

DATA SHEET

SKY67002-396LF: 1.6-2.2 GHz High Linearity, Active Bias Low-Noise Amplifier

Applications

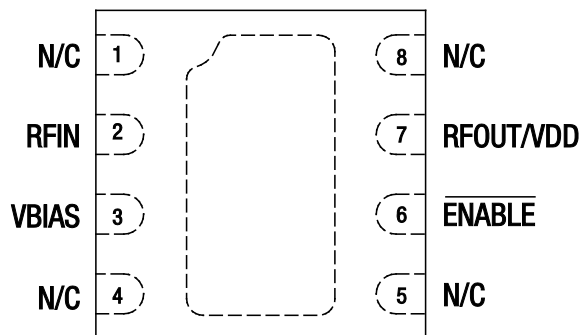
- GSM, CDMA, WCDMA, TD-SCDMA cellular infrastructure
- Ultra low-noise systems
- Balanced, single-ended low-noise amplifier designs

Features

- Extended operating temperature range: -40°C to $+100^{\circ}\text{C}$
- Low Noise Figure: 0.65 dB @ 1.85 GHz
- Excellent IIP3 performance: +22 dBm @ 1.85 GHz
- Gain: 17.5 dB @ 1.85 GHz
- Adjustable supply current
- Integrated enable circuitry
- Temperature and process-stable active bias
- Miniature DFN (8-pin, 2 x 2 mm) package (MSL1 @ 260°C per JEDEC J-STD-020)



Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04-0074.



S2240

Figure 2. SKY67002-396LF Pinout – 8-Pin DFN (Top View)

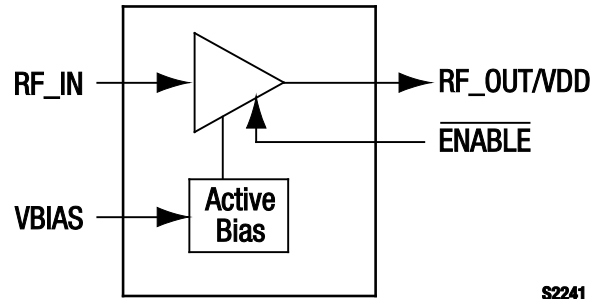


Figure 1. SKY67002-396LF Block Diagram

Description

The SKY67002-396LF is GaAs, pHEMT Low-Noise Amplifier (LNA) with an active bias and high linearity performance. The advanced GaAs pHEMT enhancement mode process provides good return loss, low noise, and high linearity performance.

The internal active bias circuitry provides stable performance over temperature and process variation. The device offers the ability to externally adjust supply current and gain. Supply voltage is applied to the RFOUT/VDD pin through an RF choke inductor. Pin 3 (VBIAS) should be connected to RFOUT/VDD through an external resistor to control the supply current. The RFIN and RFOUT/VDD pins should be DC blocked to ensure proper operation.

The SKY67002-396LF operates in the frequency range of 1.6 to 2.2 GHz. For lower and higher frequency operation, the pin-compatible SKY67001-396LF and SKY67003-396LF, respectively, should be used.

The LNA is manufactured in a compact, 2 x 2 mm, 8-pin Dual Flat No-Lead (DFN) package. A functional block diagram is shown in Figure 1. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.

Table 1. SKY67002-396LF Signal Descriptions

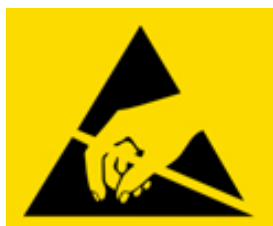
Pin #	Name	Description	Pin #	Name	Description
1	N/C	No connection. May be connected to ground with no change in performance.	5	N/C	No connection. May be connected to ground with no change in performance.
2	RFIN	RF input. DC blocking capacitor required.	6	ENABLE	Enable pin. Active “low” (0 V) = amplifier on state.
3	VBIAS	Bias for 1 st stage amplifier. External resistor sets current consumption.	7	RFOUT/VDD	RF output. Apply VDD through RF choke inductor. DC blocking capacitor required.
4	N/C	No connection. May be connected to ground with no change in performance.	8	N/C	No connection. May be connected to ground with no change in performance.

Table 2. SKY67002-396LF Absolute Maximum Ratings

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply voltage	V _{DD}			5.5	V
RF input power	P _{IN}			+20	dBm
Channel temperature	T _{CH}			+150	°C
Thermal resistance	Θ _{JC}		70		°C/W
Storage temperature	T _{STG}	–65	+25	+150	°C
Operating temperature	T _A	–55	+25	+100	°C

Notes: Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal value. Exceeding any of the limits listed here may result in permanent damage to the device.

Thermal resistance = 70 °C/W @ 5 V bias.



Attention: Observe Precautions for Handling Electrostatic Sensitive Devices

ESD Human Body Model (HBM) = 250 V (Class 1A)

ESD Machine Model (MM) = 50 V (Class A)

ESD Charged Device Model (CDM) = 1000 V (Class 4)

Electrostatic Discharge (ESD) can damage this device, which must be protected from ESD at all times. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions should be used at all times.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY67002-396LF are provided in Table 2. Electrical specifications are provided in Table 3.

Typical performance characteristics of the SKY67002-396LF are illustrated in Figures 3 through 22.

Table 4 provides noise source pull information versus frequency.

Table 3. SKY67002-396LF Electrical Specifications (Note 1, 2)**(V_{DD} = 5 V, I_{DD} = 95 mA, T_A = +25 °C, P_{IN} = -20 dBm, Characteristic Impedance [Z₀] = 50 Ω, Unless Otherwise Noted)**

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
RF Specifications						
Noise Figure (Note 3)	NF	@ 1.85 GHz		0.65	0.85	dB
Small signal gain	S ₂₁	@ 1.85 GHz	16.5	17.5	18.5	dB
Input return loss	S ₁₁	@ 1.85 GHz	15	20		dB
Output return loss	S ₂₂	@ 1.85 GHz	11	16		dB
Reverse isolation	S ₁₂	@ 1.85 GHz	27	31		dB
3 rd Order Input Intercept Point (Note 4)	IIP3	@ 1.85 GHz, Δf = 1 MHz, P _{IN} = -20 dBm/tone	+19.5	+22.0		dBm
3 rd Order Output Intercept Point (Note 4)	OIP3	@ 1.85 GHz, Δf = 1 MHz, P _{IN} = -20 dBm/tone	+37.0	+39.5		dBm
1 dB Input Compression Point	IP1dB	@ 1.85 GHz	+1.0	+3.5		dBm
1 dB Output Compression Point	OP1dB	@ 1.85 GHz	+17.5	+20.0		dBm
Stability (Note 5)	μ, μ1	Up to 18 GHz, -40 °C to +85 °C		> 1		–
DC Specifications						
Supply voltage	V _{DD}		3.3	5.0		V
Quiescent supply current	I _{DD}	Set with external resistor	30	95		mA
Amplifier enable off current (logic “high”)	I _{EN}			700	1000	μA
Enable rise time	T _R	@ 1.85 GHz			100	μs
Enable fall time	T _F	@ 1.85 GHz			100	μs

Note 1: Performance is guaranteed only under the conditions listed in this Table.**Note 2:** Circuit topology optimized for balanced configuration with best IIP3 and NF performance.**Note 3:** Loss from the input SMA connector and Evaluation Board up to component M1 has been de-embedded from the NF measurement (0.06 dB).**Note 4:** Improved intercept performance can be obtained with V_{DD} or Pin 7 set to 4 V (see Figure 15).**Note 5:** Applies to typical application circuit and components shown in Figure 25.

Typical Performance Characteristics

($V_{DD} = 5\text{ V}$, $I_{DD} = 95\text{ mA}$, $T_A = +25\text{ }^{\circ}\text{C}$, $P_{IN} = -20\text{ dBm}$, Characteristic Impedance [Z_0] = $50\text{ }\Omega$, Unless Otherwise Noted)

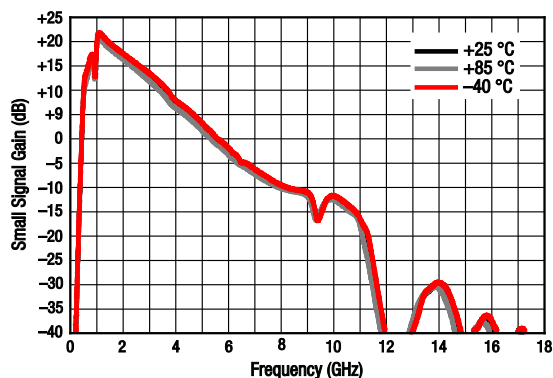


Figure 3. Broadband Gain Response vs Frequency Over Temperature

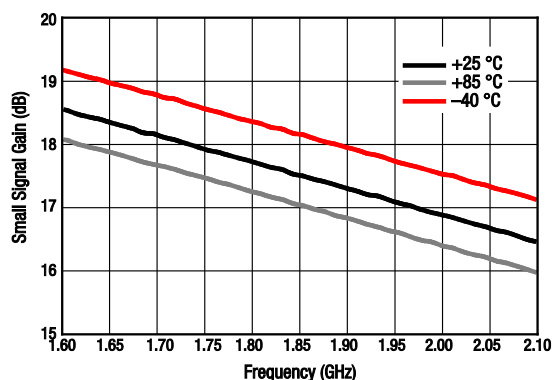


Figure 4. Narrowband Gain Response vs Frequency Over Temperature

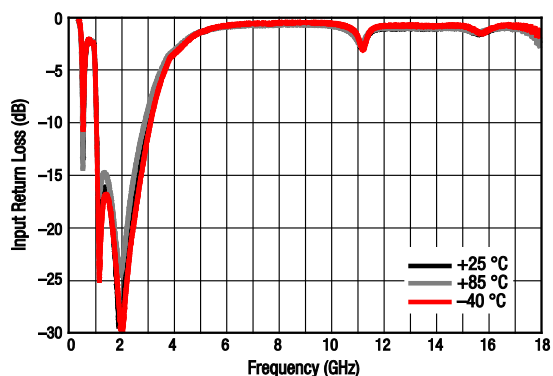


Figure 5. Broadband Input Return Loss vs Frequency Over Temperature

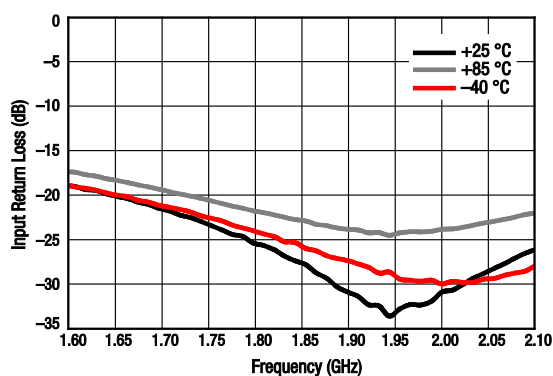


Figure 6. Narrowband Input Return Loss vs Frequency Over Temperature

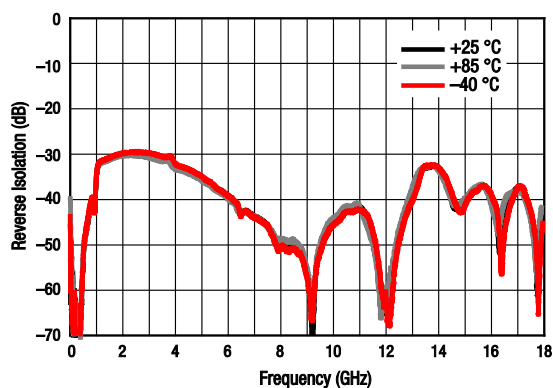


Figure 7. Broadband Reverse Isolation vs Frequency Over Temperature

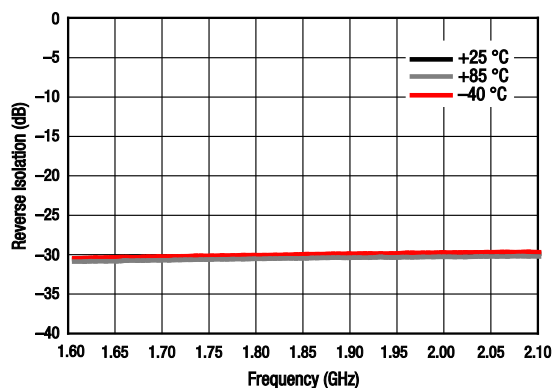


Figure 8. Narrowband Reverse Isolation vs Frequency Over Temperature

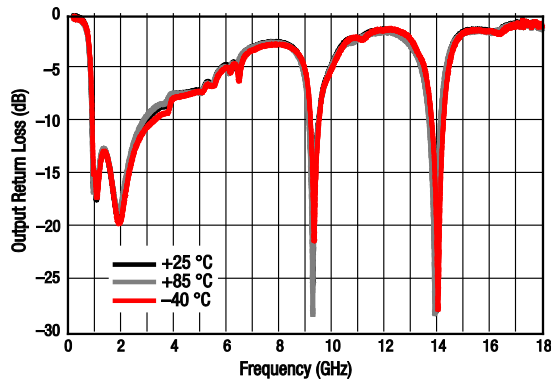


Figure 9. Broadband Output Return Loss vs Frequency Over Temperature

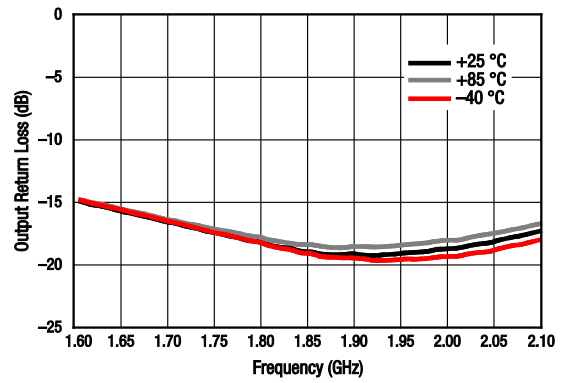


Figure 10. Narrowband Output Return Loss vs Frequency Over Temperature

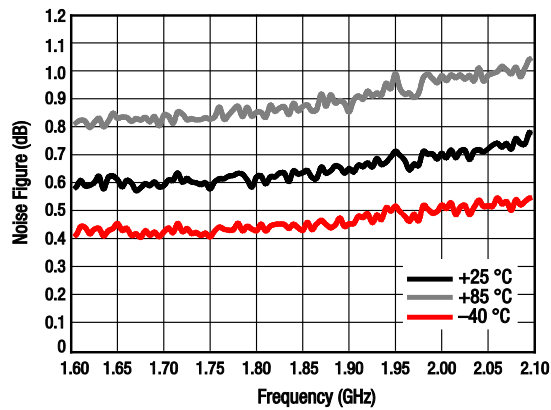


Figure 11. Noise Figure vs Frequency Over Temperature

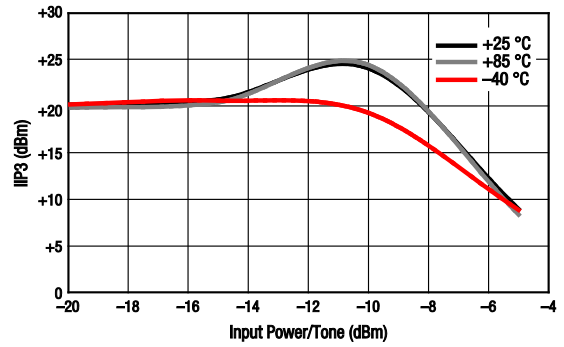


Figure 12. IIP3 vs Input Power Over Temperature
@ 5 V, 1700 MHz (Tone Spacing = 1 MHz)

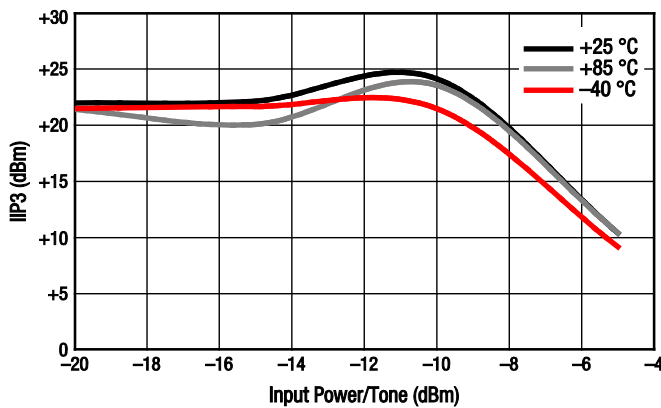


Figure 13. IIP3 vs Input Power Over Temperature
@ 5 V, 1850 MHz (Tone Spacing = 1 MHz)

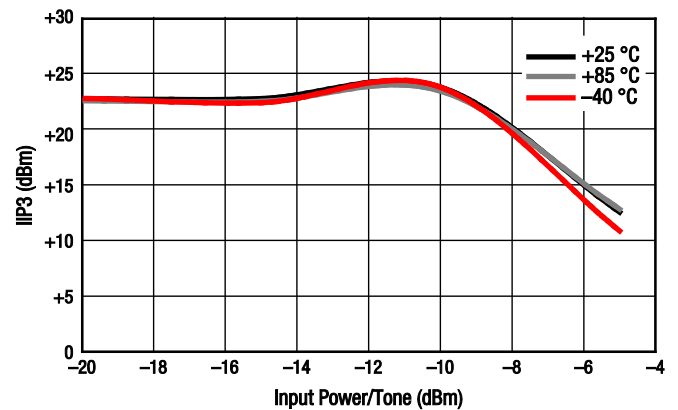
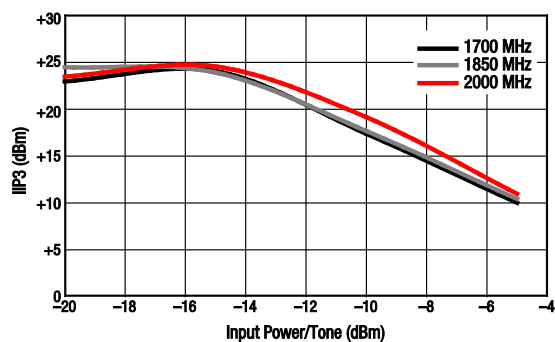
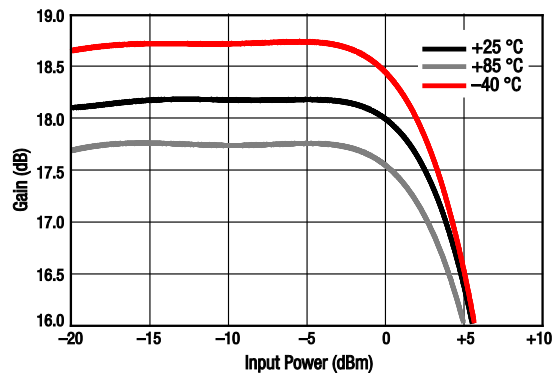


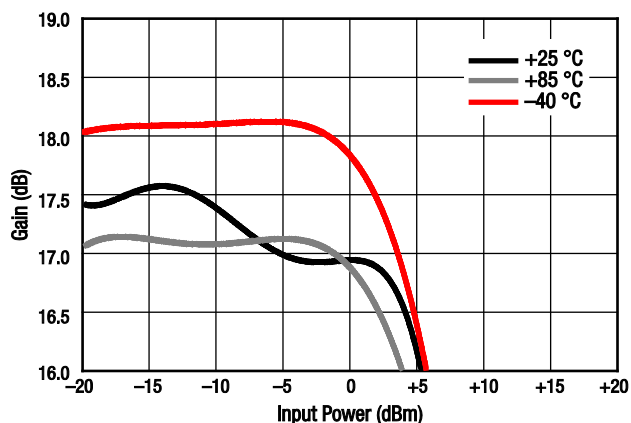
Figure 14. IIP3 vs Input Power Over Temperature
@ 5 V, 2000 MHz (Tone Spacing = 1 MHz)



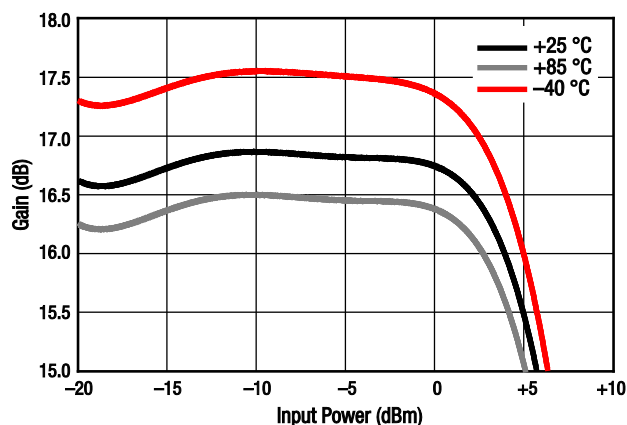
**Figure 15. IIP3 vs Input Power Over Frequency
@ 4 V (Tone Spacing = 1 MHz)**



**Figure 16. Gain vs Input Power Over Temperature
@ 5 V, 1700 MHz**



**Figure 17. Gain vs Input Power Over Temperature
@ 5 V, 1850 MHz**



**Figure 18. Gain vs Input Power Over Temperature
@ 5.0 V, 2000 MHz**

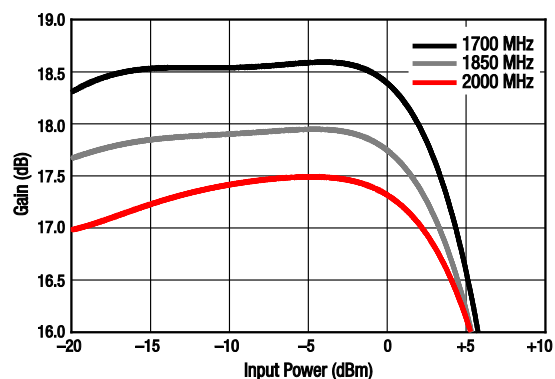
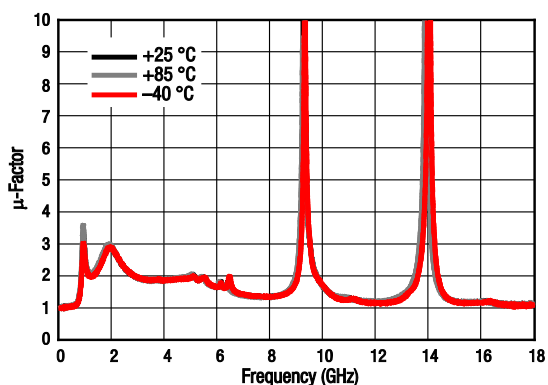
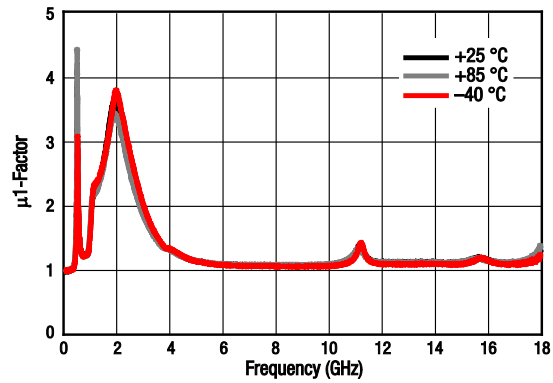


Figure 19. Gain vs Input Power Over Frequency @ 4 V



**Figure 20. Stability Factor (μ) vs Frequency Over Temperature
@ 5 V**

Figure 21. Stability Factor (μ_1) vs Frequency Over Temperature @ 5 V

Swept F1 Load Gamma Pull
 Freq = 1.8400 GHz
 ΓSource = 0.3590∠ 152.95
 Gt max = 18.13 dB
 at 0.3597∠ 87.77
 5 contours, 1.00 dB step
 (14.00 to 18.00 dB)
 Ip3 max = 40.89 dBm
 at 0.4573∠ 135.57
 5 contours, 0.50 dBm step
 (38.50 to 40.50 dBm)
 Specs: OFF

Load Pull Contours
Output Intercept Point(dBm), Gain(dB)
5V, 95mA, 1.84GHz
1MHz Tone Spacing, Pin/ Tone -20dBm

Label:
 SKY67002_LP_1.76_1.84GHz_4.6V_5V

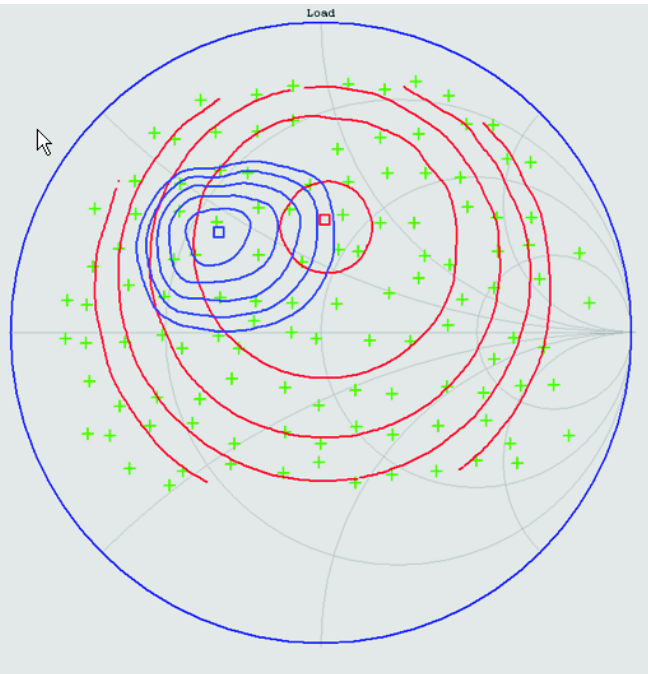


Figure 22. Load Pull, @ 5 V and 95 mA

Table 4. Noise Parameters vs Frequency (5 V, 95 mA)

Frequency (GHz)	Minimum Noise Figure (F_{MIN}) (dB)	Noise Resistance (R_N) (Ω)	Γ_{opt}		Associated Gain (dB)	Maximum Gain (G_{MAX}) (dB)
			Magnitude	Phase		
0.80	0.3943	0.0568	0.2238	87.63	24.5523	25.2847
0.84	0.4094	0.0471	0.2306	92.18	24.1907	24.8043
0.89	0.3536	0.0471	0.2612	96.64	23.7780	24.2572
1.20	0.4557	0.0492	0.2812	109.80	21.3562	21.5950
1.42	0.4733	0.0372	0.3975	129.07	20.0944	20.1705
1.52	0.5374	0.0445	0.3073	133.12	19.5423	19.6000
1.76	0.6205	0.0379	0.3401	148.53	18.3915	18.3948
1.84	0.6403	0.0360	0.3616	156.51	18.0381	18.0424
1.92	0.6477	0.0336	0.3760	158.03	17.6947	17.7022
1.98	0.7190	0.0339	0.3614	159.47	17.4468	17.4548
2.00	0.7497	0.0398	0.3744	161.91	17.3564	17.3731
2.38	0.8417	0.0321	0.4238	174.63	15.8965	15.9979
2.48	0.8800	0.0340	0.4230	179.22	15.541	15.6796
2.52	0.9242	0.0332	0.4217	-176.79	15.3704	15.5535
2.60	0.9003	0.0368	0.4334	-179.03	15.1584	15.3139
3.00	1.0519	0.0413	0.5207	-153.49	13.4396	14.2395

Evaluation Board Description

The SKY67002-396LF Evaluation Board is used to test the performance of the SKY67002-396LF LNA. An assembly drawing for the Evaluation Board is shown in Figure 23. The layer detail is provided in Figure 24. An Evaluation Board schematic diagram is provided in Figure 25. Table 5 provides the Bill of Materials (BOM) list for Evaluation Board components.

Package Dimensions

The PCB layout footprint for the SKY67002-396LF is provided in Figure 26. Typical case markings are shown in Figure 27. Package dimensions for the 8-pin DFN are shown in Figure 28, and tape and reel dimensions are provided in Figure 29.

Package and Handling Information

Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

THE SKY67002-396LF is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *Solder Reflow Information*, document number 200164.

Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format.

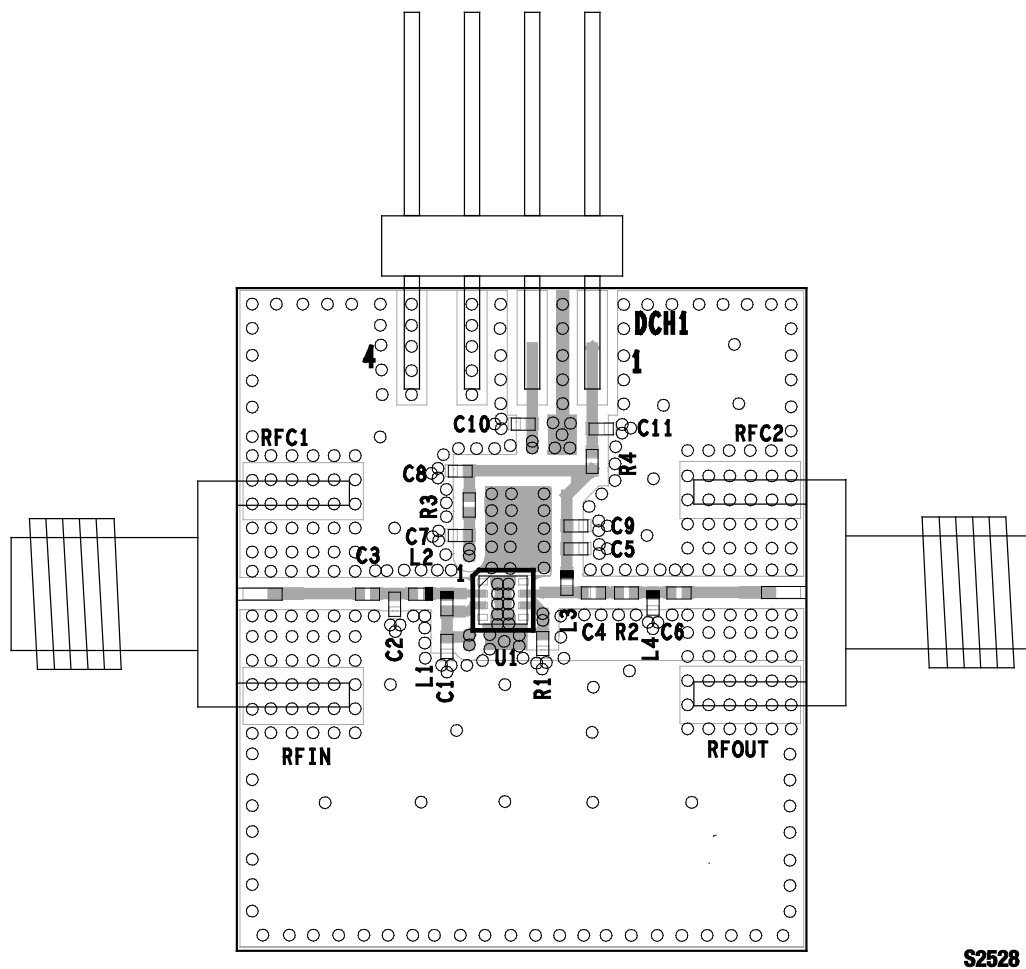


Figure 23. SKY67002-396LF Evaluation Board Assembly Diagram

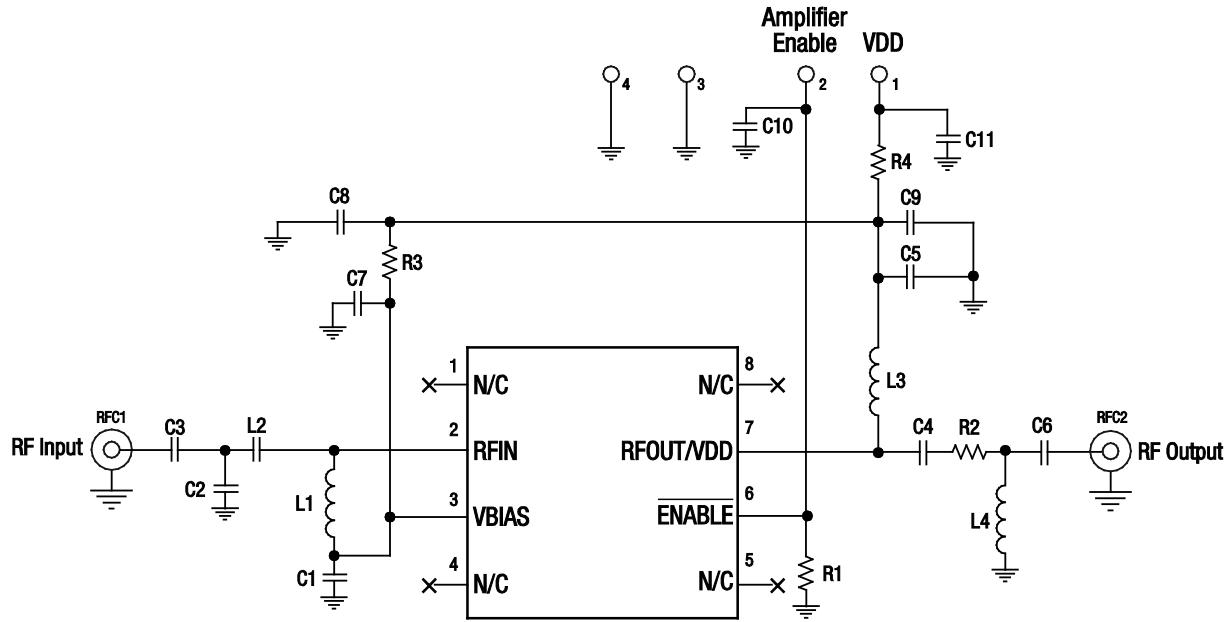
Cross Section	Name	Thickness (mm)	Material
	MSK-NS		
	TRA-NS	0.3556	Cu foil
	Laminate	0.254 ± 0.152	Rogers 4350B
	TRA-2	0.178	Cu foil
	Laminate	0.889 nom.	FR4 Prepreg (Note 1)
	TRA-3	0.0178	Cu foil
	Laminate	0.254 ± 0.152	FR4 Core
	TRA-FS	0.0178	Cu foil
	MSK-PS		

Note 1: Adjust this thickness to meet total thickness goal.

General Notes:
Material: Rogers R04350, $\epsilon_r = 3.66$
Layer 1 thickness: 0.254 mm
Overall board thickness: 1.575 mm
50 Ω transmission line width: 0.522 mm
Coplanar ground spacing: 1.575 mm
Via diameter: 0.254 mm

S2574

Figure 24. Layer Detail Physical Characteristics



Note: Remove R1 if Enable function is desired.
This circuit configured for "Amplifier On."

S2254

Figure 25. SKY67002-396LF Evaluation Board Schematic

Table 5. SKY67002-396LF Evaluation Board Bill of Materials (Optimized for 1.7 to 2.0 GHz)

Component	Size	Value (5 V @ 95 mA)	Value for Improved IIP3 (4 V @ 95 mA)	Manufacturer	Part #
C1	0402	12 pF	12 pF	Murata	GJM1555C1H120JB01
C2	0402	0.7 pF	0.7 pF	Murata	GJM1555C1HR70BB01
C3	0402	3.6 pF	3.6 pF	Murata	GJM1555C1H3R6CB01
C4	0402	2.2 pF	2.2 pF	Murata	GRM1555C1H2R2CZ01
C5, C7, C8, C10, C11	0402	1000 pF	1000 pF	Murata	GRM1555C1H102JA01
C6	0402	100 pF	100 pF	Murata	GRM1555C1H101JZ01
C9	0402	DNI	DNI	—	
L1	0402	5.6 nH	5.6 nH	Coilcraft HP	0402HP-5N6X_L
L2	0402	2.4 nH	2.4 nH	Coilcraft HP	0402HP-2N4X_L
L3	0402	4.7 nH	4.7 nH	TDK	MLG1005S4N7S
L4	0402	15 nH	15 nH	TDK	MLG1005S15NJT
R1, R2, R4	0402	0 Ω	0 Ω	Panasonic	ERJ-2GEOR00X
R3	0402	5.1 k Ω	3.6 k Ω	Panasonic	ERJ-2GEJ512X (5.1 k Ω) ERJ-2GEJ362X (3.6 k Ω)

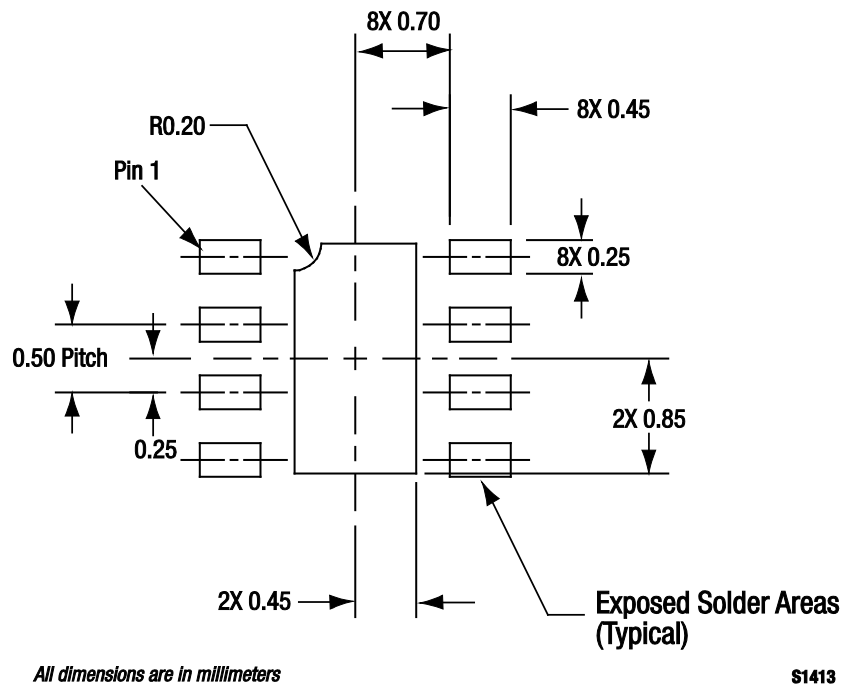


Figure 26. SKY67002-396LF PCB Layout Footprint (Top View)

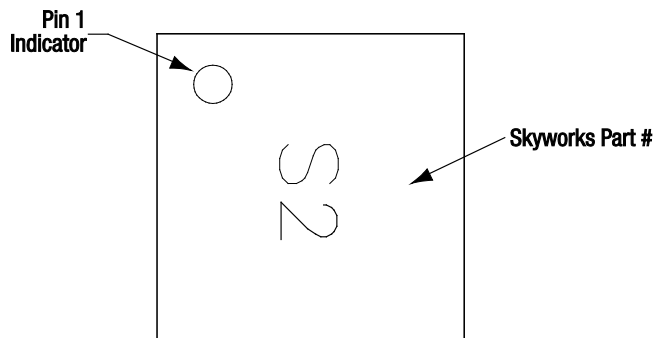
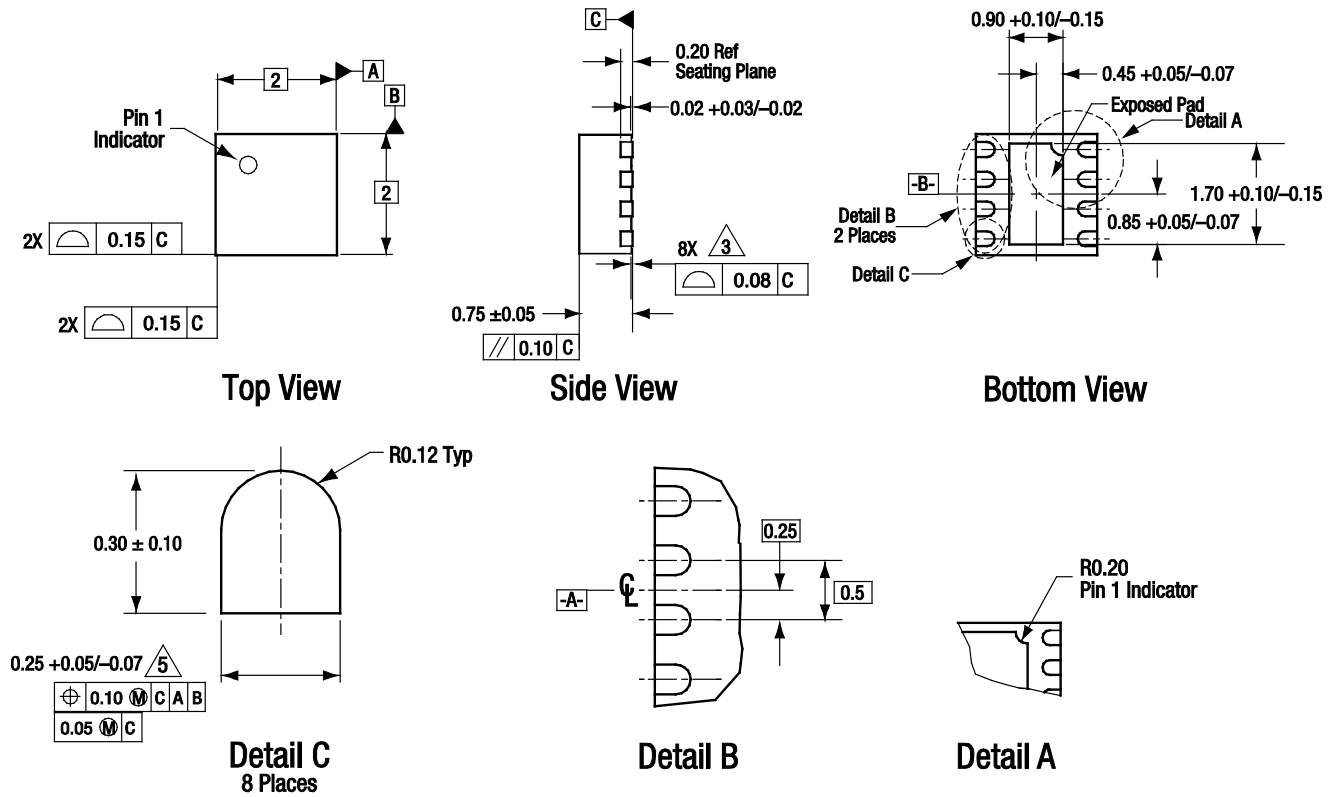


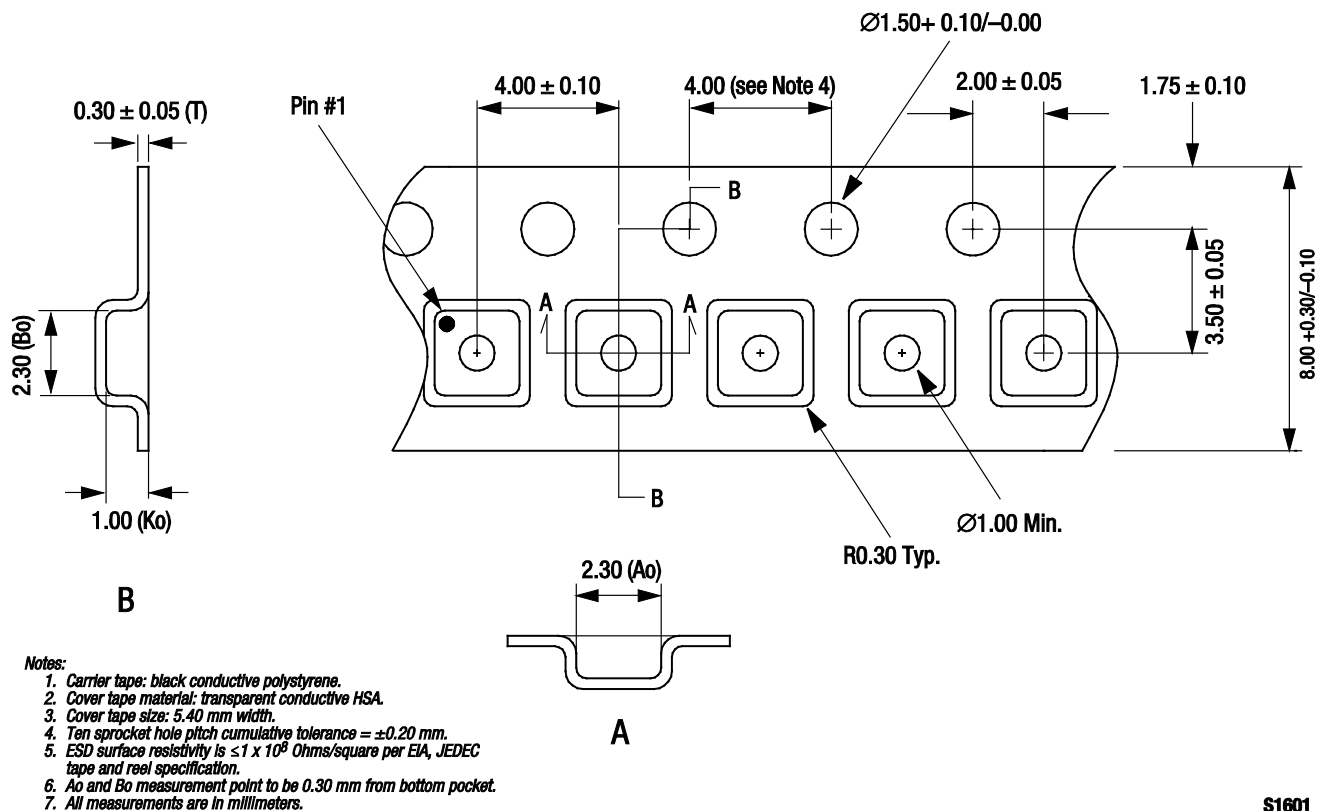
Figure 27. Typical Case Markings (Top View)



All measurements are in millimeters.
 Dimensioning and tolerancing according to ASME Y14.5M-1994.
 Coplanarity applies to the exposed heat sink slug as well as the terminals..
 Plating requirement per source control drawing (SCD) 2504.
 Dimension applies to metallized terminal and is measured between 0.15 mm and 0.30 mm from terminal tip.

S1945

Figure 28. SKY67002-396LF 8-Pin DFN Package Dimensions



S1601

Figure 29. SKY67002-396LF Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY67002-396LF LNA	SKY67002-396LF	SKY67002-396LF-EVB

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