DATA SHEET

SKY67002-396LF: 1.6-2.1 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 °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.

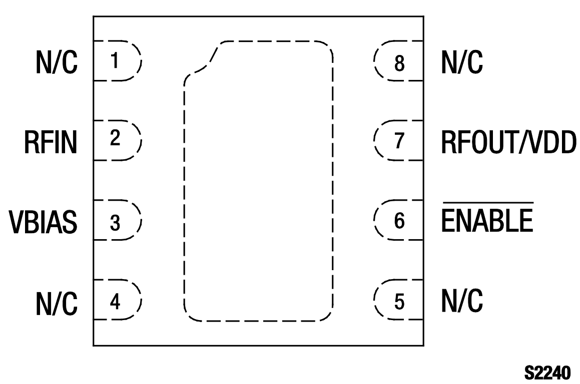


Figure 2. SKY67002-396LF Pinout – 8-Pin DFN (Top View)

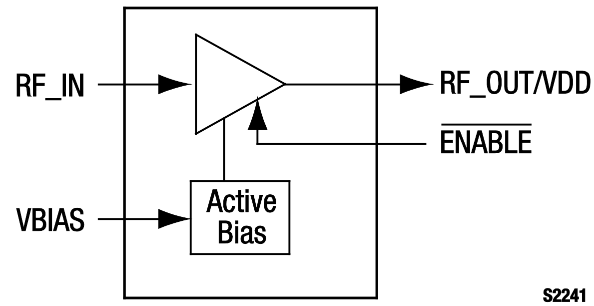


Figure 1. SKY67002-396LF Block Diagram

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 2.1 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	$\overline{\text{ENABLE}}$	Enable pin. Active "low" (0 V) = amplifier on state.
3	VBIAS	Bias for 1st 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.

***CAUTION**: Although this device is designed to be as robust as possible, Electrostatic Discharge (ESD) can damage this device. This device must be protected at all times from ESD. 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. The SKY67002-396LF is a Class 1B ESD device.*

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 [Z_O] = 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	17	20		dB
Output return loss	$\|S_{22}\|$	@ 1.85 GHz	13	16		dB
Reverse isolation	$\|S_{12}\|$	@ 1.85 GHz	29	31		dB
3rd Order Input Intercept Point (Note 4)	IIP3	@ 1.85 GHz, Δf = 1 MHz, P_{IN} = –20 dBm/tone	+20.5	+22.0		dBm
3rd Order Output Intercept Point (Note 4)	OIP3	@ 1.85 GHz, Δf = 1 MHz, P_{IN} = –20 dBm/tone	+38.0	+39.5		dBm
1 dB Input Compression Point	IP1dB	@ 1.85 GHz	+2.0	+3.5		dBm
1 dB Output Compression Point	OP1dB	@ 1.85 GHz	+18.5	+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 V, I_{DD} = 95 mA, T_A = +25 °C, P_{IN} = –20 dBm, Characteristic Impedance [Z_0] = 50 Ω, Unless Otherwise Noted)

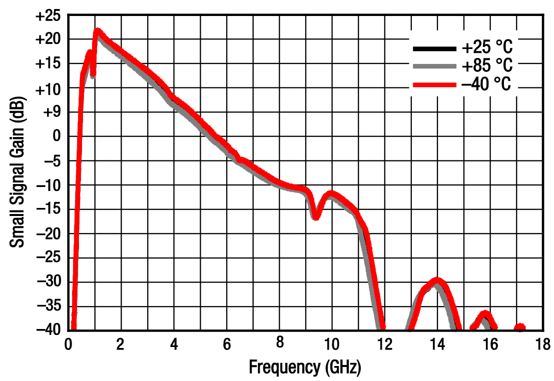


Figure 3. Broadband Gain Response vs Frequency Over Temperature

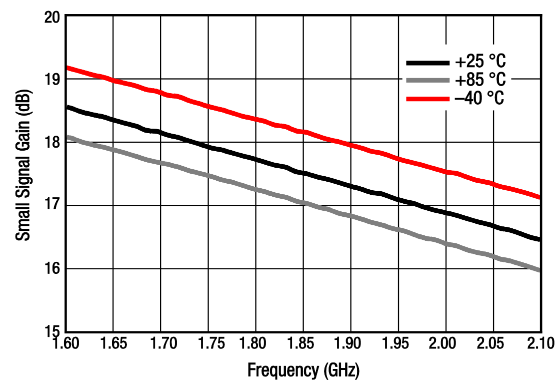


Figure 4. Narrowband Gain Response vs Frequency Over Temperature

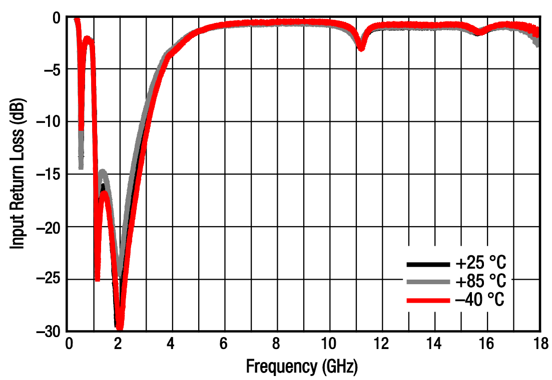


Figure 5. Broadband Input Return Loss vs Frequency Over Temperature

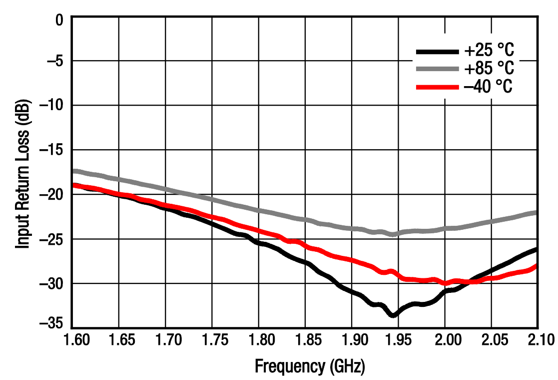


Figure 6. Narrowband Input Return Loss vs Frequency Over Temperature

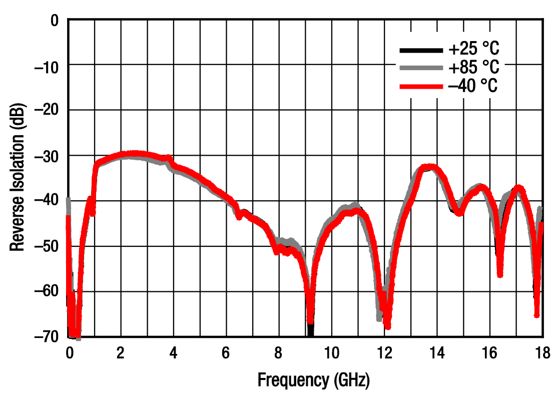


Figure 7. Broadband Reverse Isolation vs Frequency Over Temperature

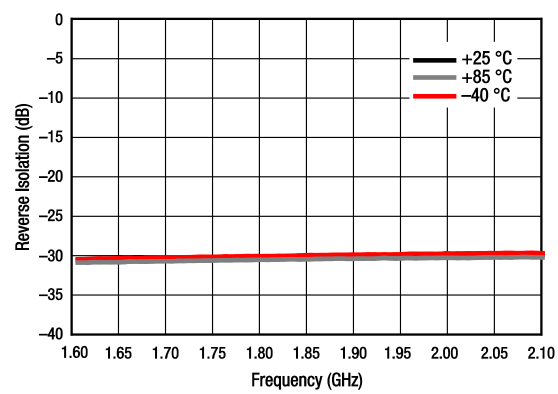


Figure 8. Narrowband Reverse Isolation vs Frequency Over Temperature

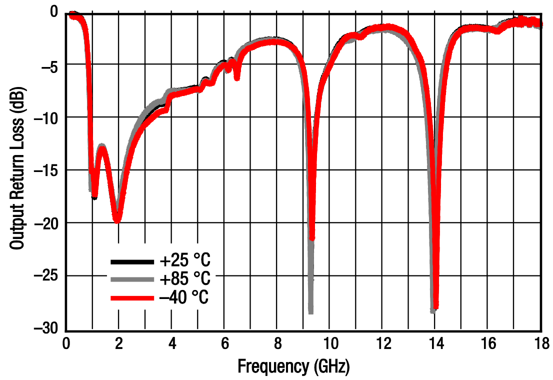


Figure 9. Broadband Output Return Loss vs Frequency Over Temperature

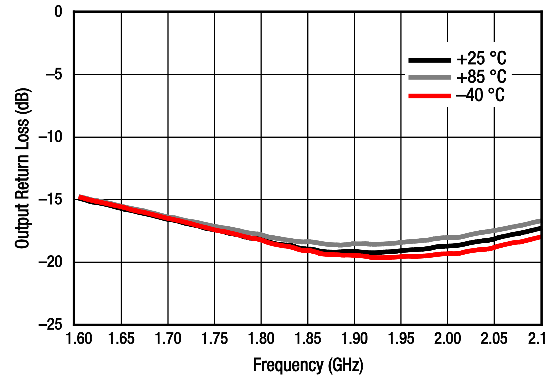


Figure 10. Narrowband Output Return Loss vs Frequency Over Temperature

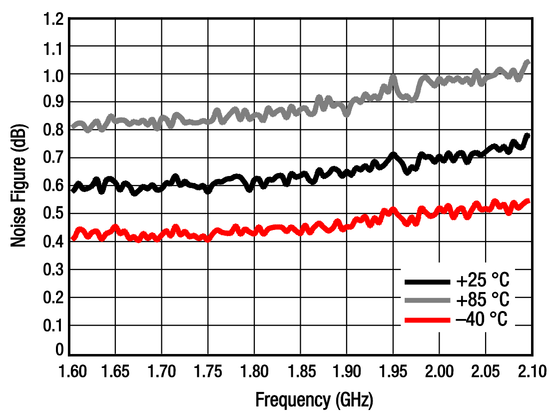


Figure 11. Noise Figure vs Frequency Over Temperature

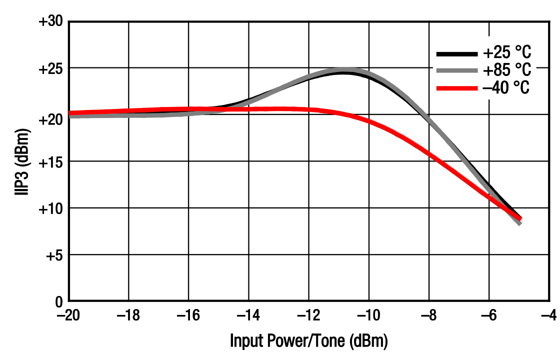


Figure 12. IIP3 vs Input Power Over Temperature @ 5 V, 1700 MHz (Tone Spacing = 1 MHz)

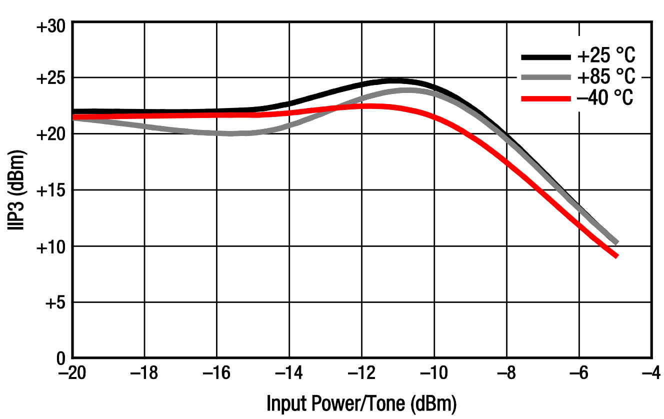


Figure 13. IIP3 vs Input Power Over Temperature @ 5 V, 1850 MHz (Tone Spacing = 1 MHz)

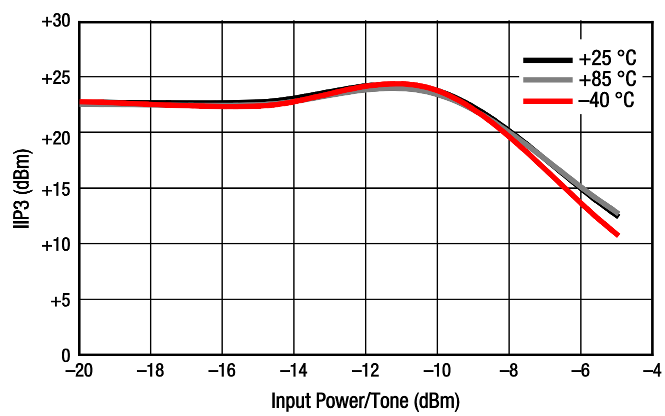


Figure 14. IIP3 vs Input Power Over Temperature @ 5 V, 2000 MHz (Tone Spacing = 1 MHz)

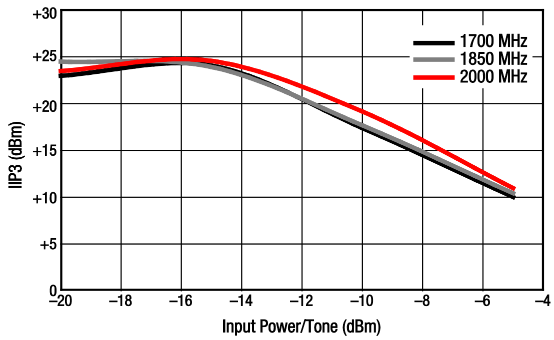


Figure 15. IIP3 vs Input Power Over Frequency @ 4 V (Tone Spacing = 1 MHz)

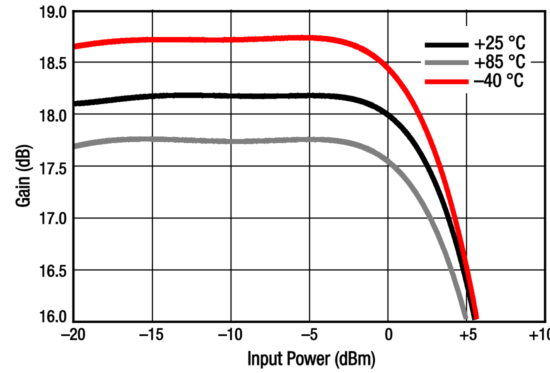


Figure 16. Gain vs Input Power Over Temperature @ 5 V, 1700 MHz

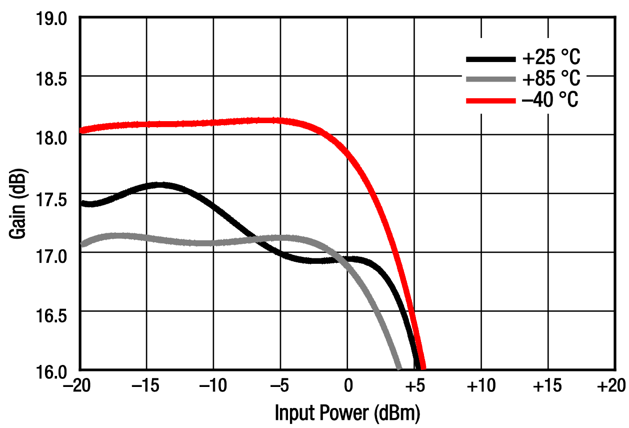


Figure 17. Gain vs Input Power Over Temperature @ 5 V, 1850 MHz

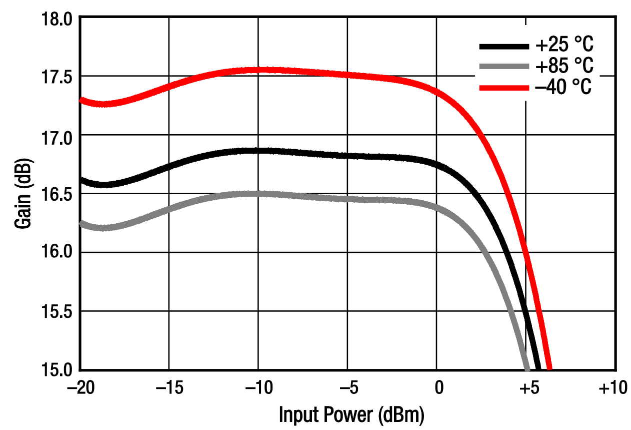


Figure 18. Gain vs Input Power Over Temperature @ 5.0 V, 2000 MHz

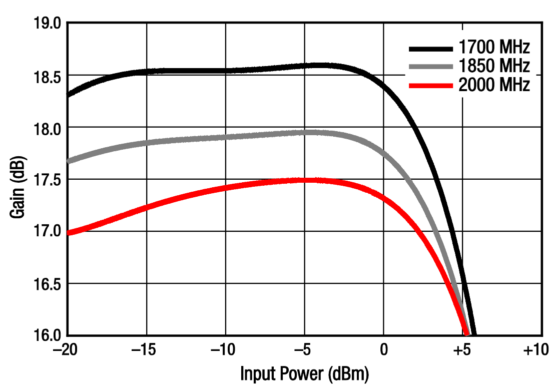


Figure 19. Gain vs Input Power Over Frequency @ 4 V

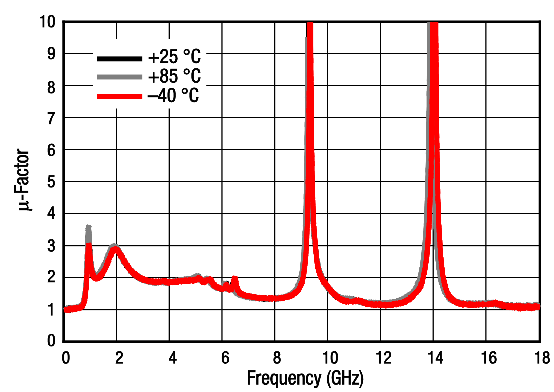


Figure 20. Stability Factor (μ) vs Frequency Over Temperature @ 5 V

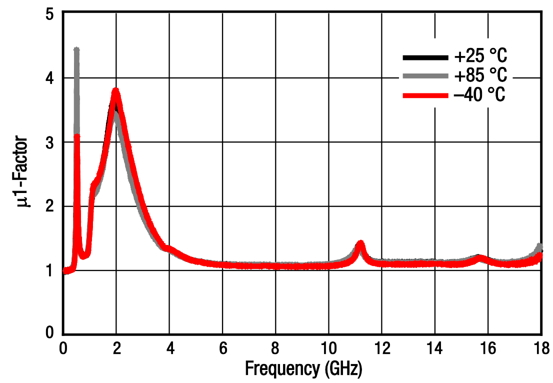


Figure 21. Stability Factor (µ1) vs Frequency Over Temperature @ 5 V

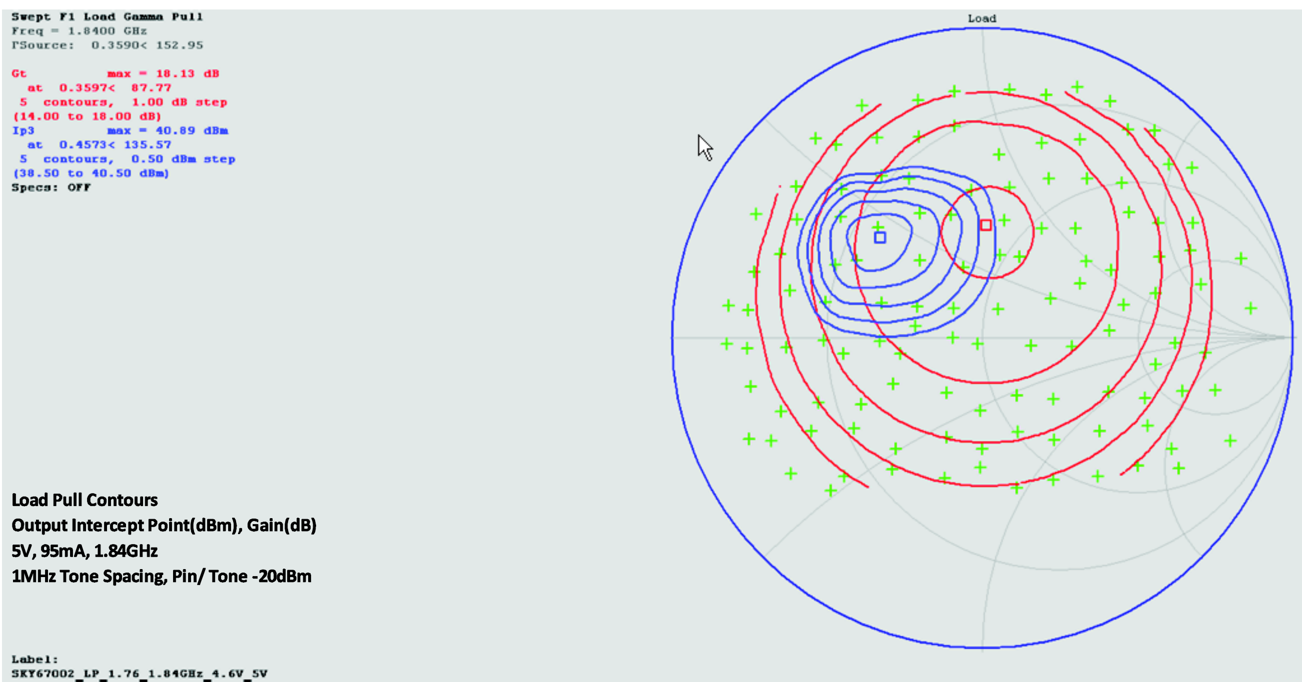


Figure 22. Load Pull, @ 5 V and 95 mA

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

Frequency (GHz)	Minimum Noise Figure (F_{MIN}) (dB)	Noise Resistance (R_N) (Ω)	Γopt Magnitude	Γopt Phase	Associated Gain (dB)	Maximum Gain (G_{MAX}) (dB)
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.

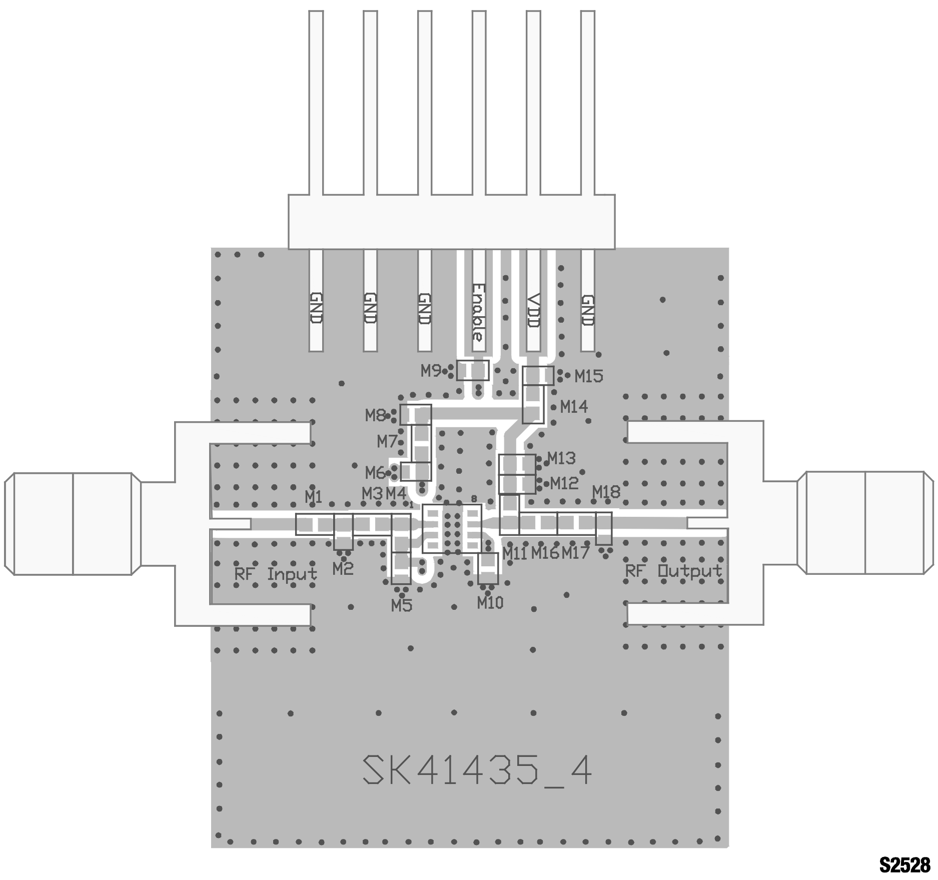
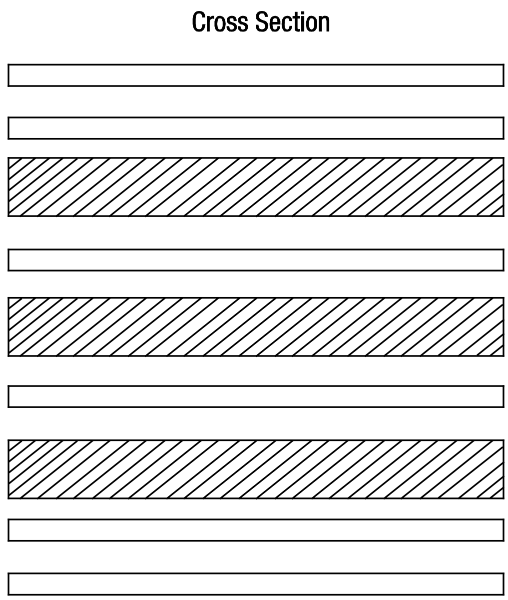


Figure 23. SKY67002-396LF Evaluation Board Assembly Diagram



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, $\varepsilon_r = 3.66$
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

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Figure 24. Layer Detail Physical Characteristics

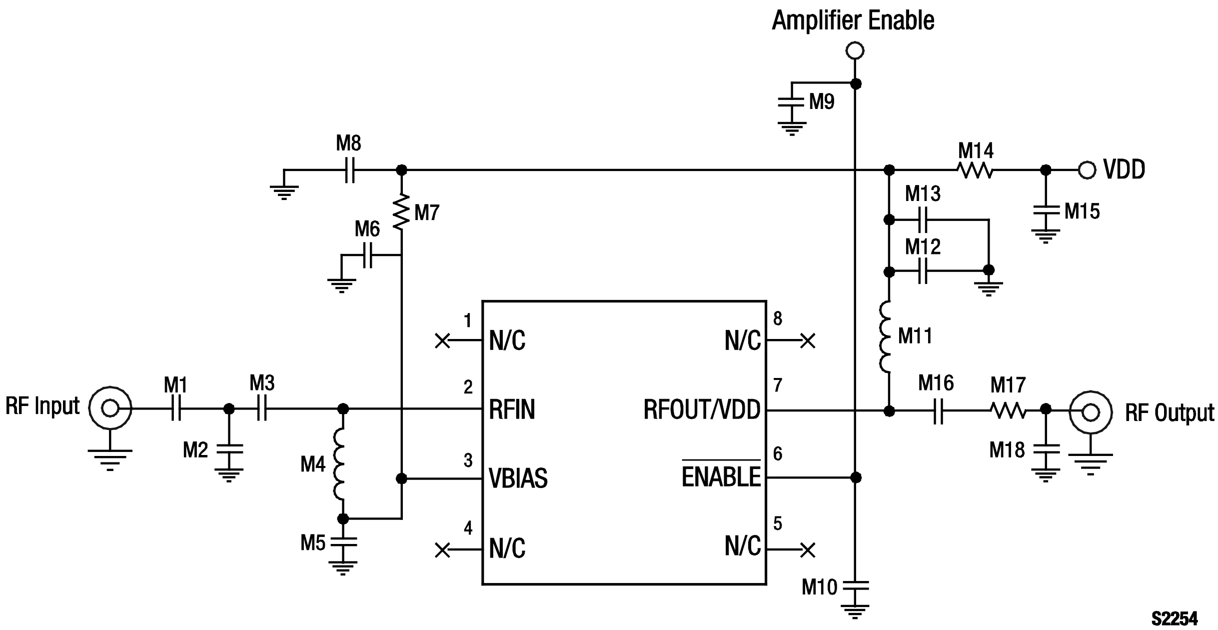


Figure 25. SKY67002-396LF Evaluation Board Schematic

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

Component	Type	Size	Value (5 V @ 95 mA)	Value for Improved IIP3 (4 V @ 95 mA)	Manufacturer
M1	Resistor	0402	0 Ω	0 Ω	Panasonic
M2	DNI				
M3	Capacitor	0402	20 pF	20 pF	Murata GJM
M4	Inductor	0402	20 nH	20 nH	Coilcraft HP
M5	Capacitor	0402	68 pF	68 pF	Murata GRM
M6	DNI				
M7	Resistor	0402	5.6 kΩ	3.6 kΩ	Panasonic
M8	Capacitor	0402	0.1 μF	0.1 μF	Murata GRM
M9	Capacitor	0402	1000 pF	1000 pF	Murata GRM
M10	Capacitor	0402	1000 pF	1000 pF	Murata GRM
M11	Inductor	0402	12 nH	12 nH	Murata LQG
M12	Capacitor	0402	10 pF	10 pF	Murata GRM
M13	Capacitor	0402	1000 pF	1000 pF	Murata GRM
M14	Resistor	0402	0 Ω	10 Ω	Panasonic
M15	DNI				
M16	Inductor	0402	4.3 nH	4.3 nH	Murata LQG
M17	Capacitor	0402	33 pF	33 pF	Murata GRM
M18	DNI				

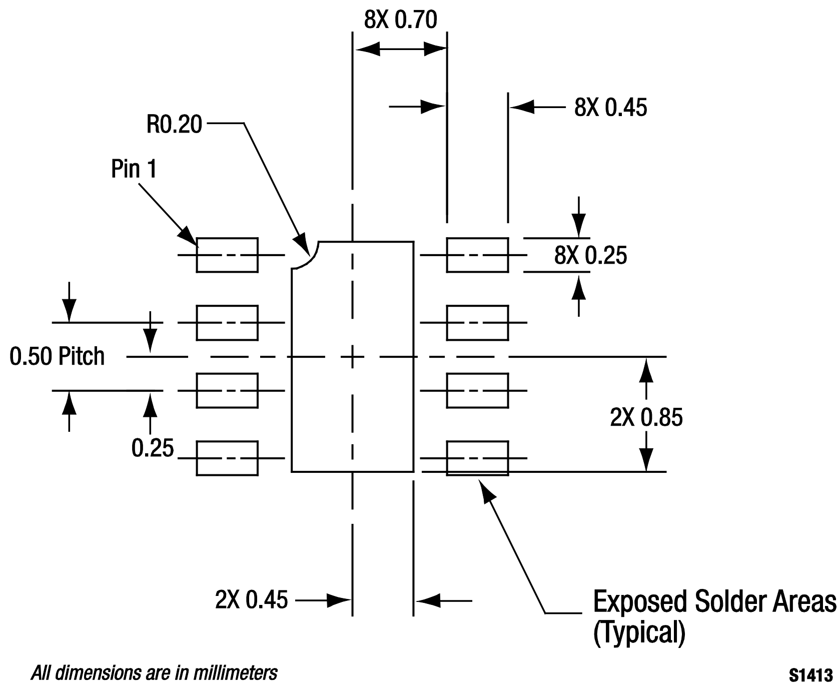


Figure 26. SKY67002-396LF PCB Layout Footprint (Top View)

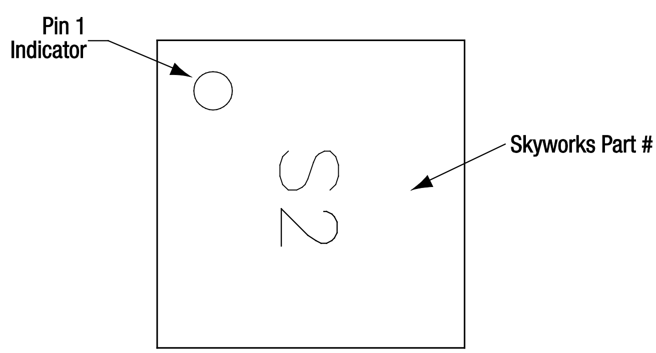
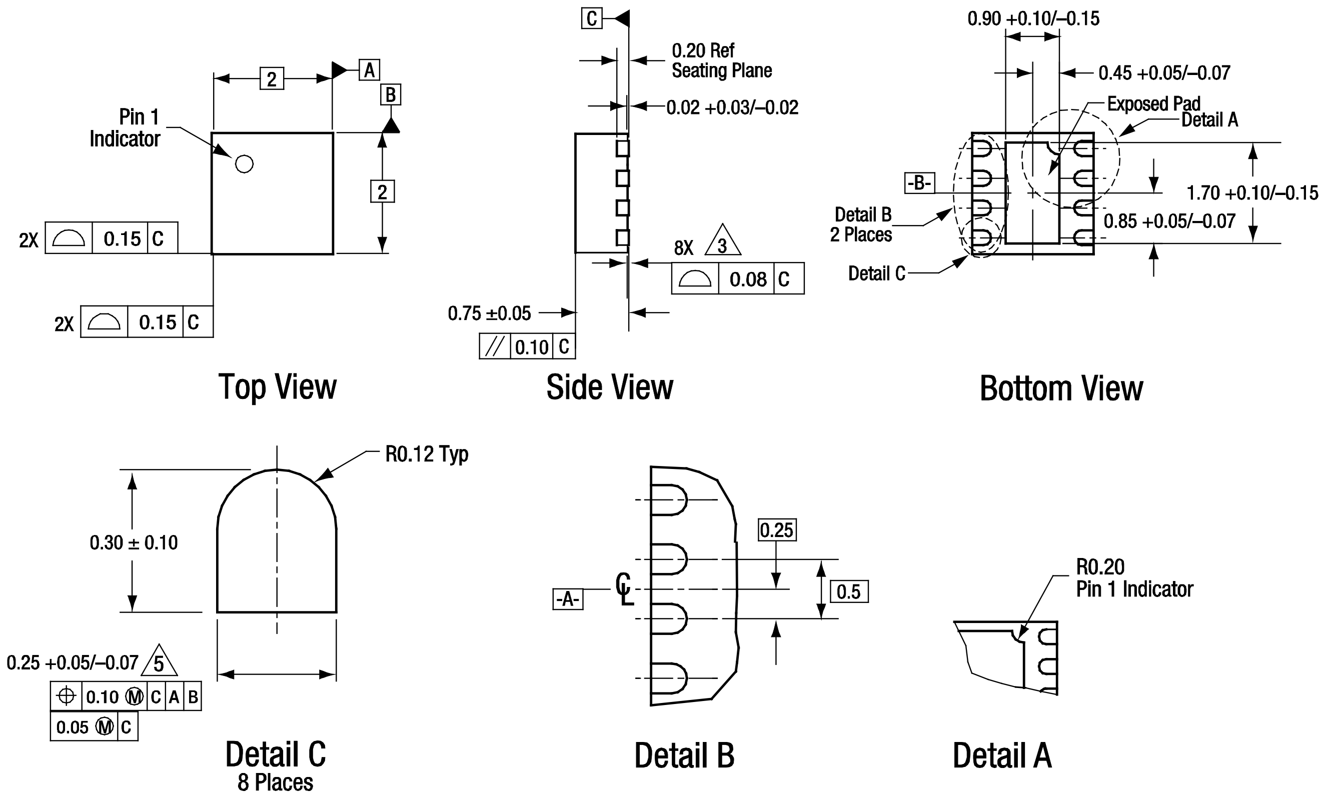


Figure 27. Typical Case Markings (Top View)



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 metalized terminal and is measured between 0.15 mm and 0.30 mm from terminal tip.

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

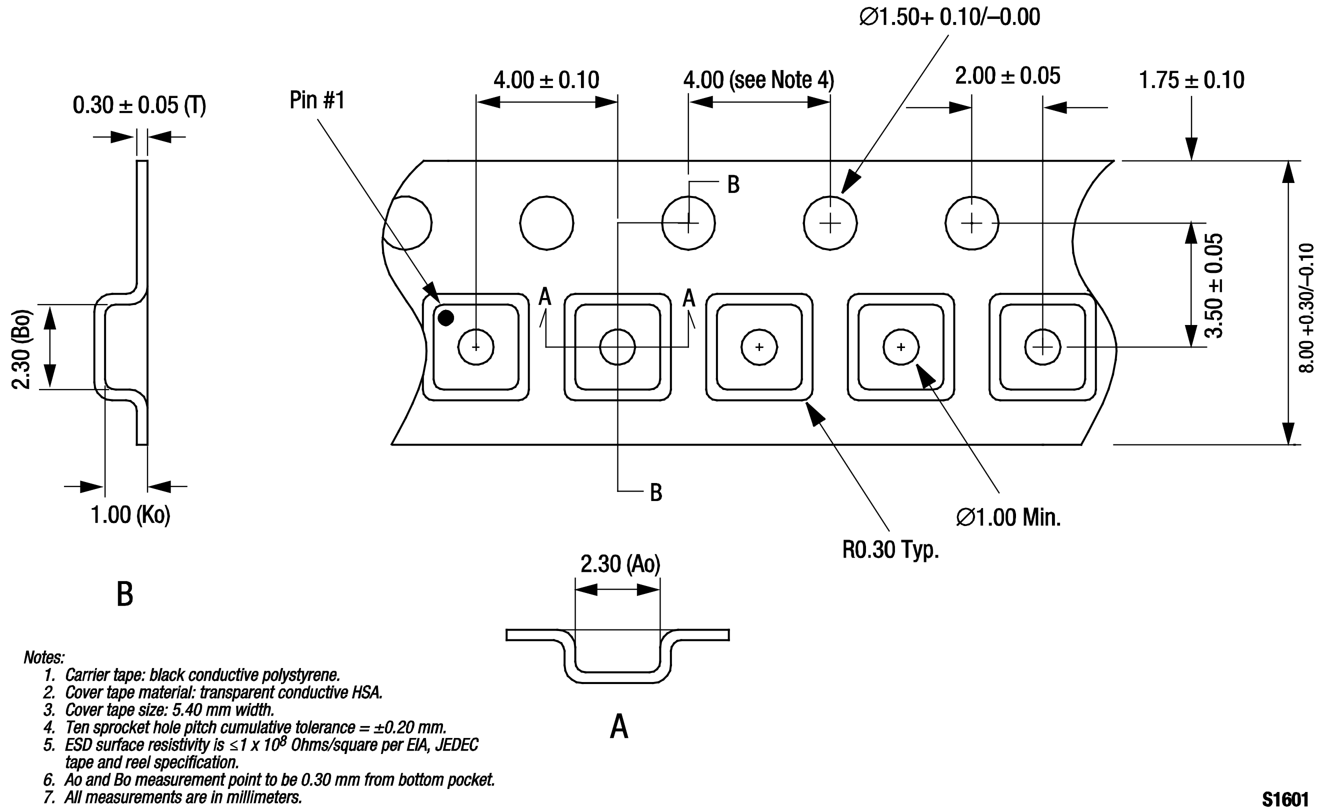

Figure 29. SKY67002-396LF Tape and Reel Dimensions

Ordering Information

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