DATA SHEET

SKY67001-396LF: 0.6-1.2 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 °C
- Low Noise Figure: 0.6 dB @ 0.9 GHz
- Excellent IIP3 performance: +23 dBm @ 0.9 GHz
- Gain: 17.5 dB @ 0.9 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.

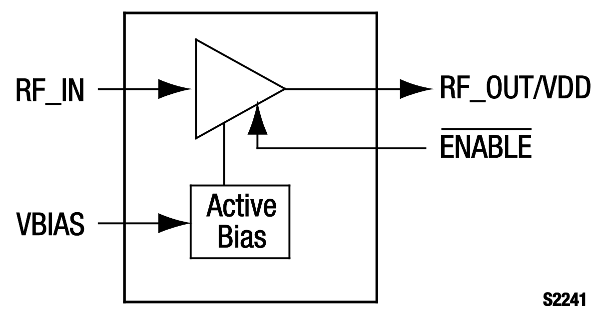

Figure 1. SKY67001-396LF Block Diagram

Description

The SKY67001-396LF 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 SKY67001-396LF operates in the frequency range of 0.6 to 1.2 GHz. For higher frequency operation, the pin-compatible SKY67002-396LF or SKY67003-396LF 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.

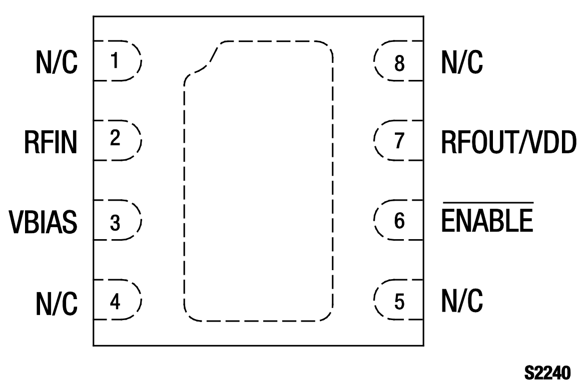

Figure 2. SKY67001-396LF Pinout – 8-Pin DFN (Top View)

Table 1. SKY67001-396LF 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. SKY67001-396LF 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}		56.4		°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 = 56.4 °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 SKY67001-396LF ESD threshold level is 500 VDC using Human Body Model (HBM) testing (Class 1B), 30 VDC using Man-Machine (MM) model testing (Class A), and 1000 VDC using Charged Device Model (CDM) testing (Class IV).*

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY67001-396LF are provided in Table 2. Electrical specifications are provided in Table 3.

Typical performance characteristics of the SKY67001-396LF are illustrated in Figures 3 through 28.

Table 4 provides noise source pull information versus frequency.

Table 3. SKY67001-396LF Electrical Specifications (Note 1, 2)
(V_{DD} = 5 V, I_{DD} = 100 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	@ 0.9 GHz		0.60	0.75	dB
Small signal gain	$\|S_{21}\|$	@ 0.9 GHz	16.5	17.5	18.5	dB
Input return loss	$\|S_{11}\|$	@ 0.9 GHz	11.0	12.5		dB
Output return loss	$\|S_{22}\|$	@ 0.9 GHz	8.0	9.5		dB
Reverse isolation	$\|S_{12}\|$	@ 0.9 GHz	27	29		dB
3rd Order Input Intercept Point	IIP3	@ 0.9 GHz, Δf = 1 MHz, P_{IN} = –20 dBm/tone	+21.5	+23.0		dBm
3rd Order Output Intercept Point	OIP3	@ 0.9 GHz, Δf = 1 MHz, P_{IN} = –10 dBm/tone	+39.0	+40.5		dBm
1 dB Input Compression Point	IP1dB	@ 0.9 GHz	+3.5	+4.5		dBm
1 dB Output Compression Point	OP1dB	@ 0.9 GHz	+20	+21		dBm
Stability (Note 4)	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	100		mA
Amplifier enable off current (logic "high")	I_{EN}			700	1000	μA
Enable rise time	T_R	@ 0.9 GHz			100	μs
Enable fall time	T_F	@ 0.9 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 not been de-embedded from the NF measurement.

Note 4: Applies to typical application circuit and components shown in Figure 31.

Typical Performance Characteristics

(VDD = 5 V, IDD = 100 mA, TA = +25 °C, PIN = –20 dBm, Characteristic Impedance [ZO] = 50 Ω, Unless Otherwise Noted)

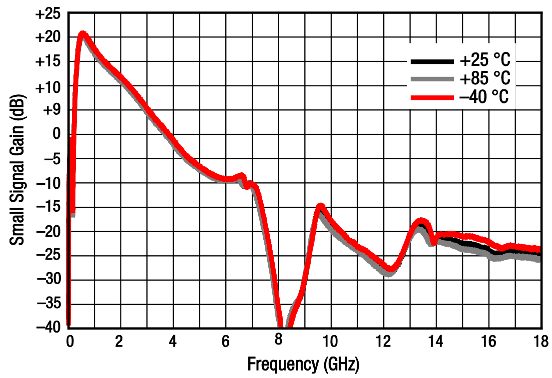

Figure 3. Broadband Gain Response vs Frequency Over Temperature

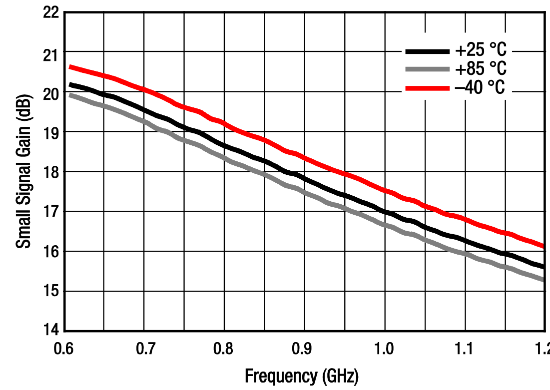

Figure 4. Narrowband Gain Response vs Frequency Over Temperature

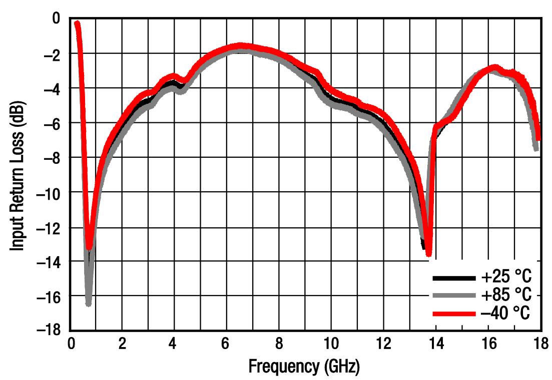

Figure 5. Broadband Input Return Loss vs Frequency Over Temperature

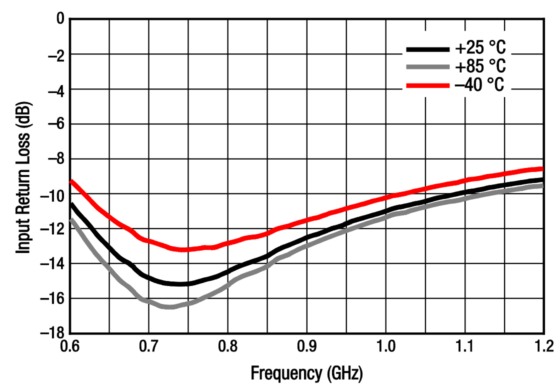

Figure 6. Narrowband Input Return Loss vs Frequency Over Temperature

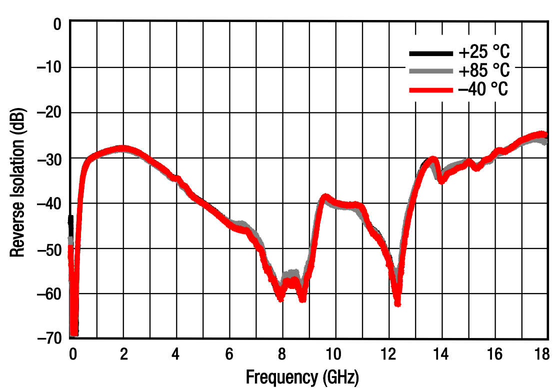

Figure 7. Broadband Reverse Isolation vs Frequency Over Temperature

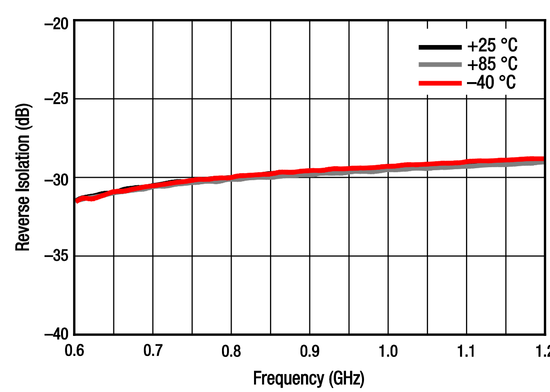

Figure 8. Narrowband Reverse Isolation vs Frequency Over Temperature

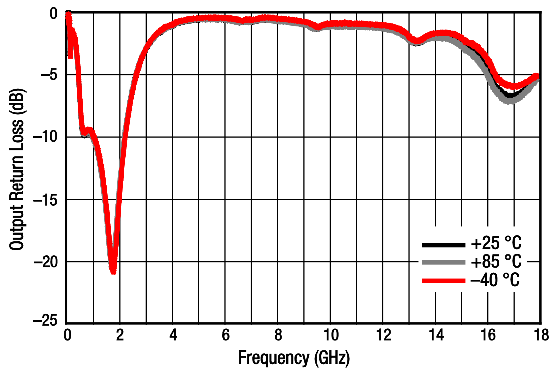

Figure 9. Broadband Output Return Loss vs Frequency Over Temperature

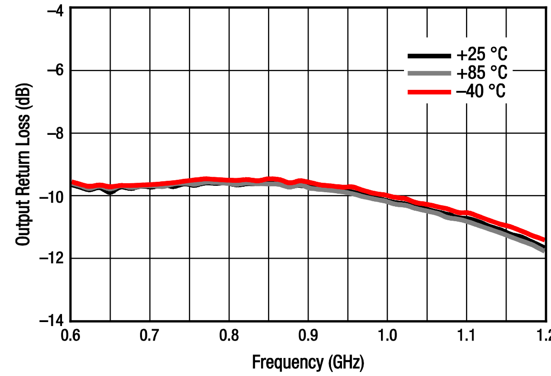

Figure 10. Narrowband Output Return Loss vs Frequency Over Temperature

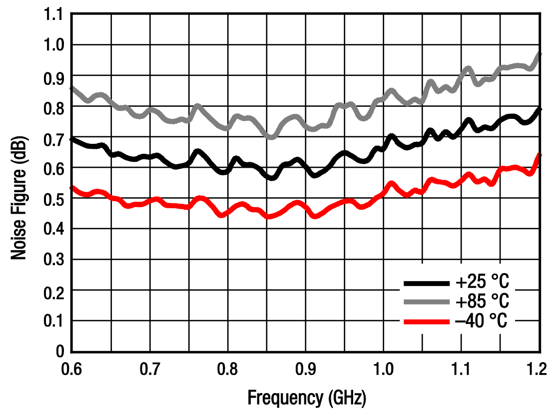

Figure 11. Noise Figure vs Frequency Over Temperature

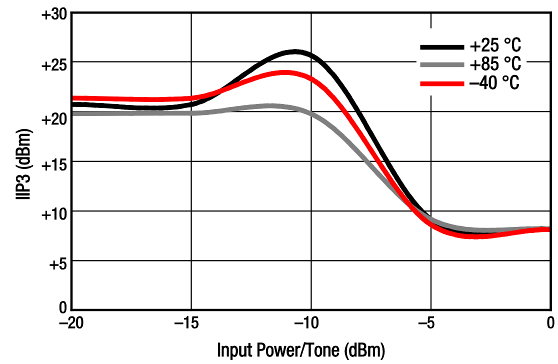

Figure 12. IIP3 vs Input Power Over Temperature @ 600 MHz (P_{IN} = –20 dBm, Tone Spacing = 1 MHz)

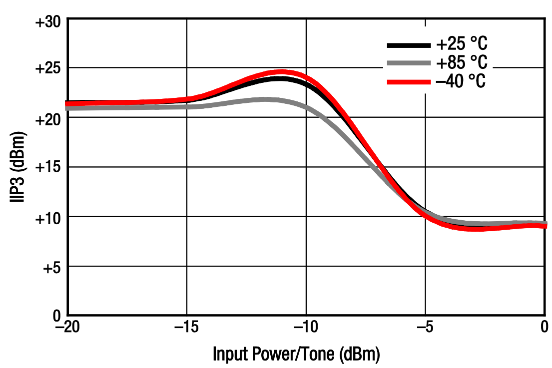

Figure 13. IIP3 vs Input Power Over Temperature @ 700 MHz (P_{IN} = –20 dBm, Tone Spacing = 1 MHz)

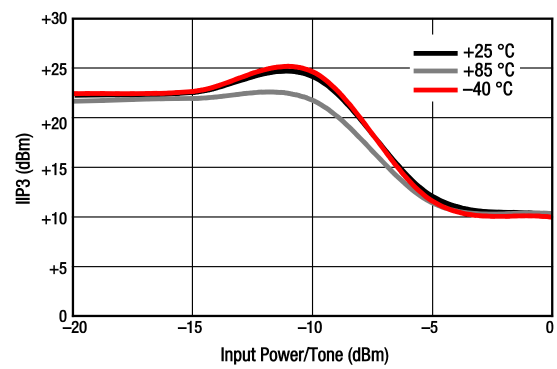

Figure 14. IIP3 vs Input Power Over Temperature @ 800 MHz (P_{IN} = –20 dBm, Tone Spacing = 1 MHz)

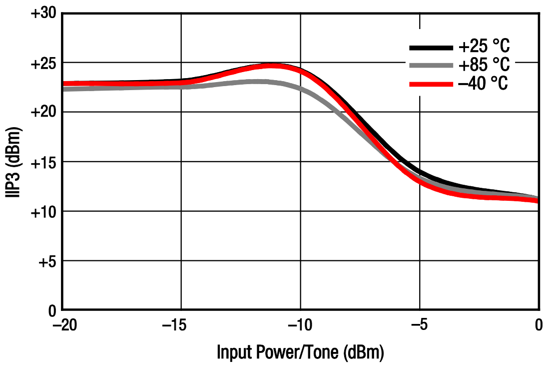

Figure 15. IIP3 vs Input Power Over Temperature @ 900 MHz (PIN = –20 dBm, Tone Spacing = 1 MHz)

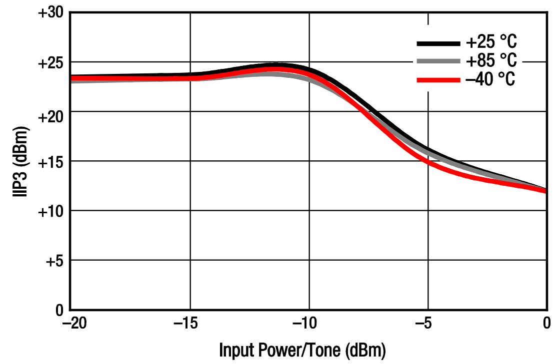

Figure 16. IIP3 vs Input Power Over Temperature @ 1000 MHz (PIN = –20 dBm, Tone Spacing = 1 MHz)

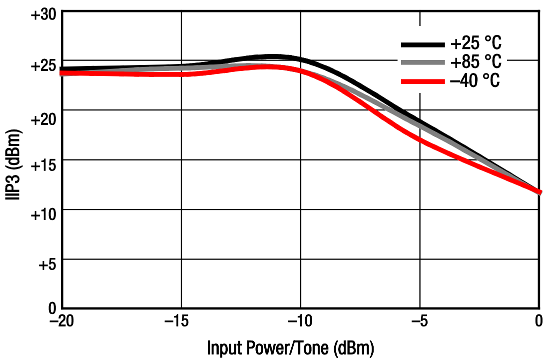

Figure 17. IIP3 vs Input Power Over Temperature @ 1200 MHz (PIN = –20 dBm, Tone Spacing = 1 MHz)

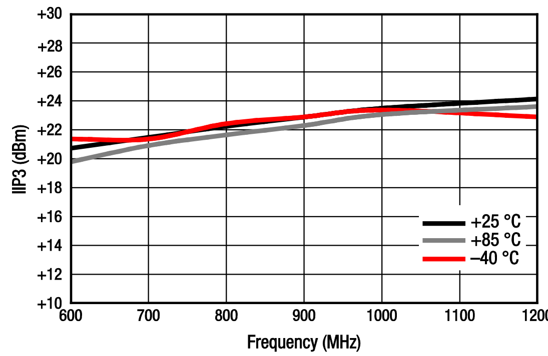

Figure 18. IIP3 vs Frequency Over Temperature (PIN = –20 dBm, Tone Spacing = 1 MHz)

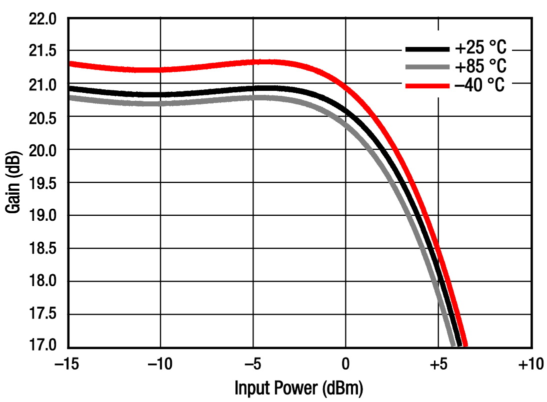

Figure 19. Gain vs Input Power Over Temperature @ 600 MHz

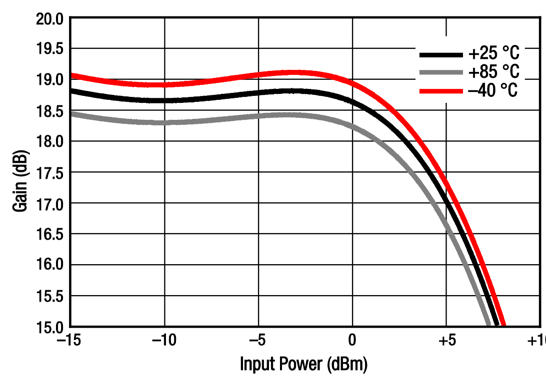

Figure 20. Gain vs Input Power Over Temperature @ 700 MHz

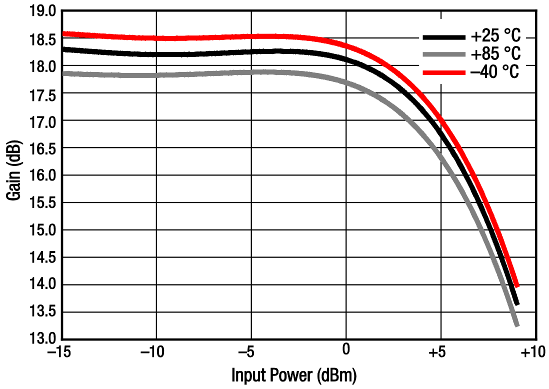

Figure 21. Gain vs Input Power Over Temperature @ 800 MHz

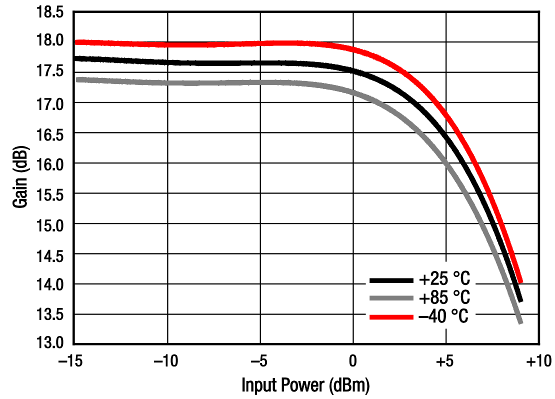

Figure 22. Gain vs Input Power Over Temperature @ 900 MHz

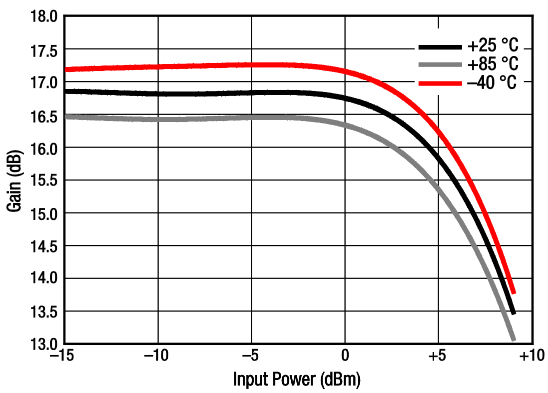

Figure 23. Gain vs Input Power Over Temperature @ 1000 MHz

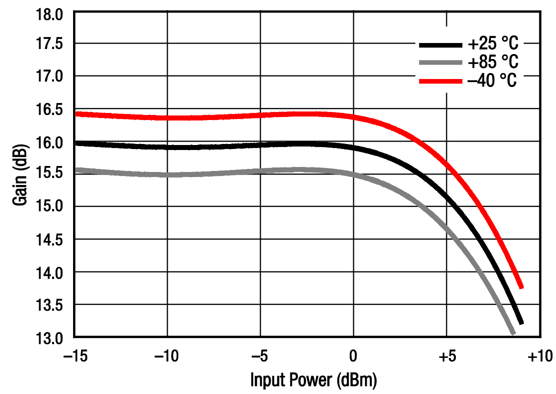

Figure 24. Gain vs Input Power Over Temperature @ 1200 MHz

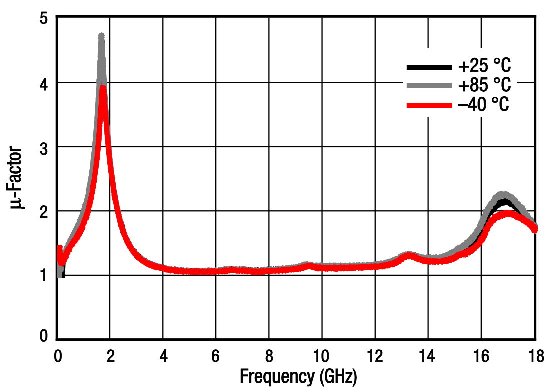

Figure 25. Stability Factor (µ) vs Frequency Over Temperature

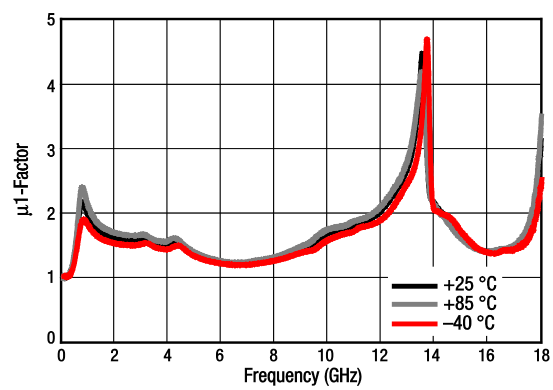

Figure 26. Stability Factor (µ1) vs Frequency Over Temperature

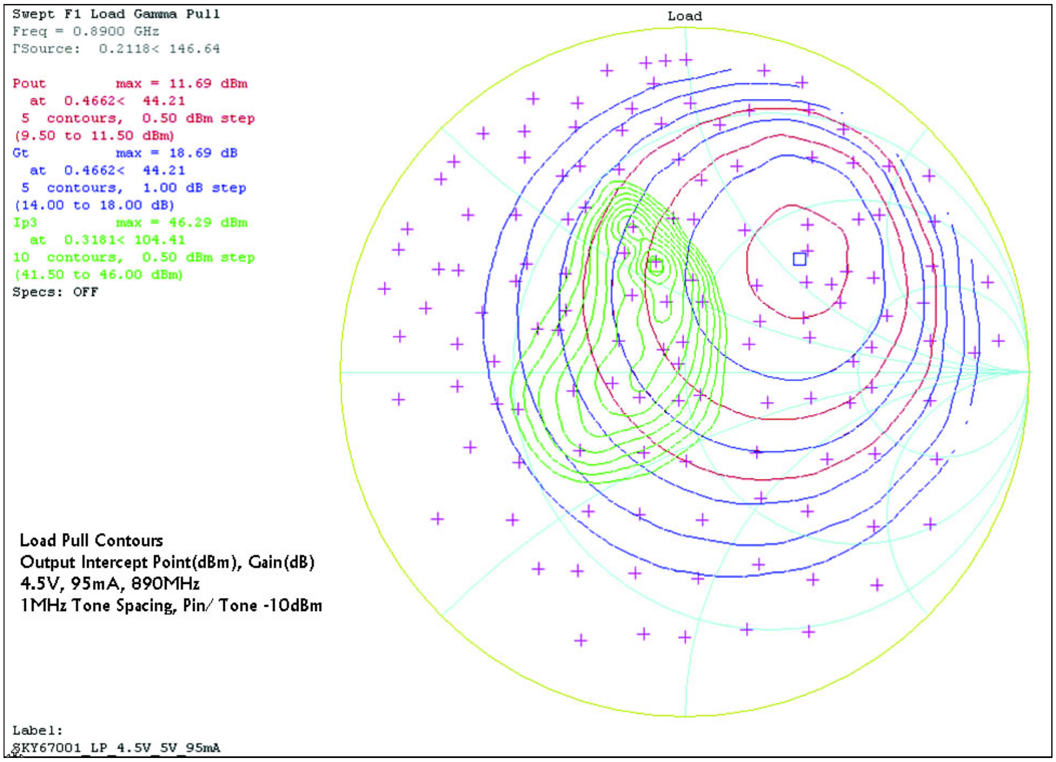

Figure 27. Load Pull, @ 4.5 V, 890 MHz, 95 mA

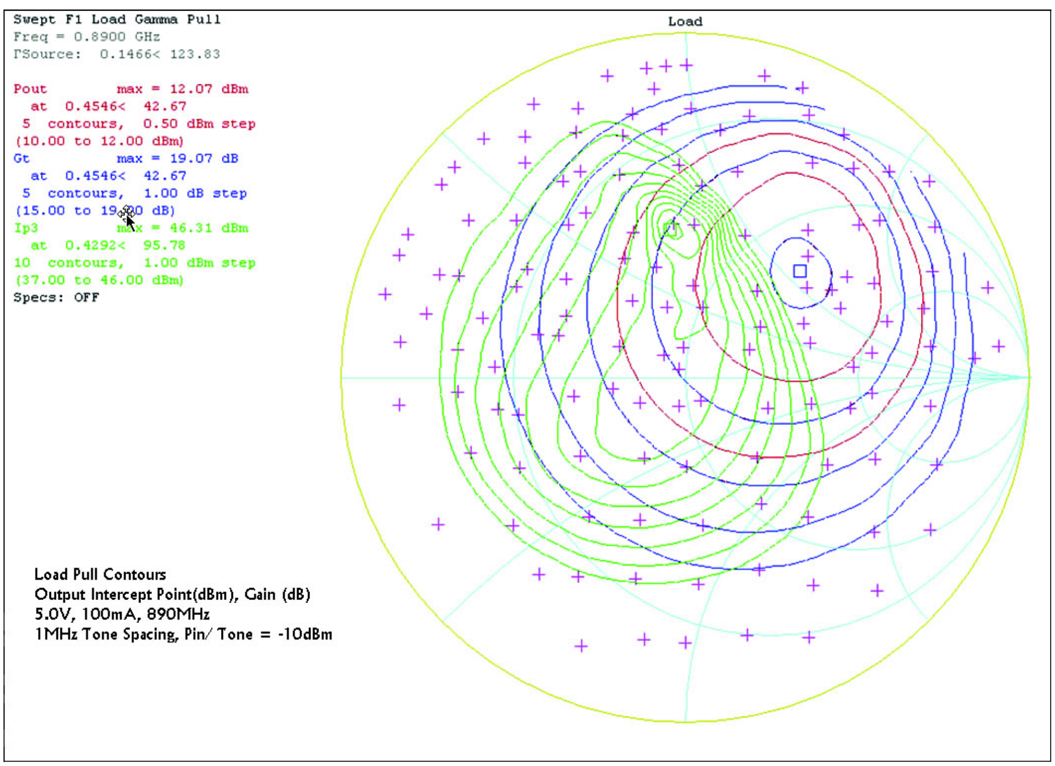

Figure 28. Load Pull, @ 5 V, 890 MHz, 100 mA

Table 4. Noise Parameters vs Frequency (1 of 2)

Frequency (GHz)	Minimum Noise Figure (F_{MIN}) (dB)	Noise Resistance (R_N) (Ω)	Γopt		Associated Gain (dB)	Maximum Gain (G_{MAX}) (dB)
			Magnitude	Phase		
4.5 V, 95 mA						
0.80	0.7137	0.0576	0.2837	113.01	18.7144	19.686
0.84	0.5306	0.0299	0.2542	128.3	18.1741	19.3168
0.89	0.4834	0.0262	0.2150	137.84	17.7119	18.8793
1.20	0.6824	0.0605	0.1897	113.45	15.7640	16.6257
1.42	0.8169	0.0756	0.1817	107.83	14.5806	15.3690
1.52	0.9034	0.0933	0.1672	111.29	14.0395	14.8646
1.76	0.9962	0.0928	0.1271	132.37	12.7526	13.7964
1.84	1.1784	0.0642	0.2013	151.97	12.1387	13.4830
1.92	1.1787	0.1031	0.1414	137.62	12.0903	13.1820
1.98	1.2367	0.1169	0.1183	146.38	11.7937	12.9662
2.00	1.3365	0.1257	0.1364	141.37	11.7663	12.8943
2.38	1.5751	0.1321	0.1093	152.37	10.4969	11.7116
2.52	1.6732	0.1548	0.1253	156.96	10.1028	11.3478
2.60	1.6486	0.1444	0.1085	–159.10	9.5429	11.1602
2.70	1.7086	0.1817	0.1144	148.14	9.7571	10.9282
3.00	2.1104	0.1750	0.1155	177.44	8.8961	10.3029
3.60	2.5576	0.2635	0.0926	177.45	6.9115	8.3171
4.00	2.8958	0.2998	0.1510	–165.45	7.4067	8.8578
5.00	3.7114	0.4350	0.2277	–158.01	6.4379	8.2996
6.00	4.5269	0.5025	0.3229	–158.65	5.8559	8.2839
7.00	5.3343	0.8091	0.3620	–154.13	5.312	8.4946
5.0 V, 100 mA						
0.80	0.5571	0.0600	0.1286	129.21	18.8608	19.7254
0.84	0.3977	0.1264	0.1201	72.63	18.8469	19.3559
0.89	0.543	0.0414	0.1575	111.37	18.1270	18.9171
1.20	0.7077	0.0667	0.1636	107.57	15.8561	16.6599
1.42	0.8033	0.0777	0.1466	110.34	14.5550	15.4004
1.52	0.8732	0.0767	0.1751	130.29	13.8350	14.8953
1.76	1.0127	0.1047	0.1240	122.01	12.8532	13.8256
1.84	1.1337	0.1062	0.1113	147.04	12.3242	13.5113
1.92	1.1686	0.1132	0.1137	134.44	12.1251	13.2098
1.98	1.232	0.1021	0.1260	163.51	11.6427	12.9939
2.00	1.3361	0.2648	0.1212	74.78	12.1585	12.9206
2.38	1.5989	0.1143	0.1302	158.37	10.4524	11.7369

Table 4. Noise Parameters vs Frequency (2 of 2)

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		
5.0 V, 100 mA (continued)						
2.52	1.6619	0.1667	0.1109	156.50	10.1114	11.3724
2.60	1.7366	0.1817	0.0974	156.70	9.9104	11.1835
2.70	1.6845	0.1032	0.1529	–165.66	9.2704	10.9525
3.00	2.1342	0.1874	0.0978	171.43	8.9475	10.3251
3.60	2.6314	0.2626	0.0816	172.61	6.9070	8.3274
4.00	2.9366	0.3237	0.1187	–160.48	7.3181	8.8760
5.00	3.7549	0.4659	0.2157	–156.72	6.3847	8.3182
6.00	4.5836	0.4105	0.3645	–149.11	5.9685	8.3084
7.00	5.4265	0.7168	0.3627	–157.54	5.3432	8.5428

Evaluation Board Description

The SKY67001-396LF Evaluation Board is used to test the performance of the SKY67001-396LF LNA. An assembly drawing for the Evaluation Board is shown in Figure 29. The layer detail is provided in Figure 30. An Evaluation Board schematic diagram is provided in Figure 31. Table 5 provides the Bill of Materials (BOM) list for Evaluation Board components.

Package Dimensions

The PCB layout footprint for the SKY67001-396LF is provided in Figure 32. Typical case markings are shown in Figure 33. Package dimensions for the 8-pin DFN are shown in Figure 34, and tape and reel dimensions are provided in Figure 35.

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 SKY67001-396LF 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.

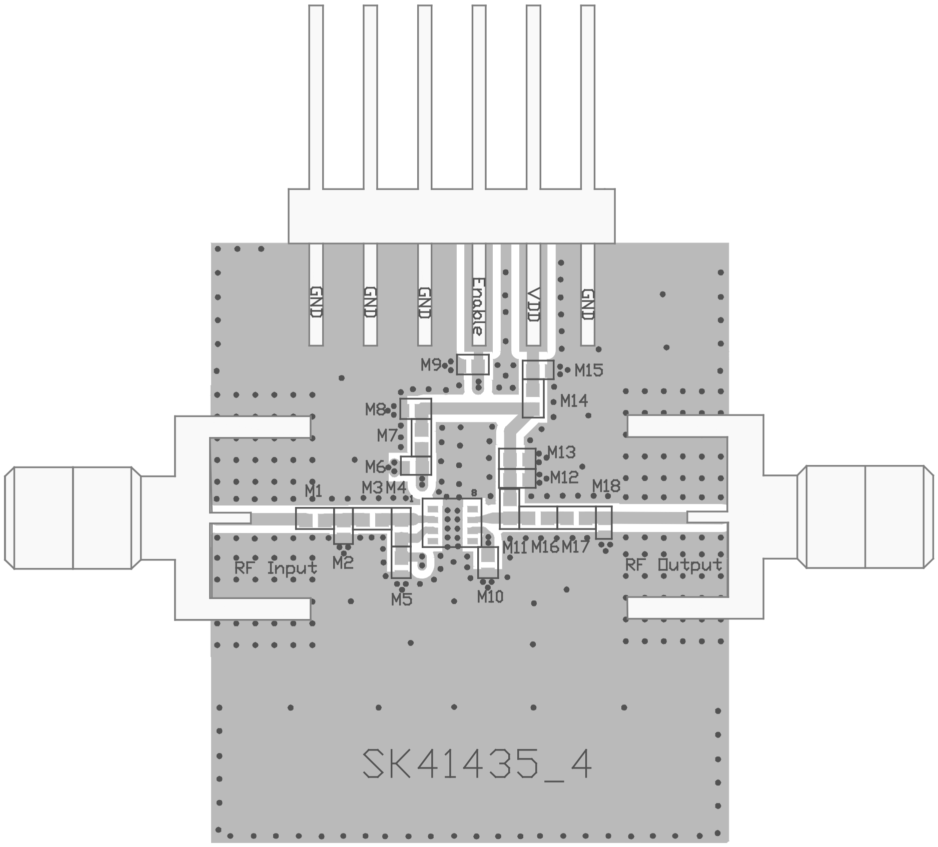

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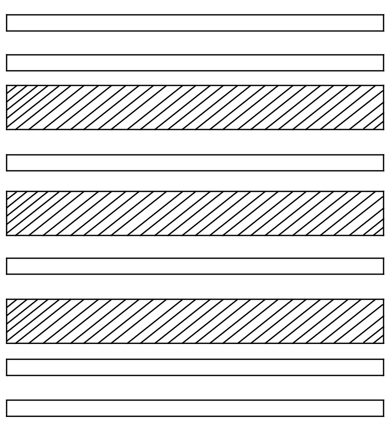
Figure 29. SKY67001-396LF Evaluation Board Assembly Diagram

Cross Section



Name	Thickness (mm)	Material
MSK-NS		
TRA-NS	0.3556	Cu foil
Laminate	0.254 ± 0.152	Rogers 4350B
TRA-2	0.0178	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: 0.394 mm
Via diameter: 0.254 mm

S2530

Figure 30. Layer Detail Physical Characteristics

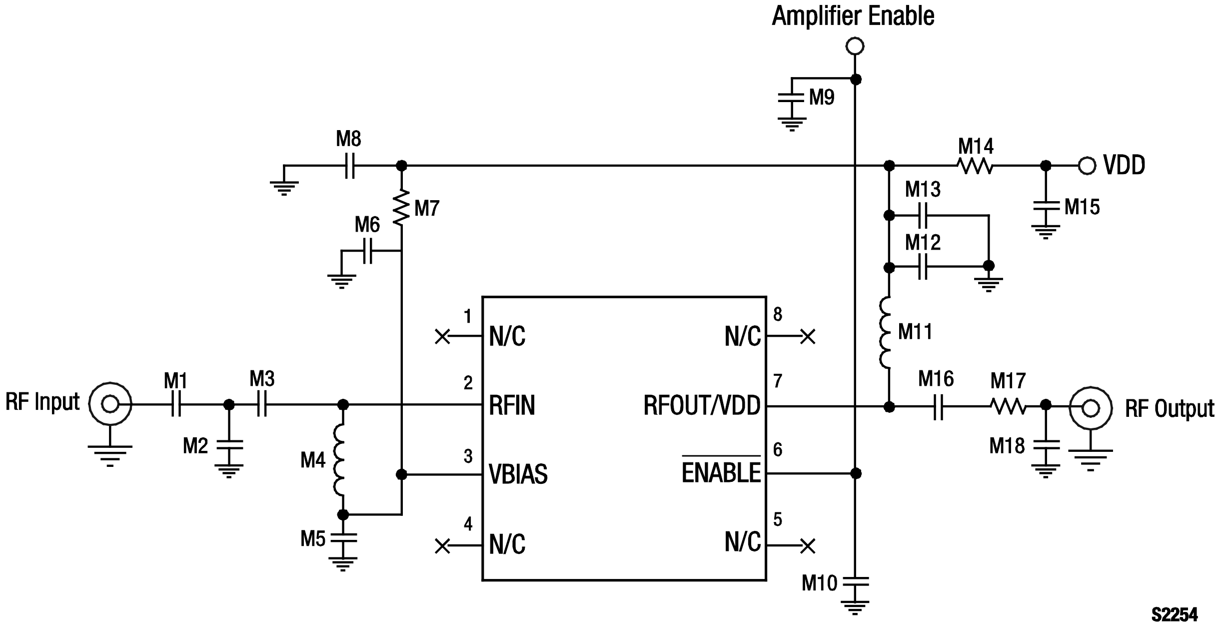


Figure 31. SKY67001-396LF Evaluation Board Schematic

Table 5. SKY67001-396LF Evaluation Board Bill of Materials

Component	Type	Value	Size	Manufacturer
M1	Resistor	0 Ω	0402	Panasonic
M2	DNI			
M3	Capacitor	6 pF	0402	Murata GJM
M4	Inductor	12 nH	0402	Coilcraft HP
M5	Capacitor	68 pF	0402	Murata GRM
M6	DNI			
M7	Resistor	3.6 kΩ	0402	Panasonic
M8	Capacitor	0.1 μF	0402	Murata GRM
M9	DNI			
M10	Capacitor	1000 pF	0402	Murata GRM
M11	Inductor	27 nH	0402	Murata LQG
M12	Capacitor	10 pF	0402	Murata GRM
M13	Capacitor	1000 pF	0402	Murata GRM
M14	Resistor	0 Ω	0402	Panasonic
M15	DNI			
M16	Inductor	4.3 nH	0402	Murata LQG
M17	Capacitor	82 pF	0402	Murata GRM
M18	DNI			

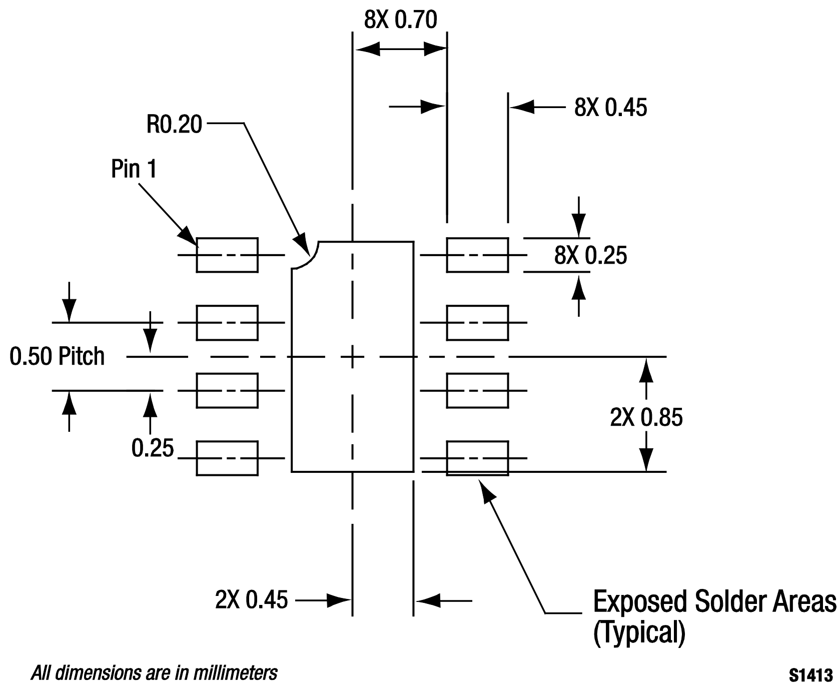


Figure 32. SKY67001-396LF PCB Layout Footprint (Top View)

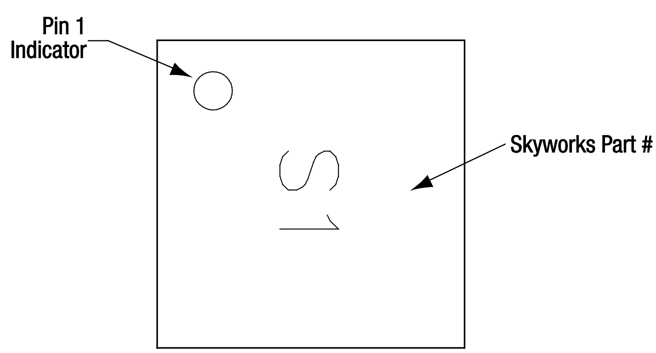
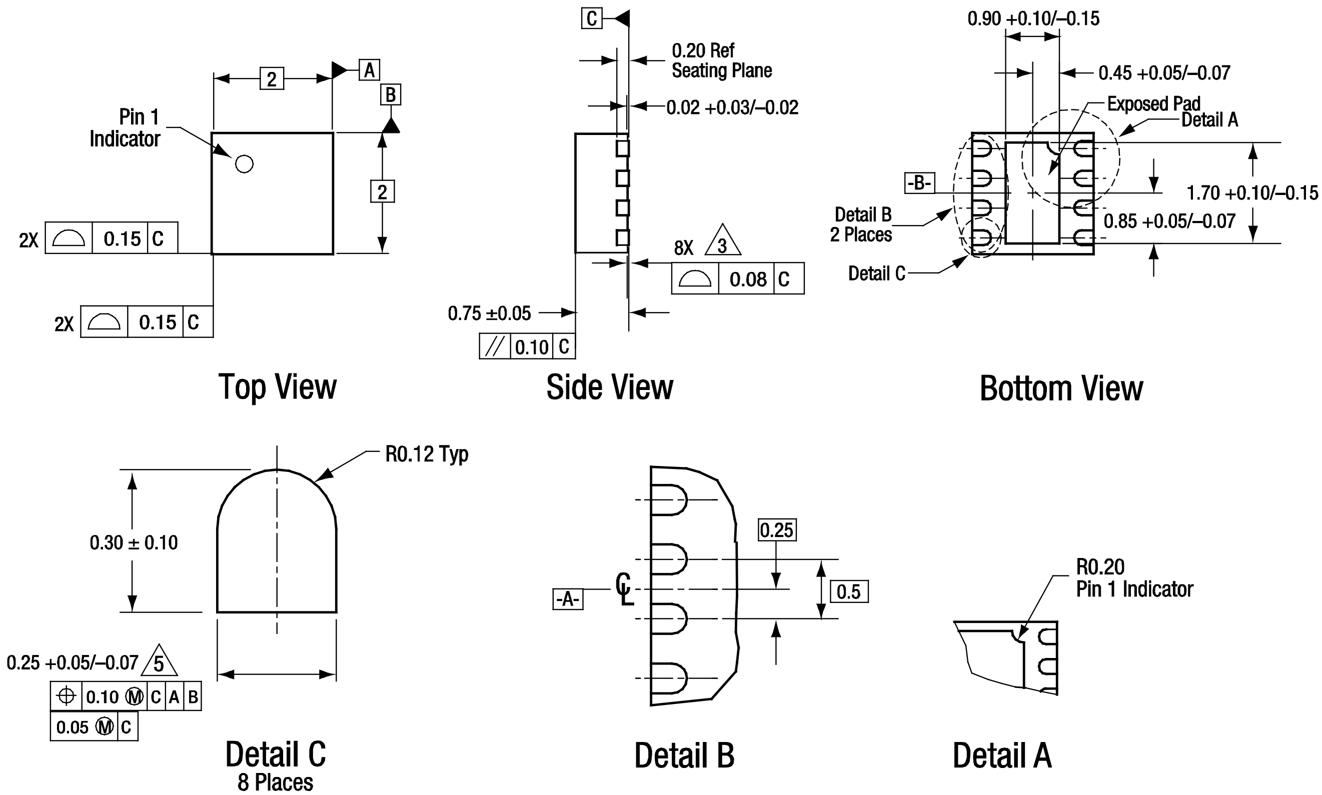


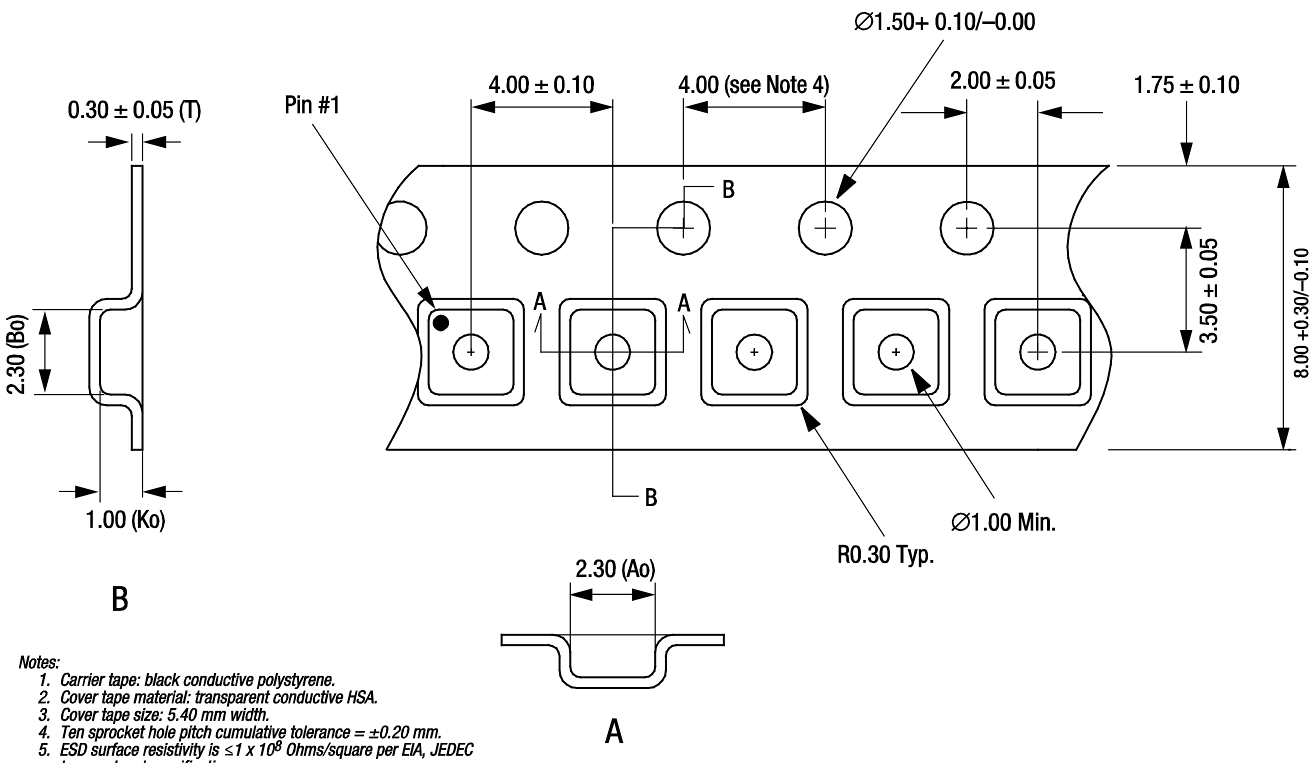
Figure 33. Typical Case Markings (Top View)



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.

S1945

Figure 34. SKY67001-396LF 8-Pin DFN Package Dimensions



Notes:
1. *Carrier tape: black conductive polystyrene.*
2. *Cover tape material: transparent conductive HSA.*
3. *Cover tape size: 5.40 mm width.*
4. *Ten sprocket hole pitch cumulative tolerance = ±0.20 mm.*
5. *ESD surface resistivity is ≤1 x 10^8 Ohms/square per EIA, JEDEC tape and reel specification.*
6. *Ao and Bo measurement point to be 0.30 mm from bottom pocket.*
7. *All measurements are in millimeters.*

Figure 35. SKY67001-396LF Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY67001-396LF LNA	SKY67001-396LF	SKY67001-396LF-EVB