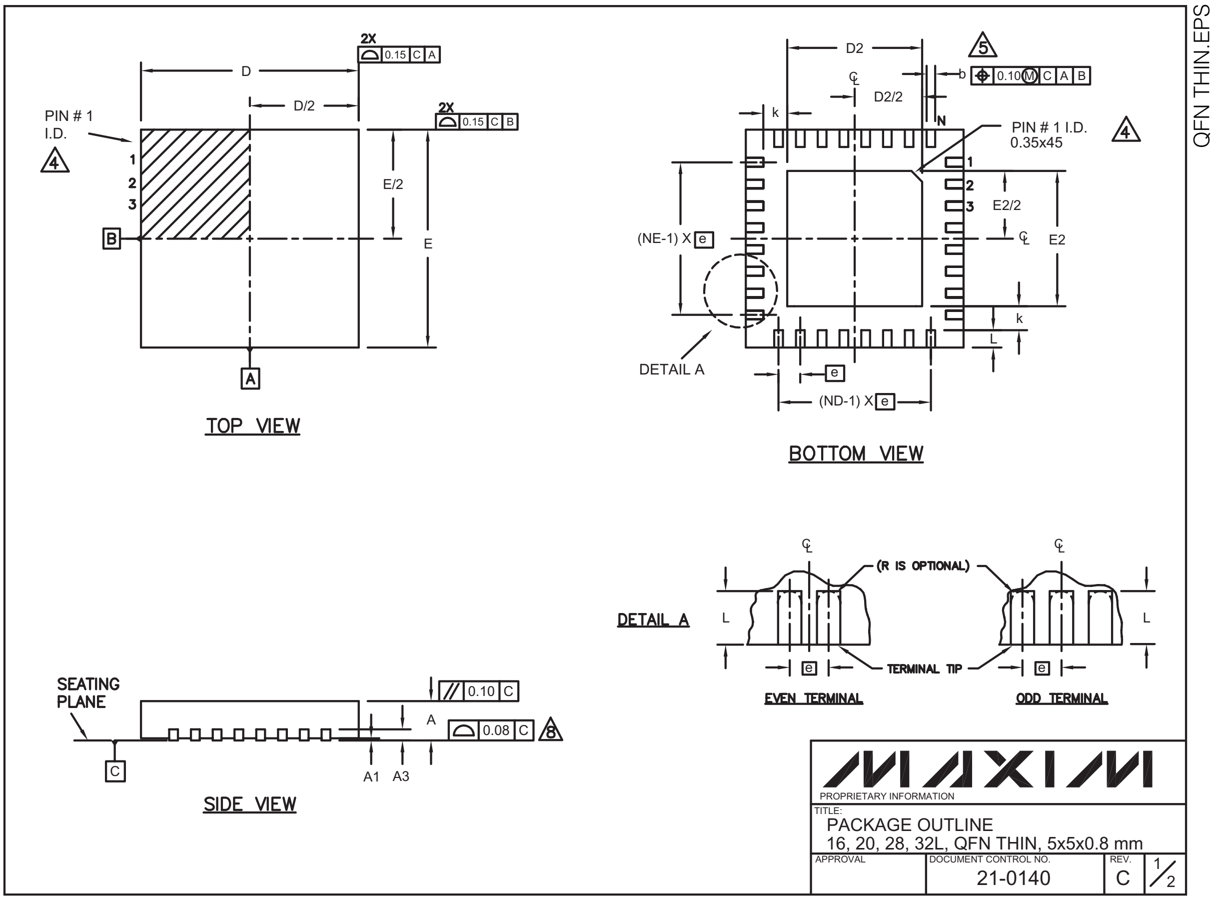
# High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch

## Typical Application Circuit



## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



# High-Linearity 1700MHz to 2200MHz Down-Conversion Mixer with LO Buffer/Switch

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

COMMON DIMENSIONS

| PKG. | 16L 5x5 | | | 20L 5x5 | | | 28L 5x5 | | | 32L 5x5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SYMBOL | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 | 0.70 | 0.75 | 0.80 |
| A1 | 0 | 0.02 | 0.05 | 0 | 0.02 | 0.05 | 0 | 0.02 | 0.05 | 0 | 0.02 | 0.05 |
| A3 | 0.20 REF. | | | 0.20 REF. | | | 0.20 REF. | | | 0.20 REF. | | |
| b | 0.25 | 0.30 | 0.35 | 0.25 | 0.30 | 0.35 | 0.20 | 0.25 | 0.30 | 0.20 | 0.25 | 0.30 |
| D | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 |
| E | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 | 4.90 | 5.00 | 5.10 |
| e | 0.80 BSC. | | | 0.65 BSC. | | | 0.50 BSC. | | | 0.50 BSC. | | |
| k | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - | 0.25 | - | - |
| L | 0.45 | 0.55 | 0.65 | 0.45 | 0.55 | 0.65 | 0.45 | 0.55 | 0.65 | 0.30 | 0.40 | 0.50 |
| N | 16 | | | 20 | | | 28 | | | 32 | | |
| ND | 4 | | | 5 | | | 7 | | | 8 | | |
| NE | 4 | | | 5 | | | 7 | | | 8 | | |
| JEDEC | WHHB | | | WHHC | | | WHHD-1 | | | WHHD-2 | | |

EXPOSED PAD VARIATIONS

| PKG. CODES | D2 | | | E2 | | |
|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| T1655-1 | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 |
| T2055-2 | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 |
| T2855-1 | 3.15 | 3.25 | 3.35 | 3.15 | 3.25 | 3.35 |
| T2855-2 | 2.60 | 2.70 | 2.80 | 2.60 | 2.70 | 2.80 |
| T3255-2 | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 |

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220.
10. WARPAGE SHALL NOT EXCEED 0.10 mm.

MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE 16, 20, 28, 32L, QFN THIN, 5x5x0.8 mm

APPROVAL | DOCUMENT CONTROL NO. 21-0140 | REV. C | 2/2

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