

19-1786; Rev 1; 11/03

EVALUATION KIT  
AVAILABLE

# MAXIM

## 2.4GHz SiGe, High IP3 Low-Noise Amplifier

MAX2644

### 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.

### 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

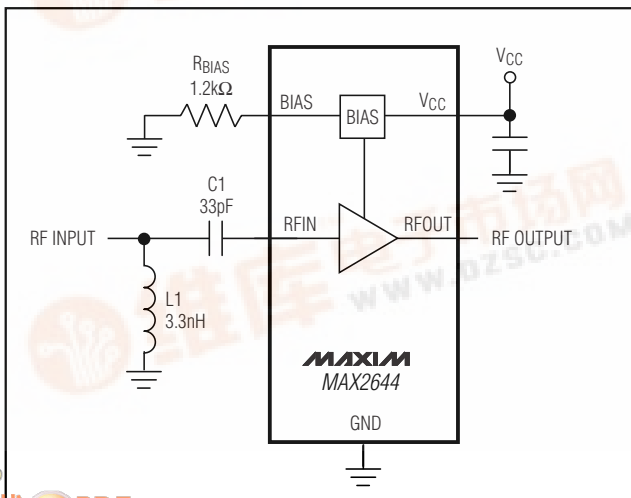
### Applications

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

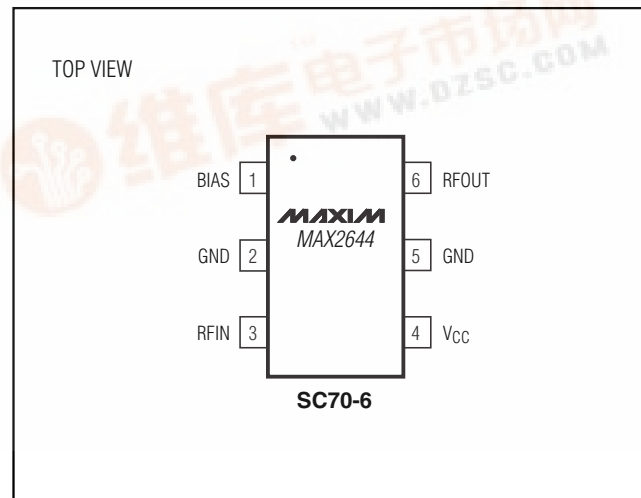
### Ordering Information

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

### Typical Operating Circuit



### Pin Configuration



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### 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) .....	245mW
RFIN Power (50Ω source) .....	+5dBm	Storage Temperature .....	-65°C to +150°C
BIAS to GND .....	0 to +0.3V	Lead Temperature (soldering, 10s) .....	+300°C
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).

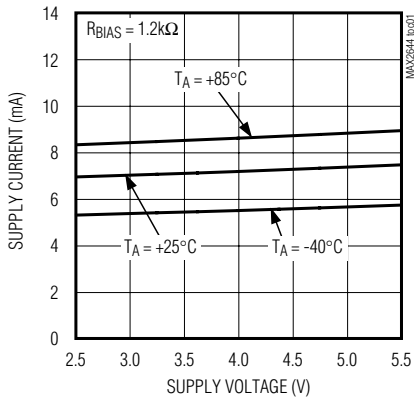
# 2.4GHz SiGe, High IP3 Low-Noise Amplifier

MAX2644

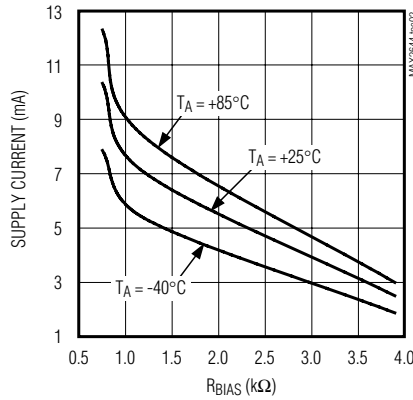
## Typical Operating Characteristics

(PRFIN = -30dBm, ZS = ZL = 50Ω, VCC = +3.0V, fRFIN = 2450MHz, RBIAS = 1.2kΩ, TA = +25°C, unless otherwise noted.)

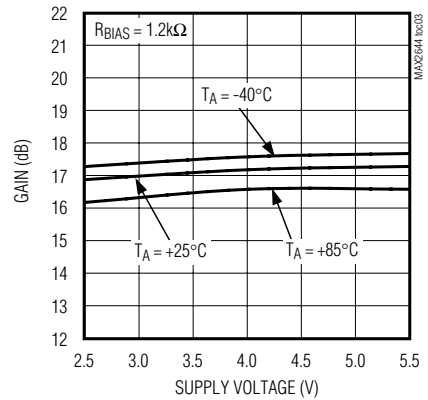
**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



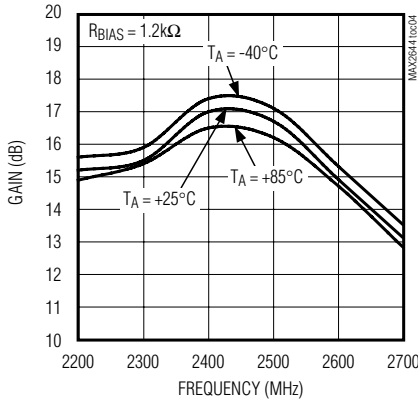
**SUPPLY CURRENT vs. RBIAS**



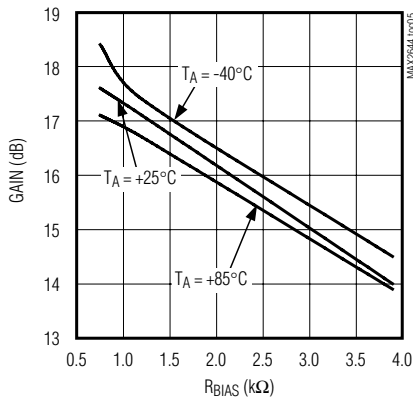
**GAIN vs. SUPPLY VOLTAGE**



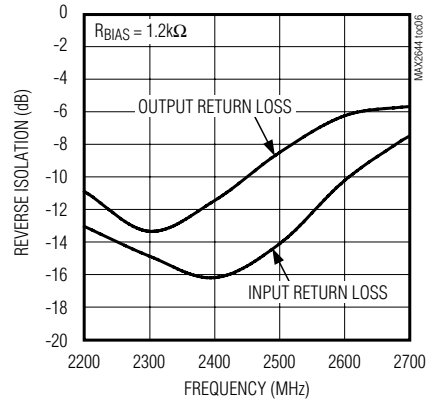
**GAIN vs. FREQUENCY**



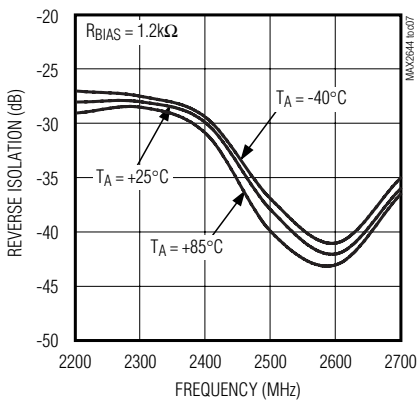
**GAIN vs. RBIAS**



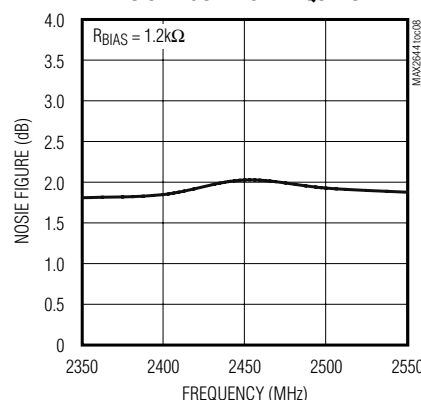
**INPUT AND OUTPUT RETURN LOSS vs. FREQUENCY**



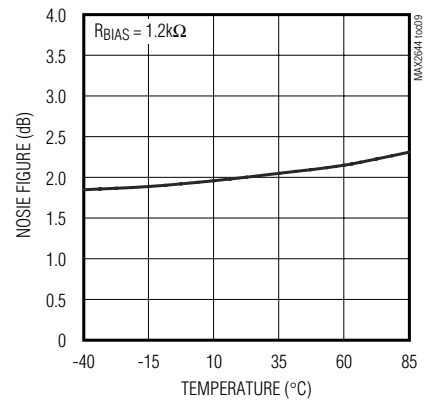
**REVERSE ISOLATION vs. FREQUENCY**



**NOISE FIGURE vs. FREQUENCY**



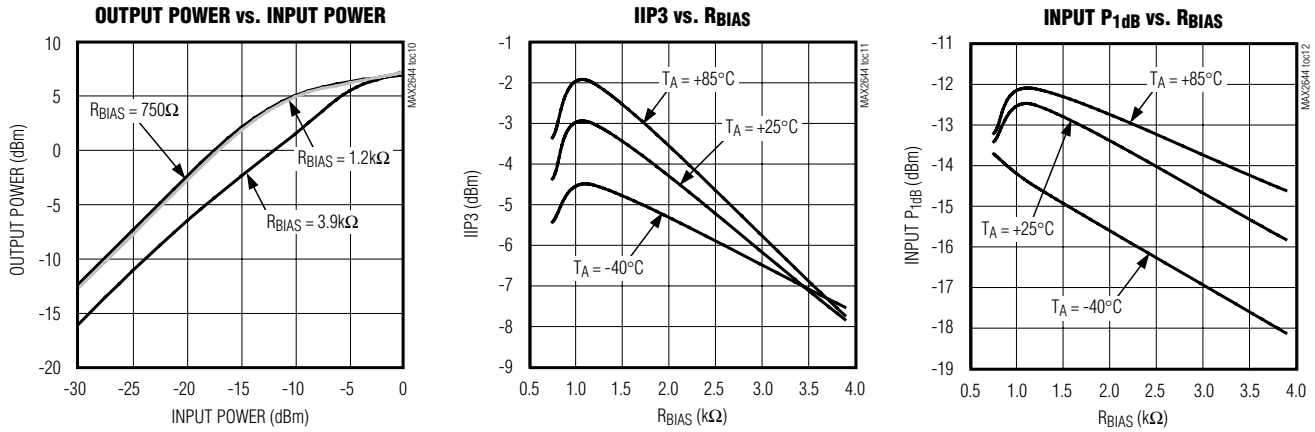
**NOISE FIGURE vs. TEMPERATURE**



# 2.4GHz SiGe, High IP3 Low-Noise Amplifier

## 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 Description

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 60mV 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	VCC	Supply Voltage. Bypass with a capacitor directly to ground at the supply pin. Refer to <i>VCC Line Bypassing</i> section for more information.
6	RFOUT	Amplifier Output. AC-coupled internally.

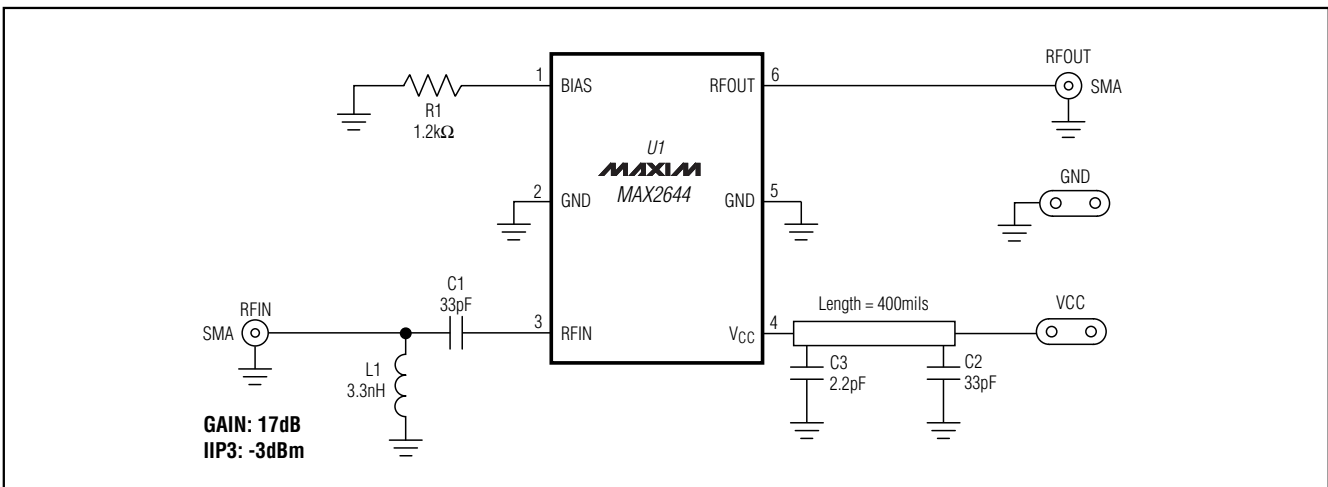


Figure 1. High Gain Design

## 2.4GHz SiGe, High IP3 Low-Noise Amplifier

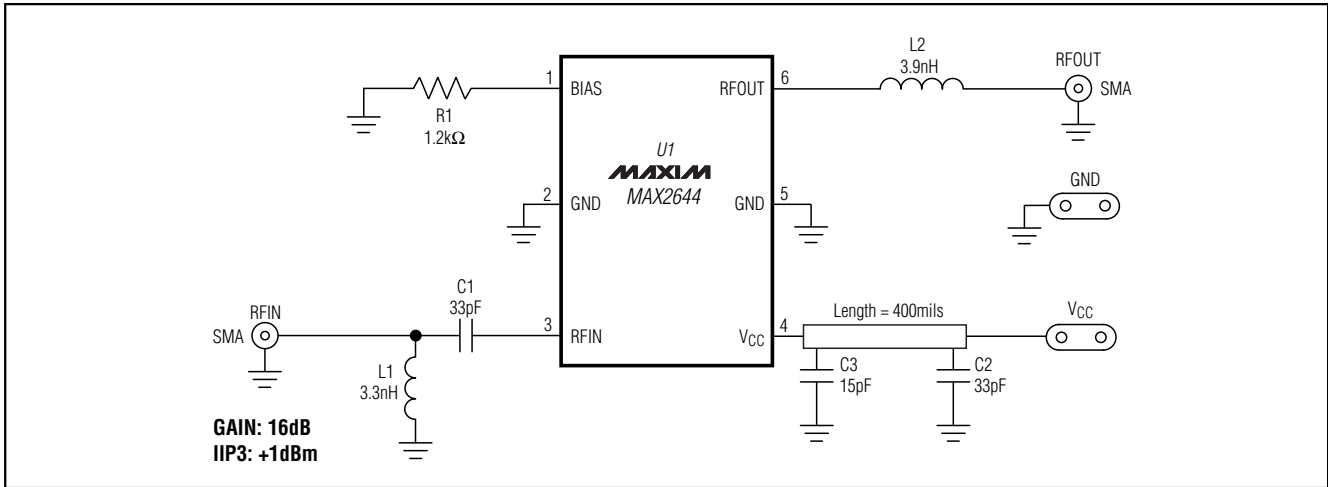


Figure 2. High Linearity Design

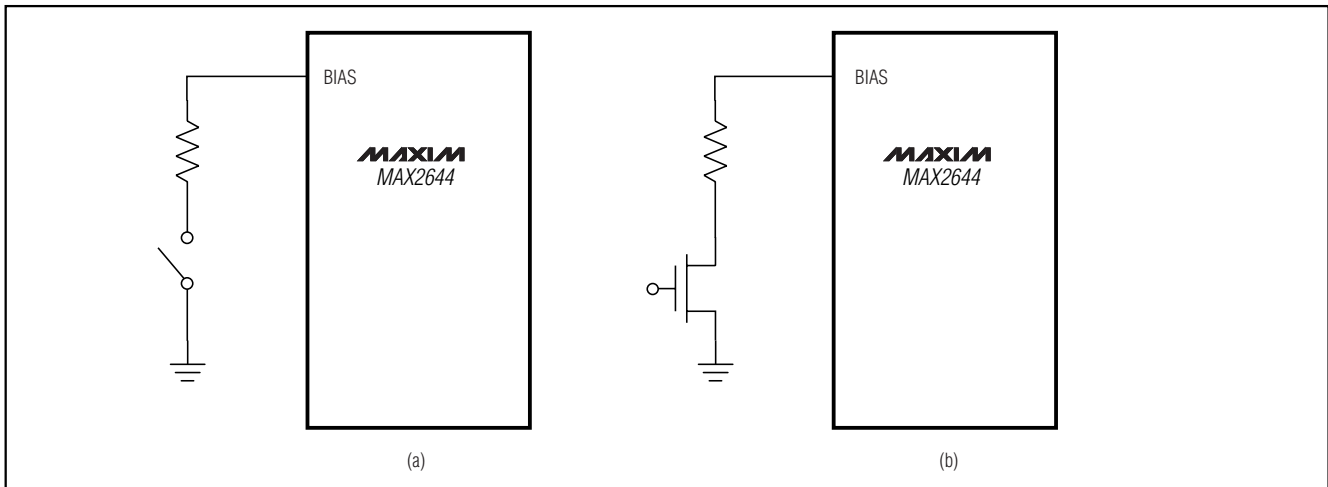


Figure 3. Recommended MAX2644 Standby Configurations

### 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) × 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.

## 2.4GHz SiGe, High IP3 Low-Noise Amplifier

**Table 1. MAX2644 Typical Scattering Parameters  
(RBIAS = 750Ω, VCC = +3.0V, TA = +25°C.)**

FREQ. (MHz)	S11 MAG	S11 PHASE (DEGREES)	S21 MAG	S21 PHASE (DEGREES)	S12 MAG	S12 PHASE (DEGREES)	S22 MAG	S22 PHASE (DEGREES)
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  
(RBIAS = 1.2kΩ, VCC = +3.0V, TA = +25°C.)**

FREQ. (MHz)	S11 MAG	S11 PHASE (DEGREES)	S21 MAG	S21 PHASE (DEGREES)	S12 MAG	S12 PHASE (DEGREES)	S22 MAG	S22 PHASE (DEGREES)
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 VCC

pin. For long VCC 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.

## 2.4GHz SiGe, High IP3 Low-Noise Amplifier

MAX2644

**Table 3. MAX2644 Typical Scattering Parameters  
(RBIAS = 3.9kΩ, VCC = +3.0V, TA = +25°C.)**

FREQ. (MHz)	S11 MAG	S11 PHASE (DEGREES)	S21 MAG	S21 PHASE (DEGREES)	S12 MAG	S12 PHASE (DEGREES)	S22 MAG	S22 PHASE (DEGREES)
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 VCC = +3.0V, TA = +25°C,  
RBIAS = 750Ω**

FREQUENCY (MHz)	FMIN (dB)	Γ <sub>opt</sub>	Γ <sub>opt</sub> ANGLE	R <sub>N</sub> (Ω)
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 VCC = +3.0V, TA = +25°C,  
RBIAS = 1.2kΩ**

FREQUENCY (MHz)	FMIN (dB)	Γ <sub>opt</sub>	Γ <sub>opt</sub> ANGLE	R <sub>N</sub> (Ω)
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 VCC = +3.0V, TA = +25°C,  
RBIAS = 3.9kΩ**

FREQUENCY (MHz)	FMIN (dB)	Γ <sub>opt</sub>	Γ <sub>opt</sub> ANGLE	R <sub>N</sub> (Ω)
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

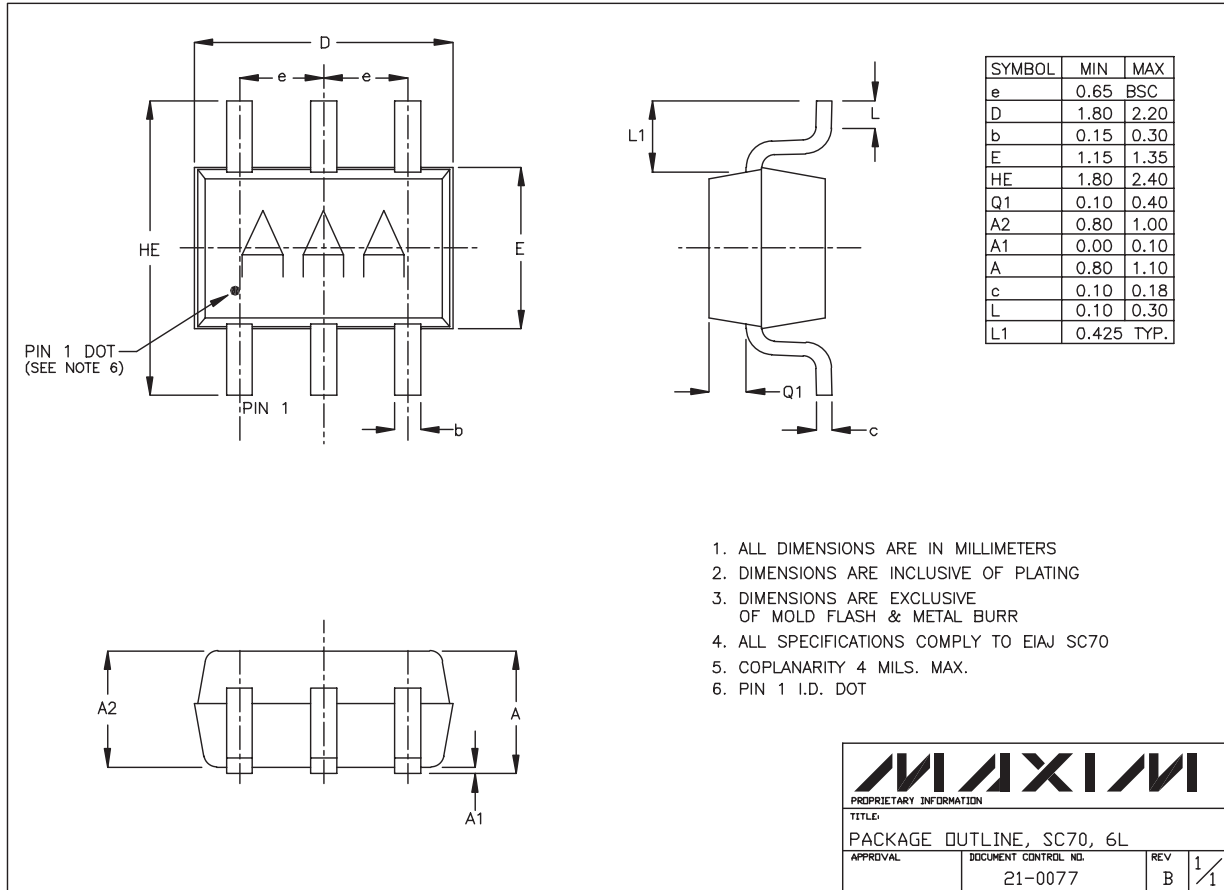
### Chip Information

TRANSISTOR COUNT: 87

# 2.4GHz SiGe, High IP3 Low-Noise Amplifier

## 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](http://www.maxim-ic.com/packages).)



1. ALL DIMENSIONS ARE IN MILLIMETERS
2. DIMENSIONS ARE INCLUSIVE OF PLATING
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR
4. ALL SPECIFICATIONS COMPLY TO EIAJ SC70
5. COPLANARITY 4 MILS. MAX.
6. PIN 1 I.D. DOT

<b>MAXIM</b>		
<small>PROPRIETARY INFORMATION</small>		
<small>TITLE:</small>		
PACKAGE OUTLINE, SC70, 6L		
<small>APPROVAL</small>	<small>DOCUMENT CONTROL NO.</small>	<small>REV</small>
	21-0077	B 1/1

SC70, 6LEFS

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