

# MAX2644

# 2.4GHz SiGe, High IP3 Low-Noise Amplifier

## General Description

The MAX2644 low-cost, high third-order intercept point (IP3) low-noise amplifier (LNA) is designed for applications in 2.4GHz WLAN, ISM, and Bluetooth radio systems. It features a programmable bias, allowing the input IP3 and supply current to be optimized for specific applications. The LNA provides up to +1dBm input IP3 while maintaining a low noise figure of 2.0dB and a typical gain of 16dB.

The MAX2644 is designed on a low-noise, advanced silicon-germanium (SiGe) technology. It operates with a +2.7V to +5.5V single supply and is available in an ultra-small 6-pin SC70 package.

## Applications

- Bluetooth
- 802.11 WLAN
- Home RF
- Satellite CD Radio
- 2.4GHz ISM Band Radios
- 2.4GHz Cordless Phones
- Wireless Local Loop (WLL)

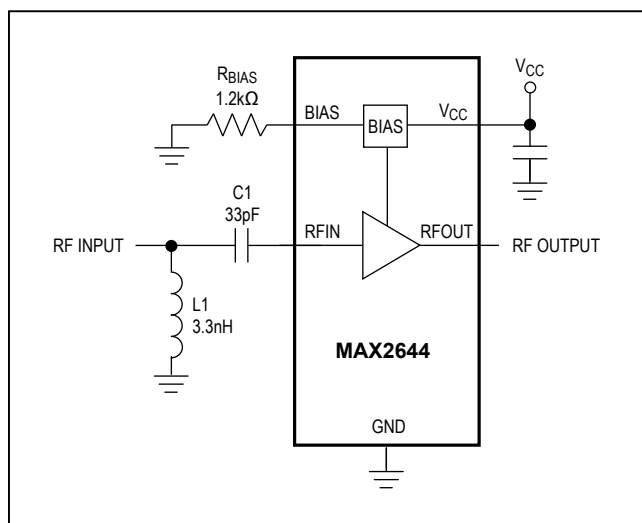
## Features

- Low Noise Figure (2.0dB at 2450MHz)
- High Gain: 16dB
- Adjustable IP3 and Bias Current
- Low-Power Standby Mode
- On-Chip Output Matching
- +2.7V to +5.5V Single-Supply Operation
- Ultra-Small 6-Pin SC70 Package

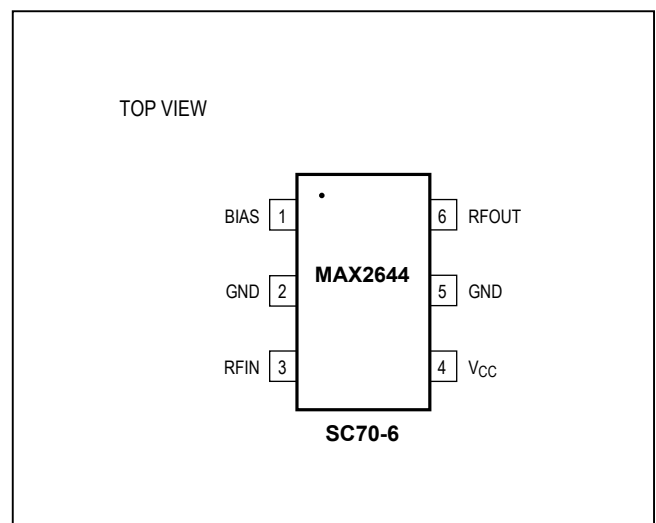
## Ordering Information

| PART         | TEMP RANGE     | PIN-PACKAGE | TOP MARK |
|--------------|----------------|-------------|----------|
| MAX2644EXT+  | -40°C to +85°C | 6 SC70      | AAG      |
| MAX2644EXT-T | -40°C to +85°C | 6 SC70      | AAG      |
| MAX2644EXT+T | -40°C to +85°C | 6 SC70      | AAG      |

## Typical Operating Circuit



## Pin Configuration



**Absolute Maximum Ratings**

|                                    |                |   |
|------------------------------------|----------------|---|
| V <sub>CC</sub> to GND .....       | -0.3V to +6V   | Continuous Power Dissipation (T <sub>A</sub> = +70°C) |
| RFIN, RFOUT to GND.....            | ±0.3V          | 6-Pin SC70 (derate 3.1mW/°C above +70°C).....         |
| RFIN Power (50Ω source).....       | +5dBm          | Storage Temperature.....                              |
| BIAS to GND .....                  | 0 to +0.3V     | Lead Temperature (soldering, 10s) .....               |
| Operating Temperature Range.....   | -40°C to +85°C |   |
| Maximum Junction Temperature ..... | +150°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**

(V<sub>CC</sub> = +2.7V to +5.5V, R<sub>BIAS</sub> = 1.2kΩ, no RF signal applied, R<sub>FIN</sub> and R<sub>FOUT</sub> are AC-coupled and terminated to 50Ω, T<sub>A</sub> = -40°C to +85°C. Typical values are at V<sub>CC</sub> = +3.0V, T<sub>A</sub> = +25 °C, unless otherwise noted.) (Note 1)

| PARAMETER                | CONDITIONS   | MIN | TYP  | MAX  | UNITS |
|--------------------------|--|-----|------|------|-------|
| Supply Voltage           |  | 2.7 |      | 5.5  | V     |
| Operating Supply Current | R <sub>BIAS</sub> = 3.9kΩ  |     | 2.7  |      | mA    |
|                          | R <sub>BIAS</sub> = 1.2kΩ, T <sub>A</sub> = +25°C                                |     | 7.0  | 9.7  |       |
|                          | R <sub>BIAS</sub> = 1.2kΩ, T <sub>A</sub> = -40°C to +85°C                       |     |      | 11.0 |       |
|                          | R <sub>BIAS</sub> = 750Ω   |     | 10.2 |      |       |
| Standby Supply Current   | R <sub>BIAS</sub> is unconnected, T <sub>A</sub> = +25°C, V <sub>CC</sub> = 3.3V |     |      | 100  | μA    |

**AC ELECTRICAL CHARACTERISTICS**

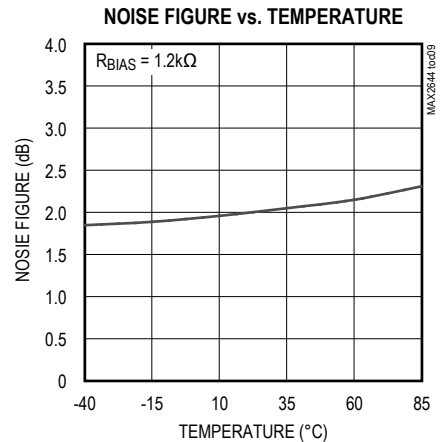
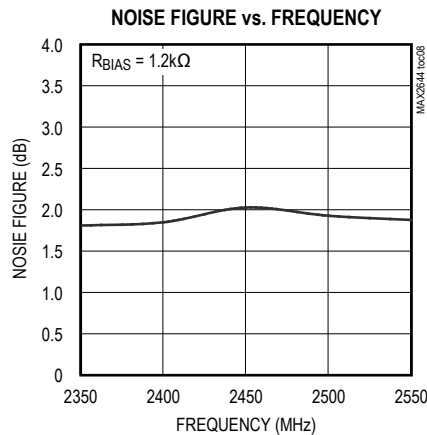
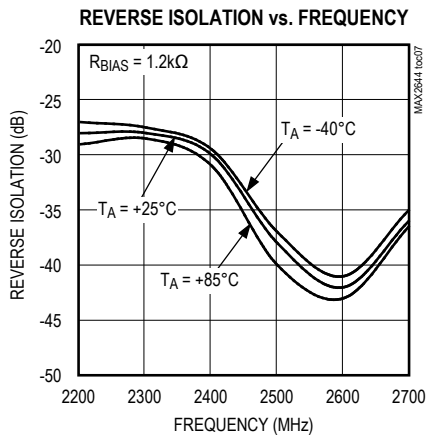
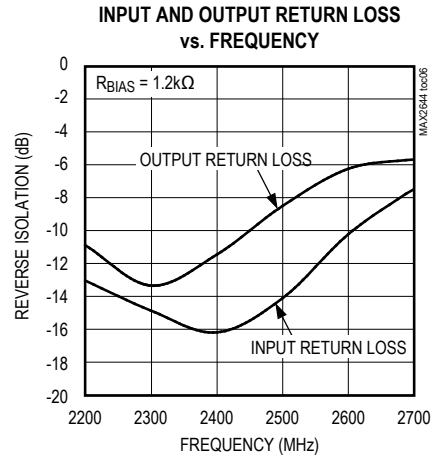
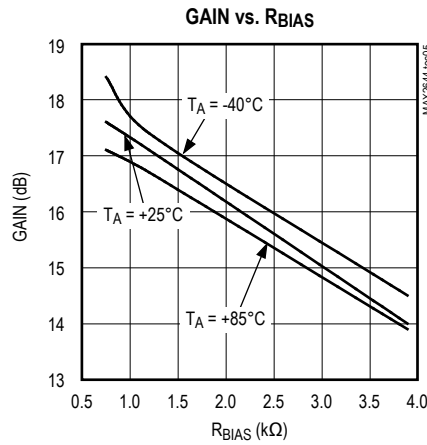
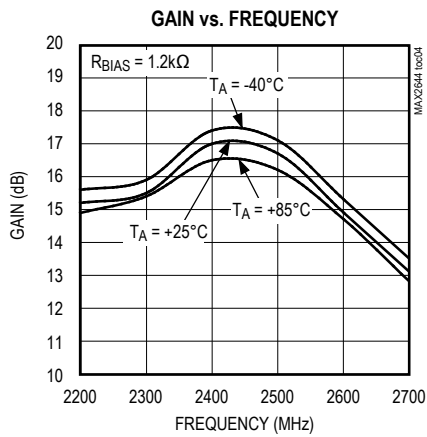
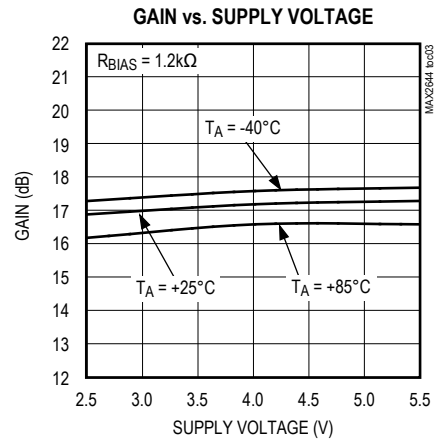
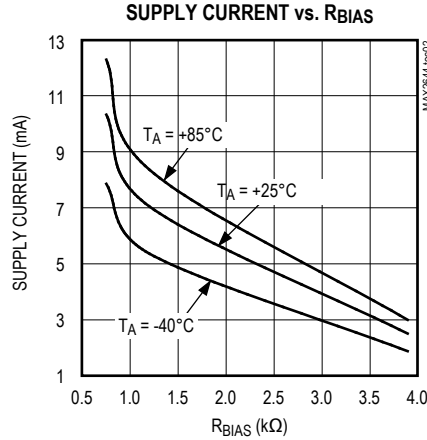
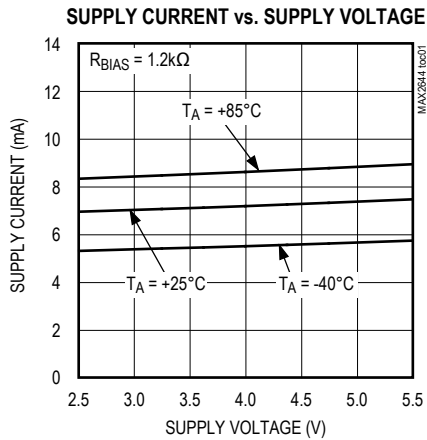
(MAX2644 EV kit, V<sub>CC</sub> = +3.0V, f<sub>RFIN</sub> = 2450MHz, P<sub>RFIN</sub> = -30dBm, input and output are terminated to 50Ω, R<sub>BIAS</sub> = 1.2kΩ, T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 2)

| PARAMETER                                  | CONDITIONS                      | MIN  | TYP  | MAX  | UNITS |
|--|---------------------------------|------|------|------|-------|
| Operating Frequency                        | (Note 3)                        | 2400 |      | 2500 | MHz   |
| Gain (Note 4)                              |                                 | 15   | 17   |      | dB    |
| Gain Variation Over Temperature            | T <sub>A</sub> = -40°C to +85°C |      | ±0.7 | ±1.0 | dB    |
| Input Third-Order Intercept Point (Note 5) | R <sub>BIAS</sub> = 750Ω        |      | -4   |      | dBm   |
|  | R <sub>BIAS</sub> = 1.2kΩ       |      | -3   |      |       |
|  | R <sub>BIAS</sub> = 3.9kΩ       |      | -8   |      |       |
| Input 1dB Compression Point                |                                 |      | -13  |      | dBm   |
| Noise Figure                               | (Note 6)                        |      | 2.0  | 2.5  | dB    |
| Input Return Loss                          |                                 |      | -15  |      | dB    |
| Output Return Loss                         |                                 |      | -10  |      | dB    |
| Reverse Isolation                          |                                 |      | -30  |      | dB    |

- Note 1:** Devices are production tested at T<sub>A</sub> = +25°C. Minimum and maximum values are guaranteed by design and characterization over temperature and supply voltages.
- Note 2:** Min/Max limits are guaranteed by design and characterization.
- Note 3:** The part has been characterized at the specified frequency range. Operation outside this range is possible but not guaranteed.
- Note 4:** Excluding PC board losses (0.3dB at the input and 0.3dB at the output of the MAX2644 EV kit).
- Note 5:** Measured with two input tones (f<sub>1</sub> = 2445MHz, f<sub>2</sub> = 2455MHz) both at -30dBm per tone. Input IP3 can be improved to +1dBm with circuit shown in Figure 2.
- Note 6:** Excluding PC board losses (0.3dB typical at the input of the MAX2644 EV kit).

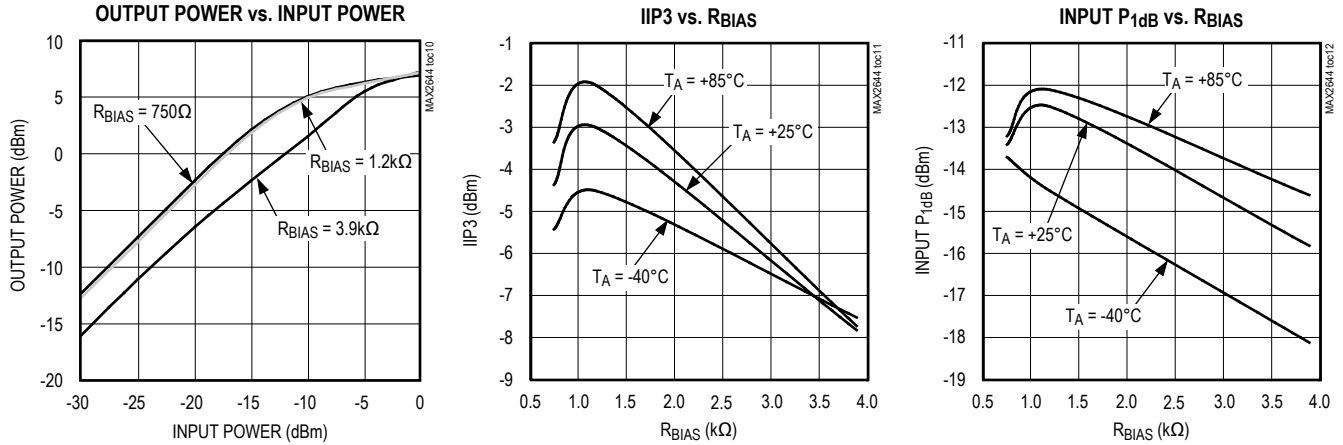
Typical Operating Characteristics

( $P_{RFIN} = -30\text{dBm}$ ,  $Z_S = Z_L = 50\Omega$ ,  $V_{CC} = +3.0\text{V}$ ,  $f_{RFIN} = 2450\text{MHz}$ ,  $R_{BIAS} = 1.2\text{k}\Omega$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



Typical Operating Characteristics (continued)

( $P_{RFIN} = -30\text{dBm}$ ,  $Z_S = Z_L = 50\Omega$ ,  $V_{CC} = +3.0\text{V}$ ,  $f_{RFIN} = 2450\text{MHz}$ ,  $R_{BIAS} = 1.2\text{k}\Omega$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



Pin Descriptions

| PIN  | NAME     | DESCRIPTION  |
|------|----------|--|
| 1    | BIAS     | Resistor Bias Control. Connect a resistor, $R_{BIAS}$ , from BIAS to ground. $R_{BIAS}$ sets IP3 and supply current. The current through this pin is approximately $60\text{mV}$ divided by $R_{BIAS}$ (see <i>Applications Information</i> ). |
| 2, 5 | GND      | Ground. For optimum performance, provide a low-inductance connection to the ground plane.  |
| 3    | RFIN     | Amplifier Input. AC-couple to this pin with a DC blocking capacitor. External matching network is required for optimum performance.  |
| 4    | $V_{CC}$ | Supply Voltage. Bypass with a capacitor directly to ground at the supply pin. Refer to <i><math>V_{CC}</math> Line Bypassing</i> section for more information.   |
| 6    | RFOUT    | Amplifier Output. AC-coupled internally.   |

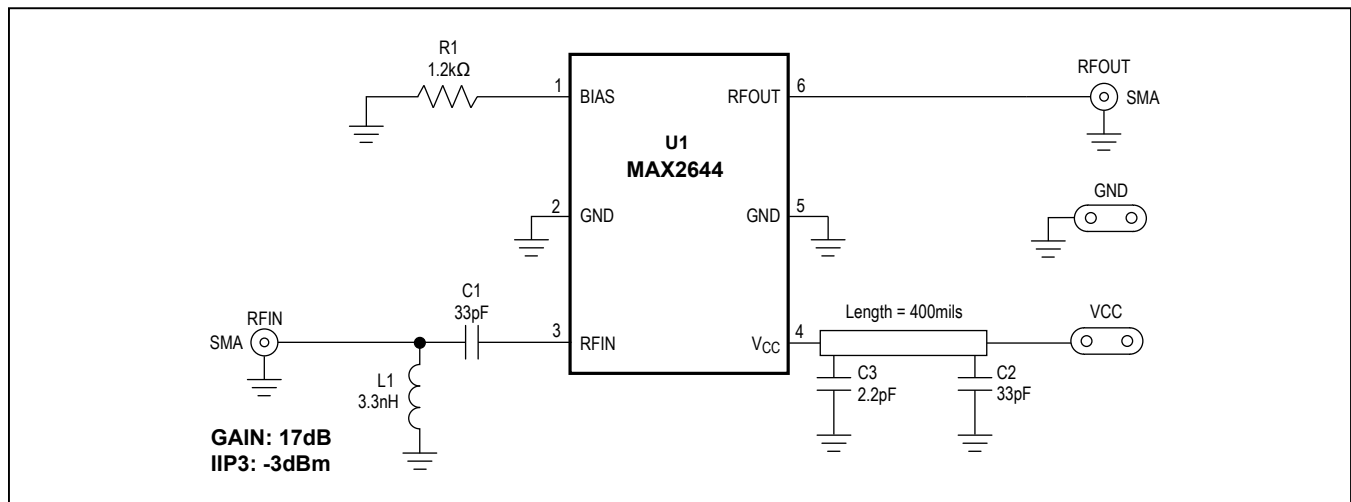


Figure 1. High Gain Design

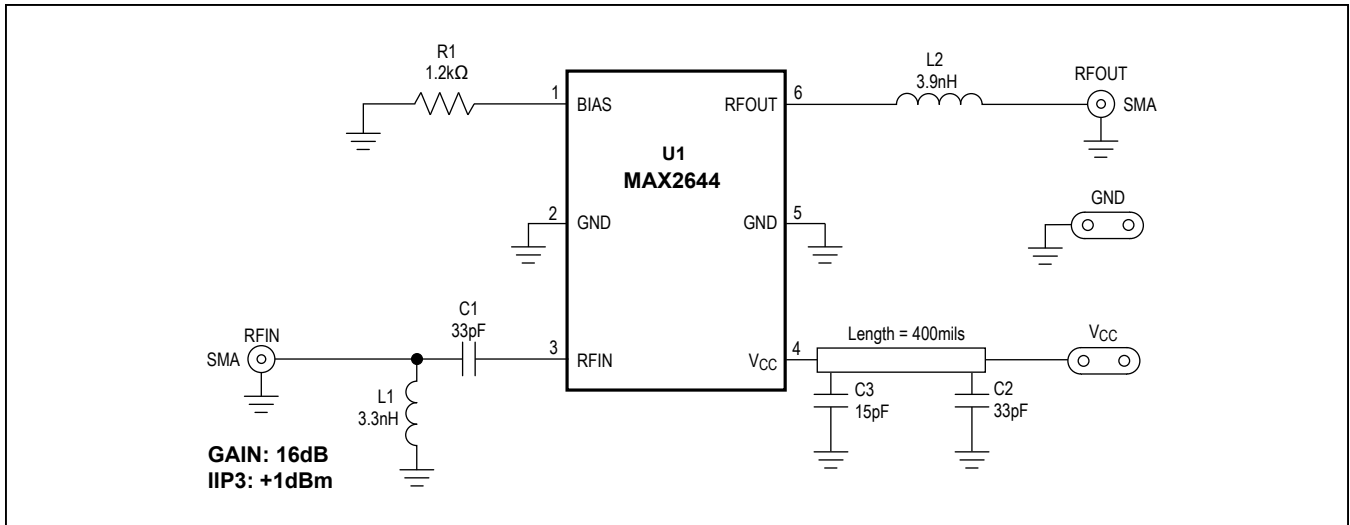


Figure 2. High Linearity Design

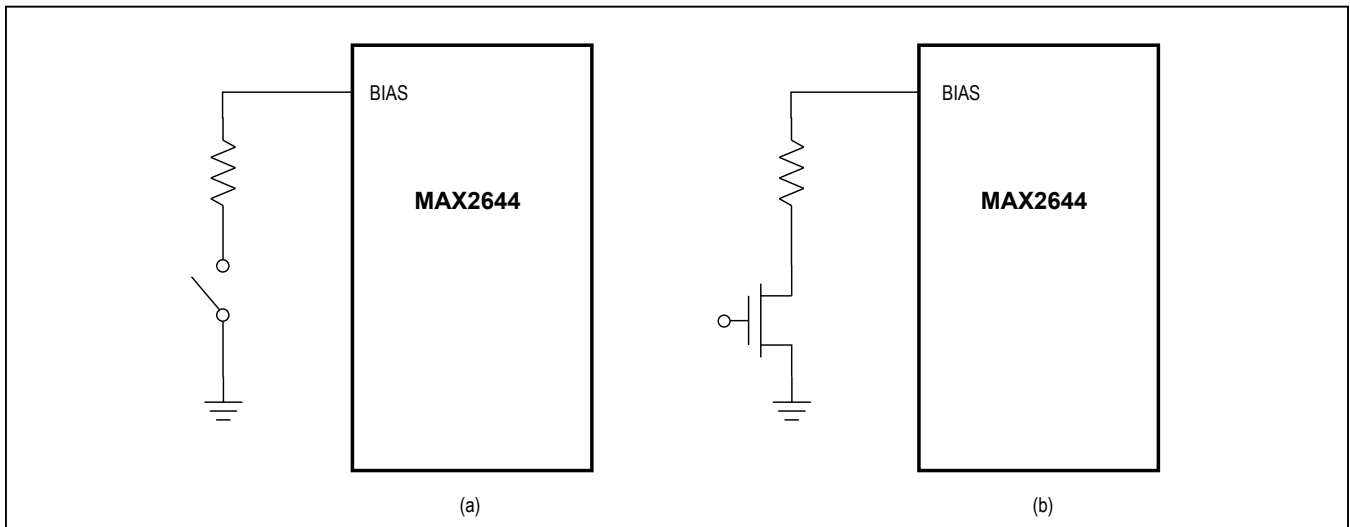


Figure 3. Recommended MAX2644 Standby Configurations

## Applications Information

### Input Matching

Input matching is required for optimum performance. The MAX2644 requires a simple LC matching network, as shown in the [Typical Operating Circuit](#). To further reduce cost and external component count, replace the external inductor with a microstrip transmission line. The [Typical Operating Circuit](#) shows the recommended input matching network for the MAX2644 at 2450MHz. These values are optimized for best simultaneous gain, noise figure, and return loss performance.

### VCC Line Bypassing

Bypassing the VCC line is necessary for optimum gain/linearity performance. A transmission line and two capacitors are required, as shown in the schematics in Figures 1 and 2. The optimum dimensions and positions of the components are as follows: the output transmission line dimension is 0.532in (length) x 0.012in (width); the distance from C2 to the IC is 0.352in; and the distance from C3 to the IC is 0.041in. Please refer to Figures 1 and 2 for component values.

**Table 1. MAX2644 Typical Scattering Parameters**  
( $R_{BIAS} = 750\Omega$ ,  $V_{CC} = +3.0V$ ,  $T_A = +25^\circ C$ .)

| FREQ. (MHz) | S11 MAG | S11 PHASE (°) | S21 MAG | S21 PHASE (°) | S12 MAG | S12 PHASE (°) | S22 MAG | S22 PHASE (°) |
|-------------|---------|---------------|---------|---------------|---------|---------------|---------|---------------|
| 2200        | 0.3372  | -79.36        | 5.1940  | 170.97        | 0.0414  | 157.19        | 0.2818  | -73.71        |
| 2250        | 0.3098  | -70.09        | 5.3156  | 166.79        | 0.0445  | 146.70        | 0.2204  | -67.13        |
| 2300        | 0.3283  | -57.20        | 5.4281  | 159.22        | 0.0469  | 130.62        | 0.1566  | -50.26        |
| 2350        | 0.4005  | -50.46        | 5.4175  | 150.70        | 0.0441  | 108.72        | 0.1480  | -3.96         |
| 2400        | 0.4839  | -50.28        | 5.3346  | 143.93        | 0.0349  | 85.67         | 0.2795  | 15.12         |
| 2450        | 0.5443  | -56.33        | 5.0687  | 136.45        | 0.0233  | 58.80         | 0.4179  | 11.12         |
| 2500        | 0.5758  | -60.09        | 4.9556  | 132.16        | 0.0113  | 27.74         | 0.5135  | 3.28          |
| 2550        | 0.5784  | -63.61        | 4.5952  | 127.68        | 0.0041  | -38.98        | 0.5622  | -2.66         |
| 2600        | 0.5698  | -66.56        | 4.2364  | 126.58        | 0.0063  | -110.49       | 0.5986  | -7.45         |
| 2650        | 0.5600  | -68.51        | 4.1376  | 126.51        | 0.0103  | -128.93       | 0.6208  | -10.43        |
| 2700        | 0.5533  | -69.86        | 4.0729  | 120.60        | 0.0133  | -140.21       | 0.6425  | -12.93        |

**Table 2. MAX2644 Typical Scattering Parameters**  
( $R_{BIAS} = 1.2k\Omega$ ,  $V_{CC} = +3.0V$ ,  $T_A = +25^\circ C$ .)

| FREQ. (MHz) | S11 MAG | S11 PHASE (°) | S21 MAG | S21 PHASE (°) | S12 MAG | S12 PHASE (°) | S22 MAG | S22 PHASE (°) |
|-------------|---------|---------------|---------|---------------|---------|---------------|---------|---------------|
| 2200        | 0.3482  | -67.06        | 5.2390  | -177.33       | 0.0402  | 161.53        | 0.2873  | -76.58        |
| 2250        | 0.3121  | -58.60        | 5.3790  | 178.72        | 0.0435  | 151.97        | 0.2305  | -69.42        |
| 2300        | 0.3051  | -43.64        | 5.5982  | 173.43        | 0.0452  | 136.90        | 0.1735  | -54.22        |
| 2350        | 0.3693  | -30.34        | 5.8137  | 166.48        | 0.0427  | 116.57        | 0.1582  | -16.42        |
| 2400        | 0.4769  | -29.48        | 5.8063  | 158.29        | 0.0341  | 95.13         | 0.2687  | 6.52          |
| 2450        | 0.5619  | -35.54        | 5.6624  | 150.06        | 0.0236  | 68.36         | 0.4043  | 5.00          |
| 2500        | 0.5948  | -42.64        | 5.3015  | 142.37        | 0.0117  | 41.34         | 0.5030  | -2.19         |
| 2550        | 0.5939  | -47.58        | 4.7813  | 136.67        | 0.0034  | -13.74        | 0.5602  | -8.04         |
| 2600        | 0.5825  | -50.94        | 4.3271  | 134.58        | 0.0056  | -104.09       | 0.5952  | -12.76        |
| 2650        | 0.5708  | -53.14        | 4.1961  | 133.48        | 0.0096  | -124.80       | 0.6215  | -15.97        |
| 2700        | 0.5604  | -54.35        | 4.1068  | 128.01        | 0.0125  | -134.75       | 0.6434  | -18.83        |

### Standby

Standby mode is achieved by disconnecting BIAS as shown in Figure 1. Avoid capacitance at the BIAS pin by connecting the bias resistor from BIAS to the switch.

### Layout Issues

A properly designed PC board is essential to any RF/microwave circuit. Use controlled impedance lines on all high-frequency inputs and outputs. Bypass with decoupling capacitors located close to the device  $V_{CC}$  pin. For

long  $V_{CC}$  lines, it may be necessary to add additional decoupling capacitors. These additional capacitors can be located farther away from the device package. Proper grounding of the GND pins is essential. If the PC board uses a topside RF ground, connect it directly to all GND pins. For a board where the ground plane is not on the component layer, the best technique is to connect the GND pins to the board with a plated through-hole located close to the package.

**Table 3. MAX2644 Typical Scattering Parameters**  
( $R_{BIAS} = 3.9k\Omega$ ,  $V_{CC} = +3.0V$ ,  $T_A = +25^\circ C$ .)

| FREQ. (MHz) | S11 MAG | S11 PHASE (°) | S21 MAG | S21 PHASE (°) | S12 MAG | S12 PHASE (°) | S22 MAG | S22 PHASE (°) |
|-------------|---------|---------------|---------|---------------|---------|---------------|---------|---------------|
| 2200        | 0.4894  | -75.32        | 3.7368  | -173.73       | 0.0348  | 156.35        | 0.2729  | -62.97        |
| 2250        | 0.4566  | -72.73        | 3.7718  | -177.51       | 0.0363  | 147.30        | 0.2459  | -53.68        |
| 2300        | 0.4335  | -68.17        | 3.8855  | 177.43        | 0.0369  | 132.32        | 0.2211  | -41.12        |
| 2350        | 0.4343  | -61.46        | 3.9783  | 171.34        | 0.0344  | 116.21        | 0.2177  | -21.15        |
| 2400        | 0.4695  | -57.00        | 4.0230  | 165.15        | 0.0272  | 95.31         | 0.2823  | -2.41         |
| 2450        | 0.5156  | -57.52        | 4.0087  | 157.68        | 0.0179  | 70.07         | 0.3924  | 1.25          |
| 2500        | 0.5403  | -61.04        | 3.8380  | 149.58        | 0.0079  | 42.40         | 0.4849  | -2.71         |
| 2550        | 0.5423  | -63.93        | 3.5140  | 143.30        | 0.0018  | -46.47        | 0.5476  | -7.30         |
| 2600        | 0.5361  | -66.30        | 3.2048  | 140.25        | 0.0055  | -112.91       | 0.5881  | -11.35        |
| 2650        | 0.5280  | -68.08        | 3.1204  | 138.55        | 0.0100  | -132.25       | 0.6170  | -14.57        |
| 2700        | 0.5217  | -69.29        | 3.0860  | 132.16        | 0.0121  | -133.97       | 0.6418  | -17.44        |

**Table 4. MAX2644 Typical Noise Parameters at  $V_{CC} = +3.0V$ ,  $T_A = +25^\circ C$ ,  $R_{BIAS} = 750\Omega$** 

| FREQUENCY (MHz) | $F_{MIN}$ (dB) | $ \Gamma_{opt} $ | $\Gamma_{opt}$ ANGLE | $R_N$ ( $\Omega$ ) |
|-----------------|----------------|------------------|----------------------|--------------------|
| 2400            | 1.725          | 0.361            | 66.13                | 24.38              |
| 2450            | 1.747          | 0.360            | 66.93                | 24.76              |
| 2500            | 1.769          | 0.358            | 67.72                | 25.14              |

**Table 5. MAX2644 Typical Noise Parameters at  $V_{CC} = +3.0V$ ,  $T_A = +25^\circ C$ ,  $R_{BIAS} = 1.2k\Omega$** 

| FREQUENCY (MHz) | $F_{MIN}$ (dB) | $ \Gamma_{opt} $ | $\Gamma_{opt}$ ANGLE | $R_N$ ( $\Omega$ ) |
|-----------------|----------------|------------------|----------------------|--------------------|
| 2400            | 1.570          | 0.409            | 69.84                | 21.77              |
| 2450            | 1.589          | 0.408            | 70.63                | 21.94              |
| 2500            | 1.609          | 0.406            | 71.63                | 22.42              |

**Table 6. MAX2644 Typical Noise Parameters at  $V_{CC} = +3.0V$ ,  $T_A = +25^\circ C$ ,  $R_{BIAS} = 3.9k\Omega$** 

| FREQUENCY (MHz) | $F_{MIN}$ (dB) | $ \Gamma_{opt} $ | $\Gamma_{opt}$ ANGLE | $R_N$ ( $\Omega$ ) |
|-----------------|----------------|------------------|----------------------|--------------------|
| 2400            | 1.497          | 0.510            | 86.55                | 20.58              |
| 2450            | 1.517          | 0.507            | 86.50                | 20.90              |
| 2500            | 1.538          | 0.504            | 88.18                | 21.25              |

**Chip Information**

TRANSISTOR COUNT: 87

Package Information

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.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.

| COMMON DIMENSIONS |            |      |      |
|-------------------|------------|------|------|
| SYMBOL            | MIN        | NOM  | MAX  |
| A                 | 0.80       | 0.95 | 1.10 |
| A1                | 0.00       | 0.07 | 0.10 |
| A2                | 0.80       | 0.90 | 1.00 |
| b                 | 0.15       | 0.22 | 0.30 |
| c                 | 0.10       | 0.14 | 0.18 |
| D                 | 1.85       | 2.00 | 2.15 |
| e                 | 0.65 BSC.  |      |      |
| E                 | 1.15       | 1.25 | 1.35 |
| HE                | 2.00       | 2.20 | 2.35 |
| L                 | 0.26       | 0.34 | 0.46 |
| L1                | 0.425 TYP. |      |      |
| Q1                | 0.10       | 0.25 | 0.40 |
| PKG. CODES        | X6SN-1     |      |      |

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.
4. COPLANARITY 4 MILS. MAX.
5. FOOT LENGTH MEASURED AT INTERCEPT POINT BETWEEN DATUM 'A' AND LEAD SURFACE.
6. MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
7. LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION 'e', ±0.05.
8. ALL DIMENSIONS COMPLY TO JEDEC MO-203.
9. ALL DIMENSIONS APPLY TO BOTH LEADED (-) AND LEAD FREE (+) PACKAGE CODES.

-DRAWING NOT TO SCALE-

|                                    |                                 |           |     |
|------------------------------------|---------------------------------|-----------|-----|
| maxim integrated.                  |                                 |           |     |
| TITLE:<br>PACKAGE OUTLINE, 6L SC70 |                                 |           |     |
| APPROVAL                           | DOCUMENT CONTROL NO.<br>21-0077 | REV.<br>H | 1/1 |



**Revision History**

| REVISION NUMBER | REVISION DATE | DESCRIPTION  | PAGES CHANGED |
|-----------------|---------------|--|---------------|
| 2               | 2/17          | Added MAX2644EXT+, MAX2644EXT-T, and MAX2644EXT-T to <i>Ordering Information</i> table | 1             |

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at [www.maximintegrated.com](http://www.maximintegrated.com).

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