# 10MHz to 500MHz VCO Buffer Amplifiers with Differential Outputs

## ABSOLUTE MAXIMUM RATINGS

$V_{CC}$ to GND ....................-0.3V to +7V
$\overline{IN}$ to GND......-0.3V to ($V_{CC}$ + 0.3V) or 3.7V (whichever is lower)
$\overline{IN}$ to IN ....................-2.2V to +2.2V
HI/$\overline{LO}$ to GND ....................-0.3V to ($V_{CC}$ + 0.3V)
Continuous Power Dissipation
SOT23-6 (derate 8.7mW/°C above +70°C)..................696mW
Operating Temperature Range ....................-40°C to +85°C
Junction Temperature ....................+150°C
Storage Temperature Range ....................-65°C to +150°C
Lead Temperature (soldering, 10sec ) ....................+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, $V_{CC}$ = +2.7V to +5.5V, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted. Typical values are at $V_{CC}$ = +3V, $T_A$ = +25°C.) (Note 1)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Supply Voltage Range | $V_{CC}$ | | | 2.7 | | 5.5 | V |
| Supply Current | $I_{CC}$ | HI/$\overline{LO}$ = $V_{CC}$ | No signal | | 5.1 | 7.4 | mA |
| | | | $P_{OUT}$ = -5dBm, $R_{LOAD}$ = 100Ω diff. | | 5.5 | | |
| | | HI/$\overline{LO}$ = GND | No signal | | 3.0 | 4.5 | |
| | | | $P_{OUT}$ = -5dBm, $R_{LOAD}$ = 100Ω diff. | | 3.6 | | |
| HI/$\overline{LO}$ Input Level High | $V_{IH}$ | | | 2.0 | | | V |
| HI/$\overline{LO}$ Input Level Low | $V_{IL}$ | | | | | 0.6 | V |
| HI/$\overline{LO}$ Input Bias Current | $I_{IN}$ | VHI/$\overline{LO}$ = GND or $V_{CC}$ | | -10 | | 10 | µA |

## AC ELECTRICAL CHARACTERISTICS—MAX2470

($V_{CC}$ = +3V, HI/$\overline{LO}$ = $V_{CC}$, all outputs are differentially measured between OUT and $\overline{OUT}$ driving a 50Ω load through a 180° hybrid, $T_A$ = +25°C, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Input Frequency Range (Note 2) | $f_{IN}$ | HI/$\overline{LO}$ = $V_{CC}$ | | 10 | | 500 | MHz |
| | | HI/$\overline{LO}$ = GND | | 10 | | 200 | |
| Gain (Note 3) | $IS_{21}I^2$ | HI/$\overline{LO}$ = $V_{CC}$ | $f_{IN}$ = 10MHz | | 14.9 | | dB |
| | | | $f_{IN}$ = 200MHz | | 14.9 | | |
| | | | $f_{IN}$ = 500MHz, $T_A$ = $T_{MIN}$ to $T_{MAX}$ | 8.9 | 13.3 | 15.3 | |
| | | HI/$\overline{LO}$ = GND | $f_{IN}$ = 10MHz | | 13.8 | | |
| | | | $f_{IN}$ = 200MHz | | 14.1 | | |
| | | | $f_{IN}$ = 200MHz, $T_A$ = $T_{MIN}$ to $T_{MAX}$ | 9.9 | 13.4 | 15.0 | |
| Voltage Gain (Note 4) | $A_V$ | $f_{IN}$ = 10MHz, HI/$\overline{LO}$ = GND | | | 16 | | V/V |
| Noise Figure | NF | $R_{SOURCE}$ = 50Ω | $f_{OUT}$ = 500MHz, HI/$\overline{LO}$ = $V_{CC}$ | | 10.2 | | dB |
| | | | $f_{OUT}$ = 200MHz, RHI/$\overline{LO}$ = GND | | 10.2 | | |

## AC ELECTRICAL CHARACTERISTICS—MAX2470 (continued)

($V_{CC}$ = +3V, HI/$\overline{LO}$ = $V_{CC}$, all outputs are differentially measured between OUT and $\overline{OUT}$ driving a 50Ω load through a 180° hybrid, $T_A$ = +25°C, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Maximum Output VSWR (OUT, $\overline{OUT}$) (Note 5) | $VSWR_{OUT}$ | 10MHz < $f_{OUT}$ < 500MHz, HI/$\overline{LO}$ = $V_{CC}$ | | | 1.5:1 | | |
| | | 10MHz < $f_{OUT}$ < 200MHz, HI/$\overline{LO}$ = GND | | | 1.2:1 | | |
| Reverse Isolation (Note 6) | $\|S_{12}\|^2$ | HI/$\overline{LO}$ = $V_{CC}$ | $f_{IN}$ = 100MHz | | 75 | | dB |
| | | | $f_{IN}$ = 500MHz | | 48 | | |
| | | HI/$\overline{LO}$ = GND | $f_{IN}$ = 100MHz | | 75 | | |
| | | | $f_{IN}$ = 200MHz | | 64 | | |
| Isolation OUT to $\overline{OUT}$ (Note 7) | | $f_{IN}$ = 500MHz, HI/$\overline{LO}$ = $V_{CC}$ | | | 37 | | dB |
| | | $f_{IN}$ = 200MHz, HI/$\overline{LO}$ = GND | | | 45 | | |
| Harmonic Suppression | | $f_{IN}$ = 500MHz, $P_{OUT}$ = -5dBm, HI/$\overline{LO}$ = $V_{CC}$ | | | -26 | | dBc |
| | | $f_{IN}$ = 200MHz, $P_{OUT}$ = -5dBm, HI/$\overline{LO}$ = GND | | | -30 | | |

## AC ELECTRICAL CHARACTERISTICS—MAX2471

(Typical values are measured at $V_{CC}$ = +3V, $T_A$ = +25°C, unless otherwise noted.) (Note 8)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Input Frequency Range (Note 2) | $f_{IN}$ | | 10 | | 500 | MHz |
| Gain (Note 3) | $\|S_{21}\|^2$ | $f_{IN}$ = 10MHz | | 15.9 | | dB |
| | | $f_{IN}$ = 200MHz | | 16.9 | | |
| | | $f_{IN}$ = 500MHz, $T_A$ = $T_{MIN}$ to $T_{MAX}$ | 11.3 | 15.6 | 17.8 | |
| Voltage Gain (Note 4) | $A_V$ | $f_{IN}$ = 10MHz | | 16 | | V/V |
| Noise Figure | NF | $f_{OUT}$ = 500MHz, $R_{SOURCE}$ = 50Ω | | 8.4 | | dB |
| Maximum Output VSWR (OUT, $\overline{OUT}$) (Note 5) | $VSWR_{OUT}$ | 10MHz < $f_{OUT}$ < 500MHz | | 1.5:1 | | |
| Reverse Isolation | $\|S_{12}\|^2$ | $f_{IN}$ = 100MHz | | 74 | | dB |
| | | $f_{IN}$ = 500MHz | | 57 | | |
| Isolation OUT to $\overline{OUT}$ (Note 7) | | $f_{IN}$ = 500MHz | | 35 | | dB |
| Harmonic Suppression | | $f_{IN}$ = 500MHz, $P_{OUT}$ = -5dBm | | -29 | | dBc |

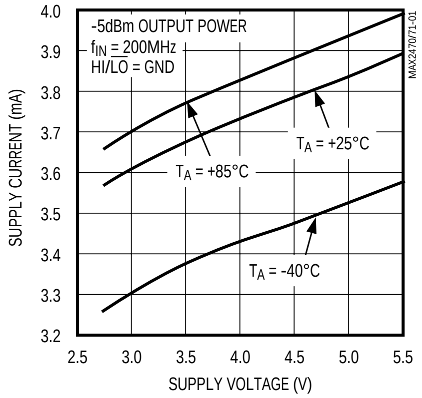
**Note 1:** Limits are 100% production tested at $T_A$ = +25°C. Limits over the entire operating temperature range are guaranteed by design and characterization but are not production tested.
**Note 2:** The part has been characterized over the specified frequency range. Operation outside of this range is possible but not guaranteed.
**Note 3:** Gain specified for $P_{OUT}$ = -5dBm.
**Note 4:** Voltage gain measured with no input termination and no output load.
**Note 5:** Output VSWR is a single-ended measurement for each OUT and $\overline{OUT}$.
**Note 6:** OUT to IN isolation with $\overline{OUT}$ terminated with 50Ω.
**Note 7:** Input terminated with 50Ω.
**Note 8:** Unless otherwise noted: all inputs are differentially measured between IN and $\overline{IN}$ driven by a 50Ω load through a 180° hybrid; all outputs are differentially measured between OUT and $\overline{OUT}$ driving a 50Ω load through a 180° hybrid.

# 10MHz to 500MHz VCO Buffer Amplifiers with Differential Outputs

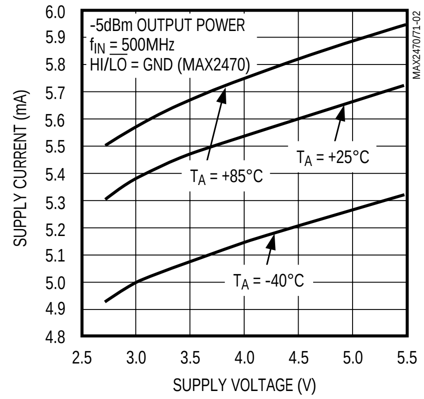
## Typical Operating Characteristics

($V_{CC}$ = +3.0V, MAX2470 output and MAX2471 input and output measurements taken differentially, $T_A$ = +25°C, unless otherwise noted.)

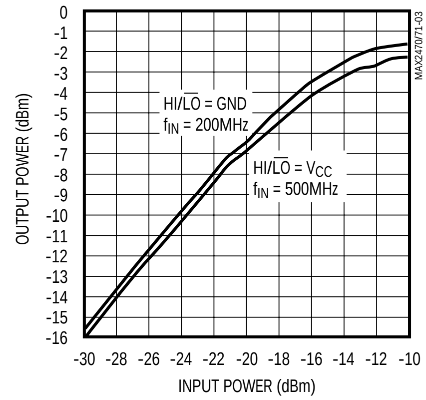
**MAX2470 SUPPLY CURRENT vs. SUPPLY VOLTAGE (HI/$\overline{LO}$ = GND)**



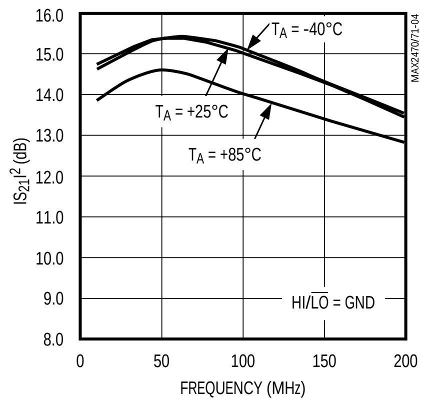

**MAX2470 (HI/$\overline{LO}$ = $V_{CC}$) AND MAX2471 SUPPLY CURRENT vs. SUPPLY VOLTAGE**



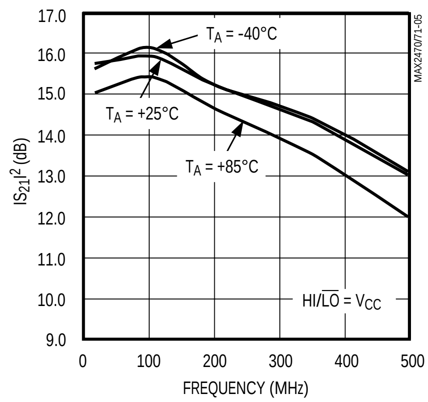

**MAX2470 OUTPUT POWER vs. INPUT POWER**



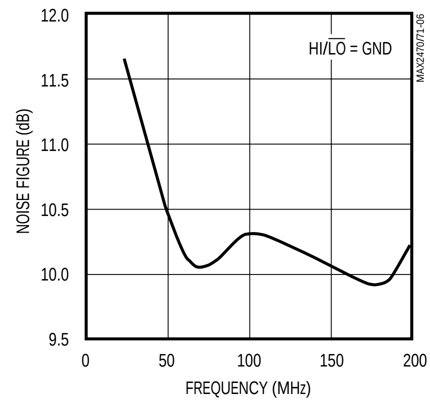

**MAX2470 TRANSDUCER GAIN vs. FREQUENCY (HI/$\overline{LO}$ = GND)**



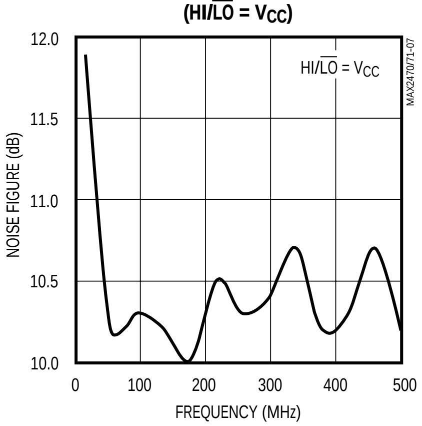

**MAX2470 TRANSDUCER GAIN vs. FREQUENCY (HI/$\overline{LO}$ = $V_{CC}$)**



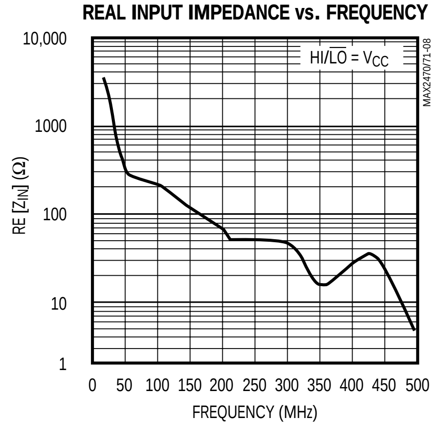

**MAX2470 NOISE FIGURE vs. FREQUENCY (HI/$\overline{LO}$ = GND)**



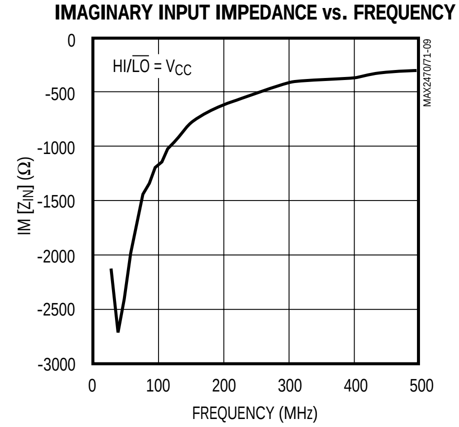

**MAX2470 NOISE FIGURE vs. FREQUENCY (HI/$\overline{LO}$ = $V_{CC}$)**




**MAX2470 REAL INPUT IMPEDANCE vs. FREQUENCY**



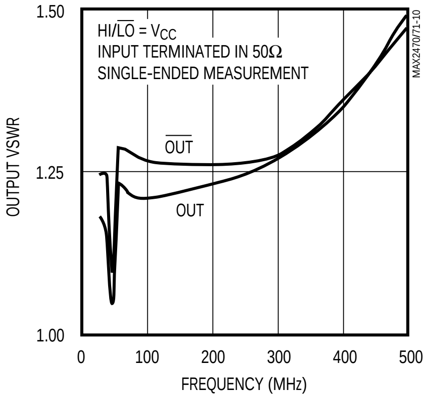

**MAX2470 IMAGINARY INPUT IMPEDANCE vs. FREQUENCY**



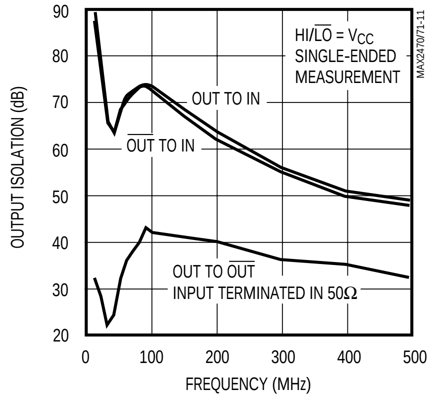
## *Typical Operating Characteristics (continued)*

($V_{CC}$ = +3.0V, MAX2470 output and MAX2471 input and output measurements taken differentially, $T_A$ = +25°C unless otherwise noted.)

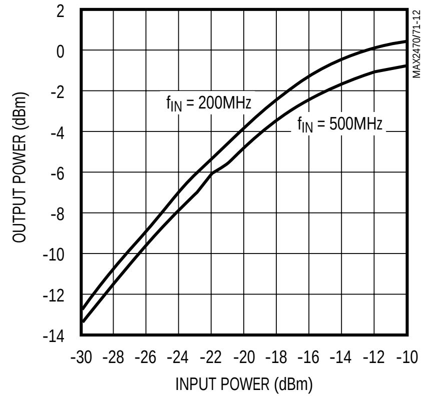
**MAX2470**
**OUTPUT VSWR vs. FREQUENCY**



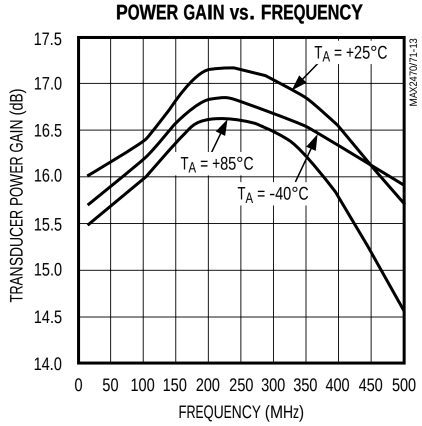

**MAX2470**
**OUTPUT ISOLATION vs. FREQUENCY**



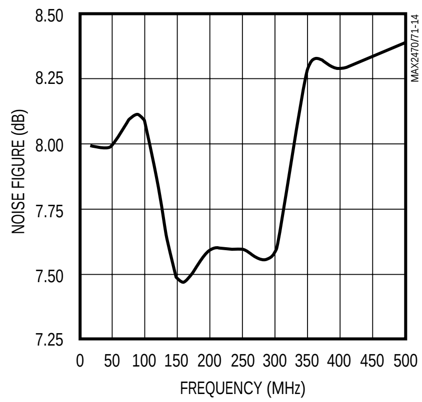

**MAX2471**
**OUTPUT POWER vs. INPUT POWER**



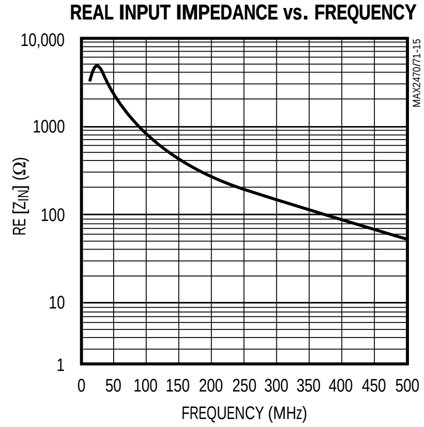

**MAX2471**
**DIFFERENTIAL TRANSDUCER POWER GAIN vs. FREQUENCY**



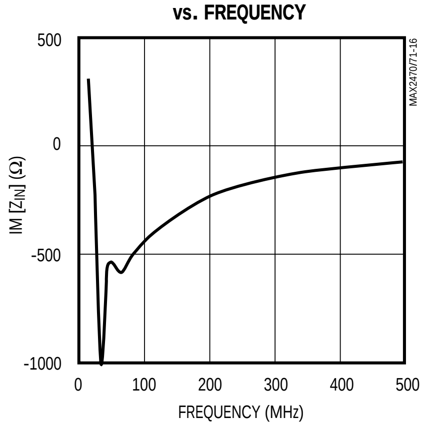

**MAX2471**
**NOISE FIGURE vs. FREQUENCY**



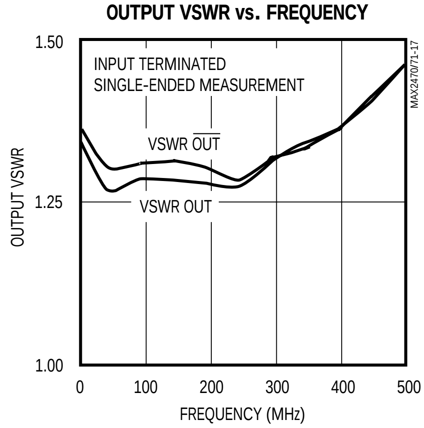

**MAX2471**
**REAL INPUT IMPEDANCE vs. FREQUENCY**



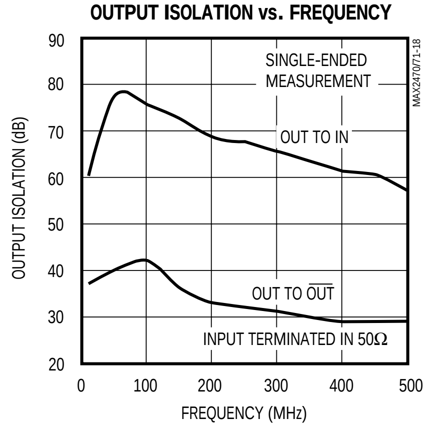

**MAX2471**
**IMAGINARY INPUT IMPEDANCE vs. FREQUENCY**




**MAX2471**
**OUTPUT VSWR vs. FREQUENCY**




**MAX2471**
**OUTPUT ISOLATION vs. FREQUENCY**



# 10MHz to 500MHz VCO Buffer Amplifiers with Differential Outputs

## Pin Description

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| MAX2470 | MAX2471 | | |
| 1 | 1 | OUT | Differential Noninverting Buffer Output. Broadband 50Ω output. AC coupling is required. **Do not DC couple to this pin.** |
| 2 | 2 | GND | RF Ground. Connect to the ground plane as close as possible to the IC to minimize ground path inductance. |
| 3 | 3 | $\overline{\text{OUT}}$ | Differential Inverting Buffer Output. Broadband 50Ω output. AC coupling is required. **Do not DC couple to this pin**. |
| 4 | — | HI/$\overline{\text{LO}}$ | Bias and Bandwidth Control Input. Connect to $V_{CC}$ to set internal bias for higher bandwidth operation (10MHz to 500MHz). Connect to GND to set internal bias for lower bandwidth operation (10MHz to 200MHz) and to reduce overall current consumption. |
| — | 4 | $\overline{\text{IN}}$ | Differential Inverting Buffer Input. High impedance input to buffer amplifier. See *Setting The Input Impedance* section. |
| 5 | 5 | IN | Differential Noninverting Buffer Input. High impedance to buffer amplifier. See *Setting The Input Impedance* section. |
| 6 | 6 | $V_{CC}$ | Supply Voltage Input. +2.7V < $V_{CC}$ < +5.5V. |

## Detailed Description

### Bandwidth Control Circuitry

The MAX2470 features a logic-controlled bias circuit which optimizes the performance for input frequencies from 10MHz to 500MHz (HI/$\overline{\text{LO}}$ = $V_{CC}$) and 10MHz to 200MHz (HI/$\overline{\text{LO}}$ = GND). Operating with HI/$\overline{\text{LO}}$ = GND significantly reduces power consumption.

## Applications Information

### Input Considerations

The MAX2470/MAX2471 offer high-impedance inputs, ideal for low-distortion buffering of a VCO. For applications with discrete transistor-based oscillator designs, simply AC-couple the oscillator directly to the inputs. The buffer's high input impedance results in minimal loading on the oscillator. For still higher real input impedance and reduced loading effects, match the inputs with a shunt-L matching circuit followed by a series blocking capacitor. For use with 50Ω VCO modules, terminate the buffer input(s) with a 50Ω shunt resistor followed by a series-blocking capacitor. This provides a very stable 50Ω termination and increases reverse isolation. For those applications needing both high gain and good input match, reactively match the buffer inputs to 50Ω with simple two-element matching circuits followed by a series blocking capacitor.

### Output Considerations

The MAX2470 and MAX2471 incorporate fully differential output stages capable of driving an AC-coupled 100Ω differential load or two AC-coupled 50Ω single-ended loads. This is ideal for applications that require the oscillator to drive two application circuits (e.g. mixer and PLL) simultaneously. The high output-to-output isolation ensures minimal interaction between multiple load circuits.

### Layout and Power-Supply Bypassing

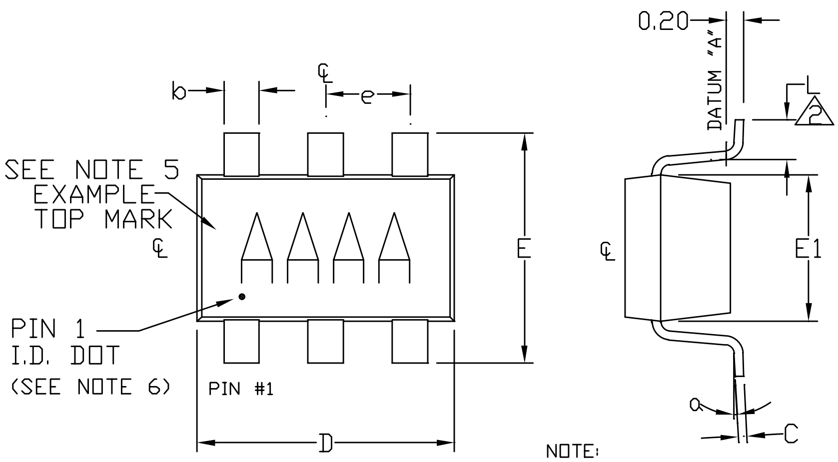
A properly designed PC board is essential to any RF/microwave circuit. Be sure to use controlled impedance lines on all high-frequency inputs and outputs. Bypass the power supply with decoupling capacitors as close to the $V_{CC}$ pins as possible. For long $V_{CC}$ lines (inductive), it may be necessary to add additional decoupling capacitors located further away from the device package.

Proper grounding of GND is essential. If the PC board uses a topside RF ground, connect GND directly to it. For a board where the ground plane is not on the component side, the best technique is to connect GND to the board with a plated through-hole (via) to the ground plane close to the package.

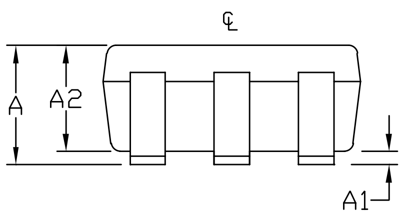
## Chip Information

TRANSISTOR COUNT: 67

## Package Information




| SYMBOL | MIN | MAX |
|---|---|---|
| A | 0.90 | 1.45 |
| A1 | 0.00 | 0.15 |
| A2 | 0.90 | 1.30 |
| b | 0.35 | 0.50 |
| C | 0.08 | 0.20 |
| D | 2.80 | 3.00 |
| E | 2.60 | 3.00 |
| E1 | 1.50 | 1.75 |
| L | 0.35 | 0.55 |
| e | 0.95 REF | |
| α | 0° | 10° |




NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM A & LEAD SURFACE.
3. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. PACKAGE OUTLINE INCLUSIVE OF SOLDER PLATING.
5. PIN 1 IS LOWER LEFT PIN WHEN READING TOP MARK FROM LEFT TO RIGHT. (SEE EXAMPLE TOP MARK)
6. PIN 1 I.D. DOT IS 0.3 MM ø MIN. LOCATED ABOVE PIN 1.

MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, SOT23, 6L

| APPROVAL | DOCUMENT CONTROL NO. | REV | |
|---|---|---|---|
| | 21-0058 | D | 1/1 |

6LSOT.EPS

**NOTES**