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 °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.

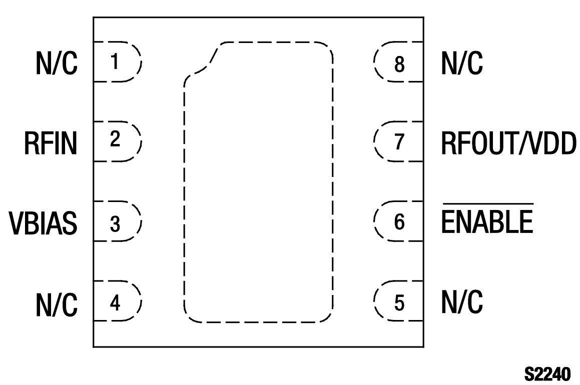



**Figure 2. SKY67002-396LF Pinout – 8-Pin DFN (Top View)**

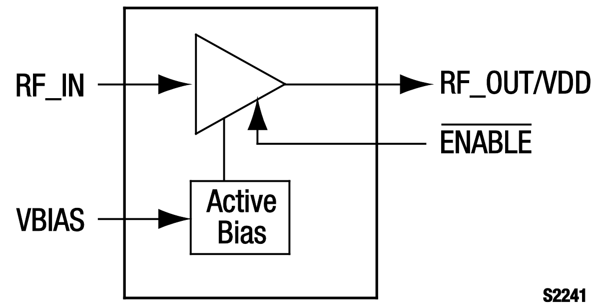



**Figure 1. SKY67002-396LF Block Diagram**

## 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 2.2 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**

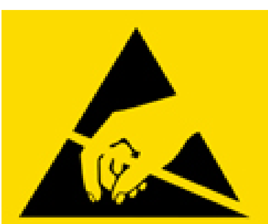
| Pin # | Name | Description | Pin # | Name | Description |
|---|---|---|---|---|---|
| 1 | N/C | No connection. May be connected to ground with no change in performance. | 5 | N/C | No connection. May be connected to ground with no change in performance. |
| 2 | RFIN | RF input. DC blocking capacitor required. | 6 | $\overline{\text{ENABLE}}$ | 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 | $\Theta_{JC}$ | | 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 [$Z_O$] = 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 | 15 | 20 | | dB |
| Output return loss | $\|S_{22}\|$ | @ 1.85 GHz | 11 | 16 | | dB |
| Reverse isolation | $\|S_{12}\|$ | @ 1.85 GHz | 27 | 31 | | dB |
| 3rd Order Input Intercept Point (Note 4) | IIP3 | @ 1.85 GHz, Δf = 1 MHz, $P_{IN}$ = –20 dBm/tone | +19.5 | +22.0 | | dBm |
| 3rd 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

**(VDD = 5 V, IDD = 95 mA, TA = +25 °C, PIN = –20 dBm, Characteristic Impedance [ZO] = 50 Ω, Unless Otherwise Noted)**

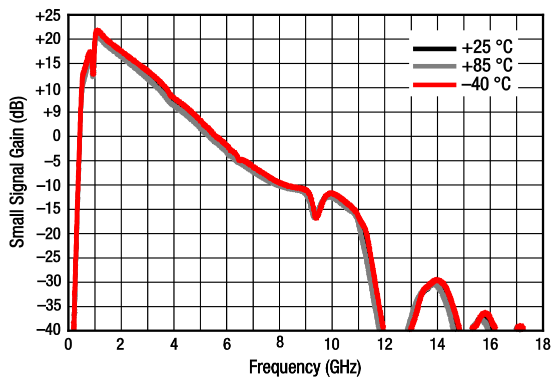



**Figure 3. Broadband Gain Response vs Frequency Over Temperature**

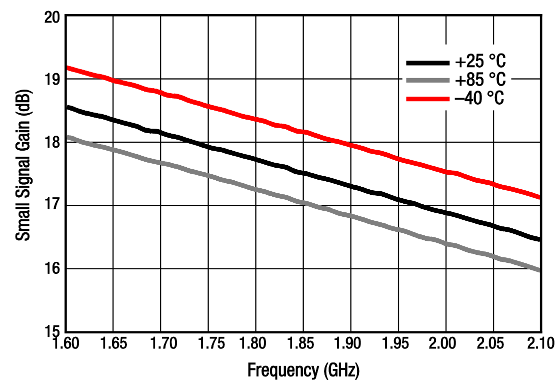



**Figure 4. Narrowband Gain Response vs Frequency Over Temperature**

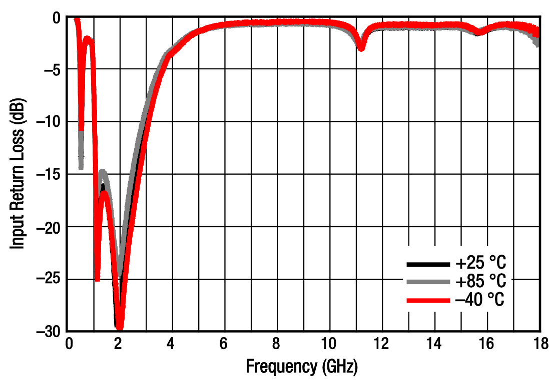



**Figure 5. Broadband Input Return Loss vs Frequency Over Temperature**

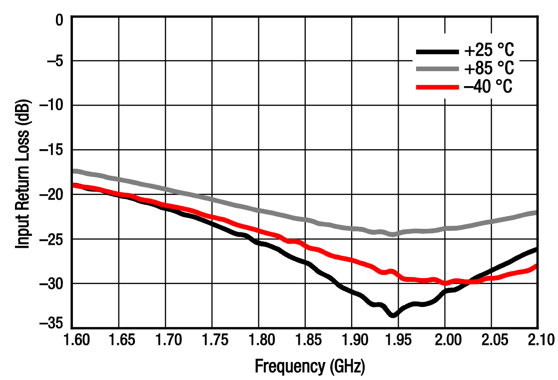



**Figure 6. Narrowband Input Return Loss vs Frequency Over Temperature**

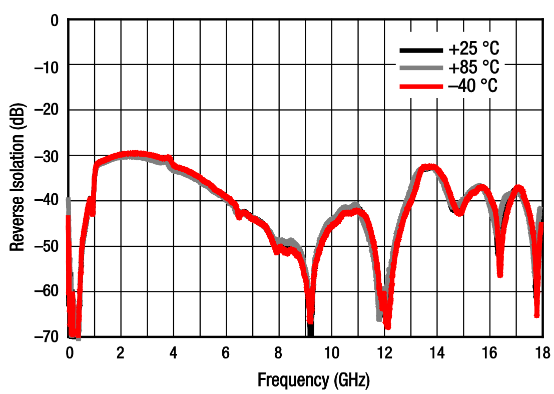



**Figure 7. Broadband Reverse Isolation vs Frequency Over Temperature**

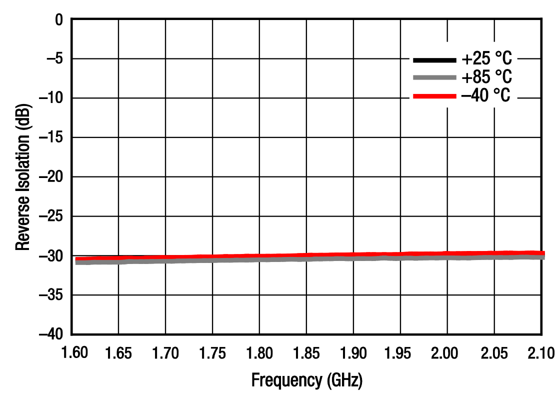



**Figure 8. Narrowband Reverse Isolation vs Frequency Over Temperature**

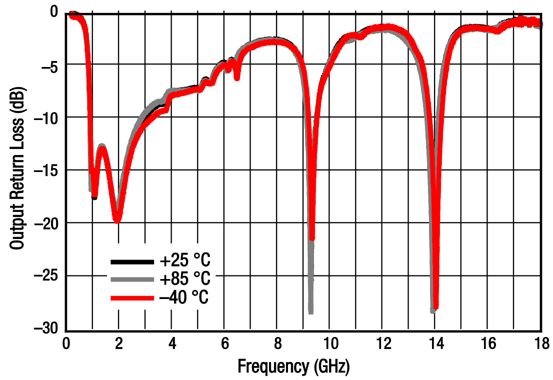



**Figure 9. Broadband Output Return Loss vs Frequency Over Temperature**

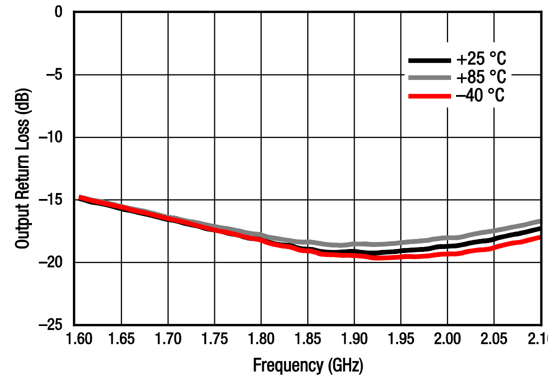



**Figure 10. Narrowband Output Return Loss vs Frequency Over Temperature**

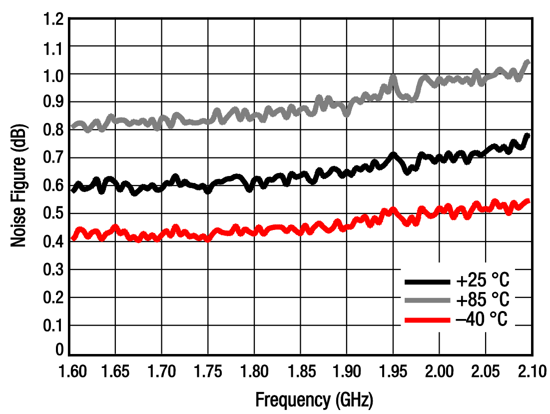



**Figure 11. Noise Figure vs Frequency Over Temperature**

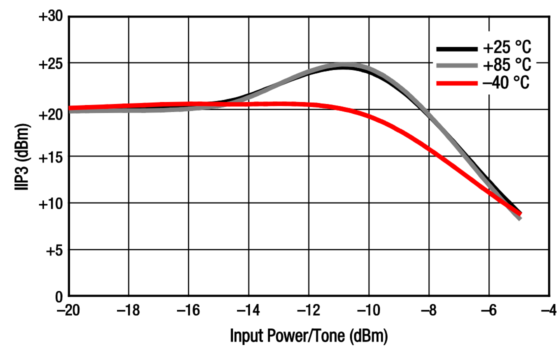



**Figure 12. IIP3 vs Input Power Over Temperature @ 5 V, 1700 MHz (Tone Spacing = 1 MHz)**

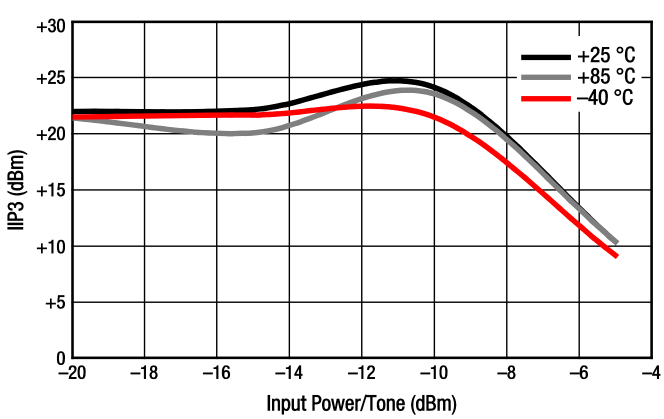



**Figure 13. IIP3 vs Input Power Over Temperature @ 5 V, 1850 MHz (Tone Spacing = 1 MHz)**

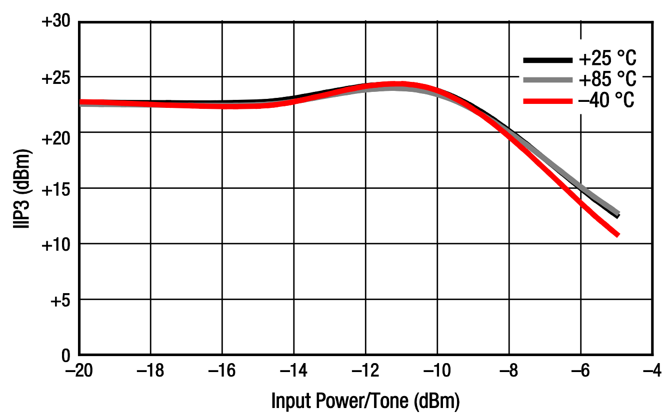



**Figure 14. IIP3 vs Input Power Over Temperature @ 5 V, 2000 MHz (Tone Spacing = 1 MHz)**

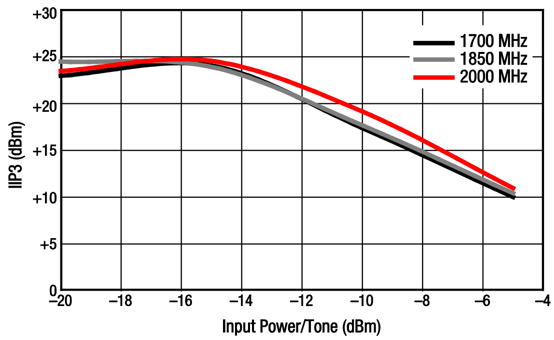



**Figure 15. IIP3 vs Input Power Over Frequency @ 4 V (Tone Spacing = 1 MHz)**

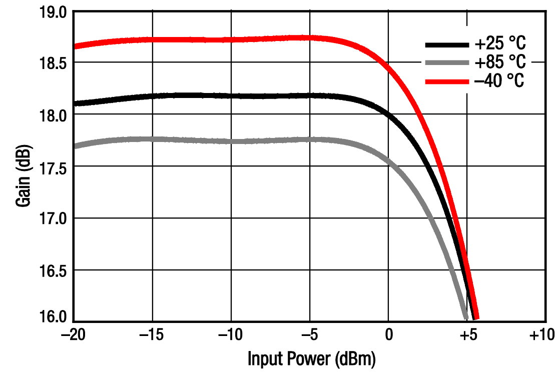



**Figure 16. Gain vs Input Power Over Temperature @ 5 V, 1700 MHz**

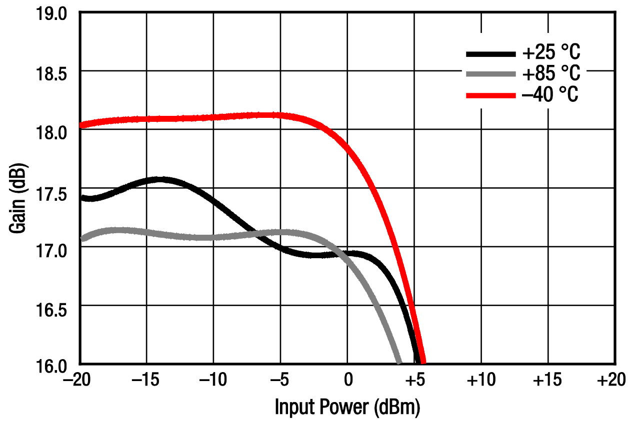



**Figure 17. Gain vs Input Power Over Temperature @ 5 V, 1850 MHz**

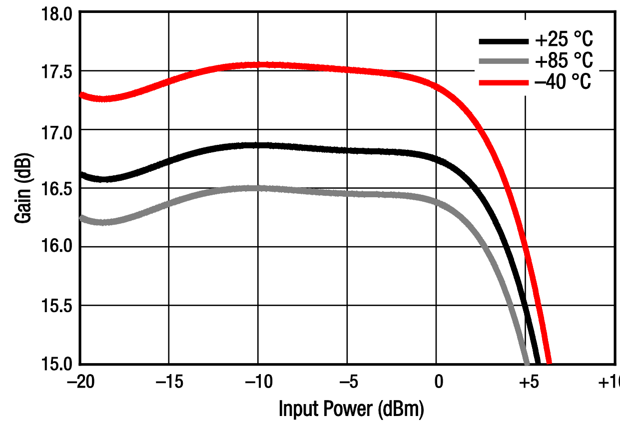



**Figure 18. Gain vs Input Power Over Temperature @ 5.0 V, 2000 MHz**

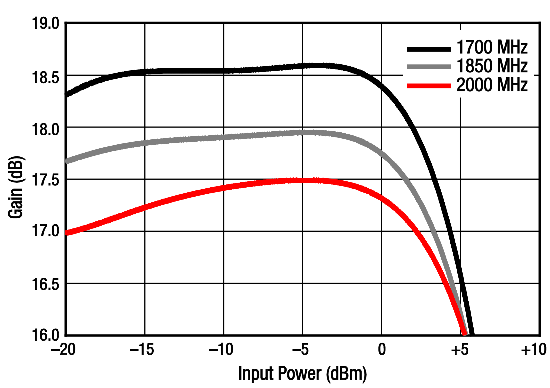



**Figure 19. Gain vs Input Power Over Frequency @ 4 V**

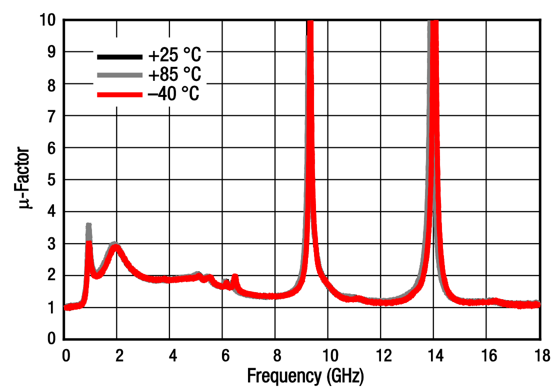



**Figure 20. Stability Factor (μ) vs Frequency Over Temperature @ 5 V**

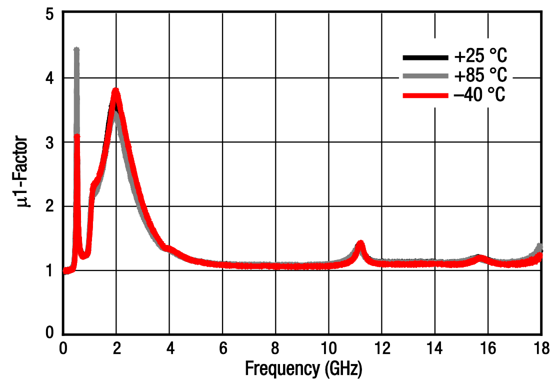



**Figure 21. Stability Factor (µ1) vs Frequency Over Temperature @ 5 V**

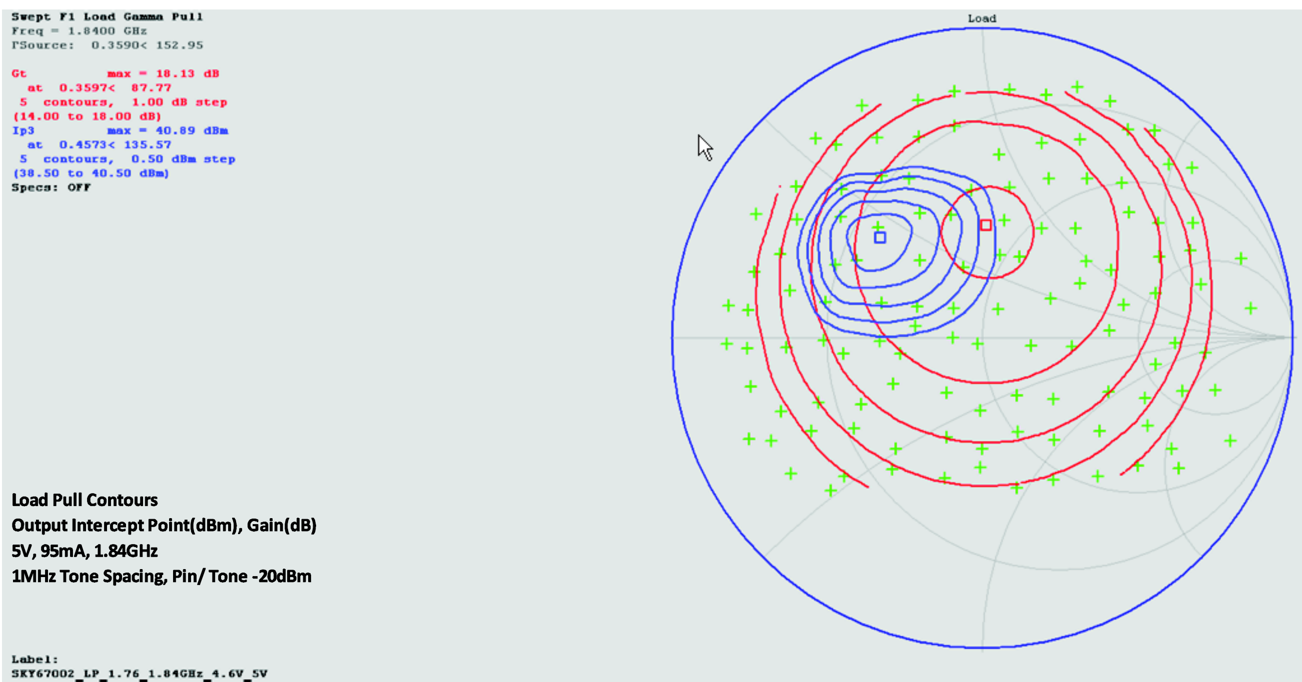



**Figure 22. Load Pull, @ 5 V and 95 mA**

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

| Frequency (GHz) | Minimum Noise Figure ($F_{MIN}$) (dB) | Noise Resistance ($R_N$) (Ω) | Γopt | | 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.

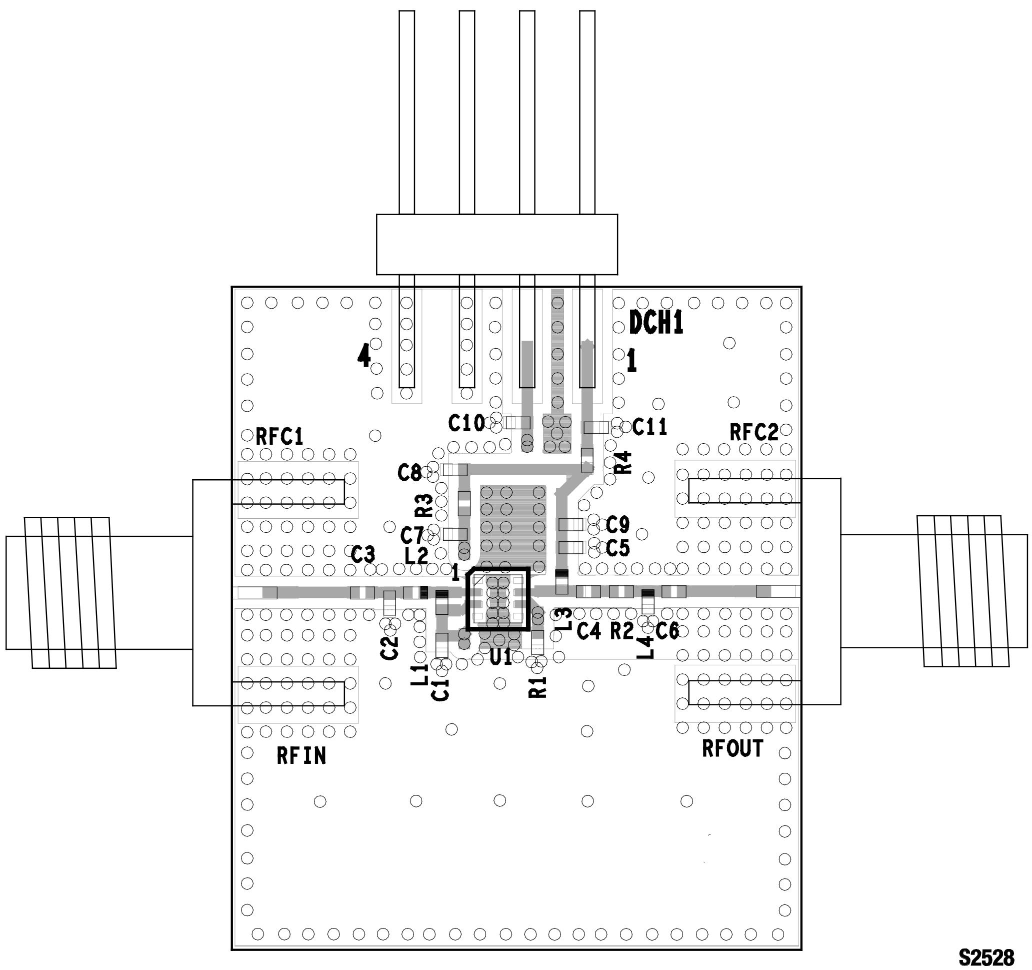
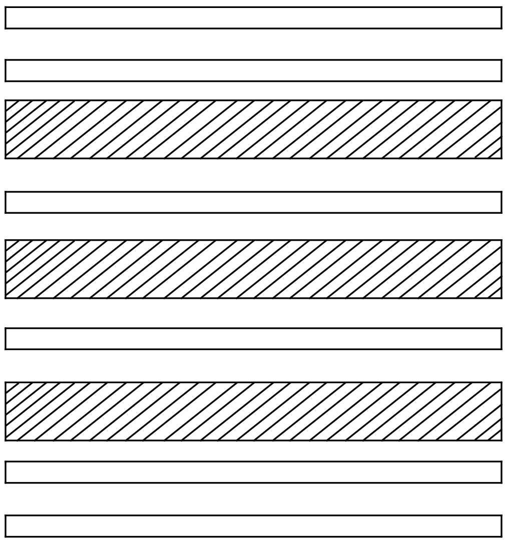



**Figure 23. SKY67002-396LF Evaluation Board Assembly Diagram**

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, $\varepsilon_r = 3.66$*
*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**

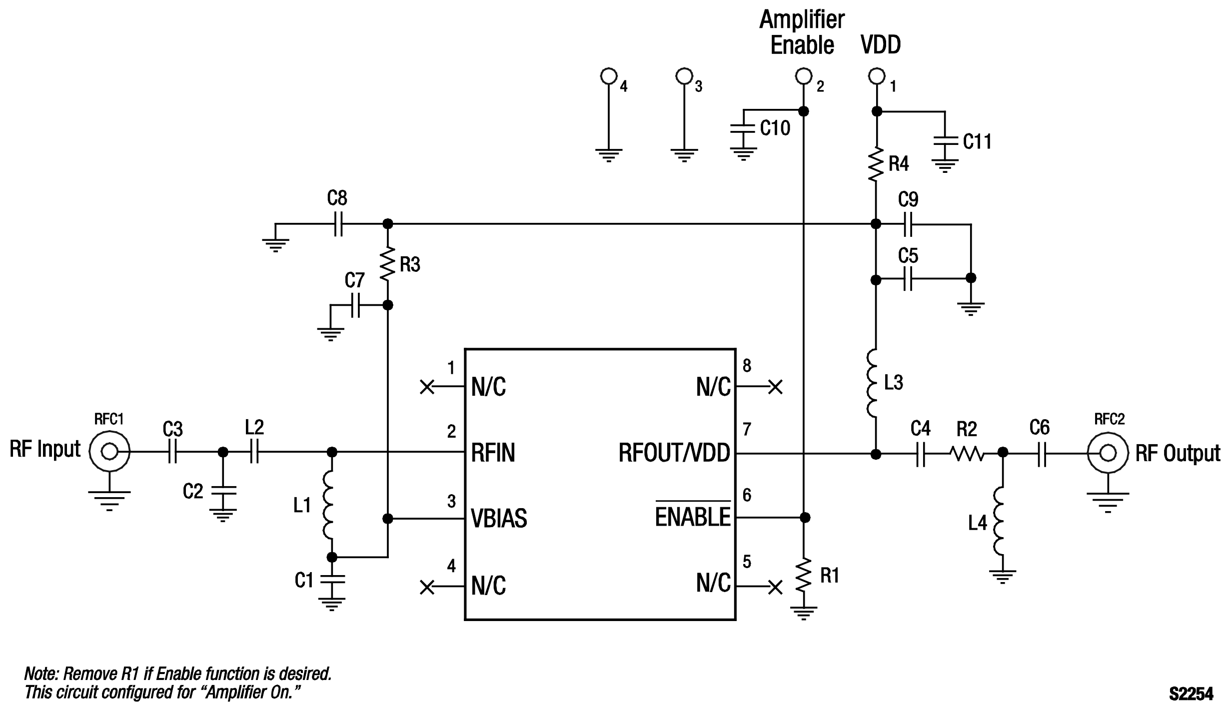



**Figure 25. SKY67002-396LF Evaluation Board Schematic**

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

| Component | 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-2GE0R00X |
| R3 | 0402 | 5.1 kΩ | 3.6 kΩ | Panasonic | ERJ-2GEJ512X (5.1 kΩ)<br>ERJ-2GEJ362X (3.6 kΩ) |

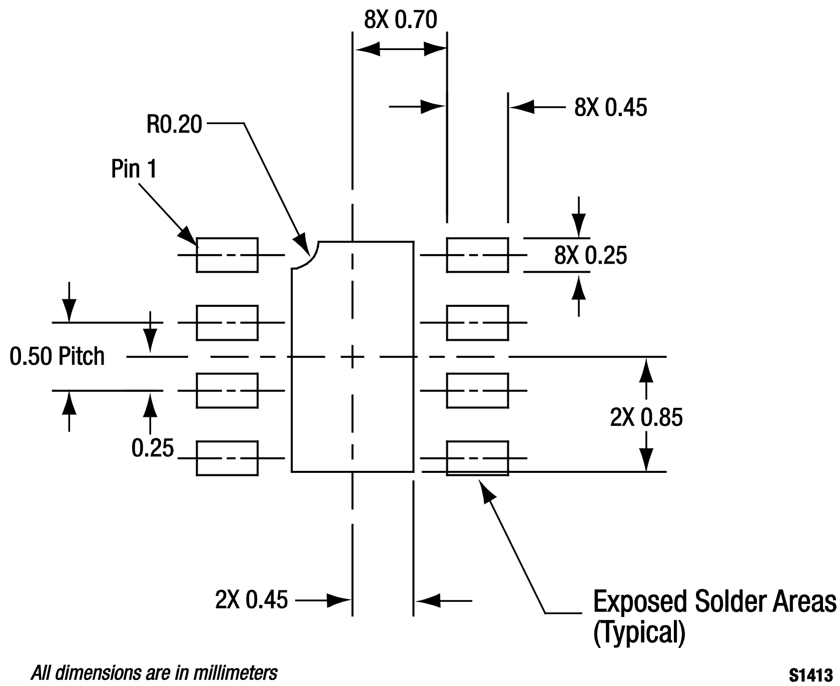



**Figure 26. SKY67002-396LF PCB Layout Footprint (Top View)**

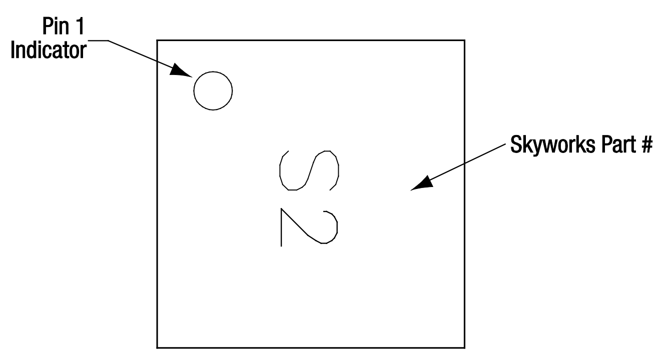
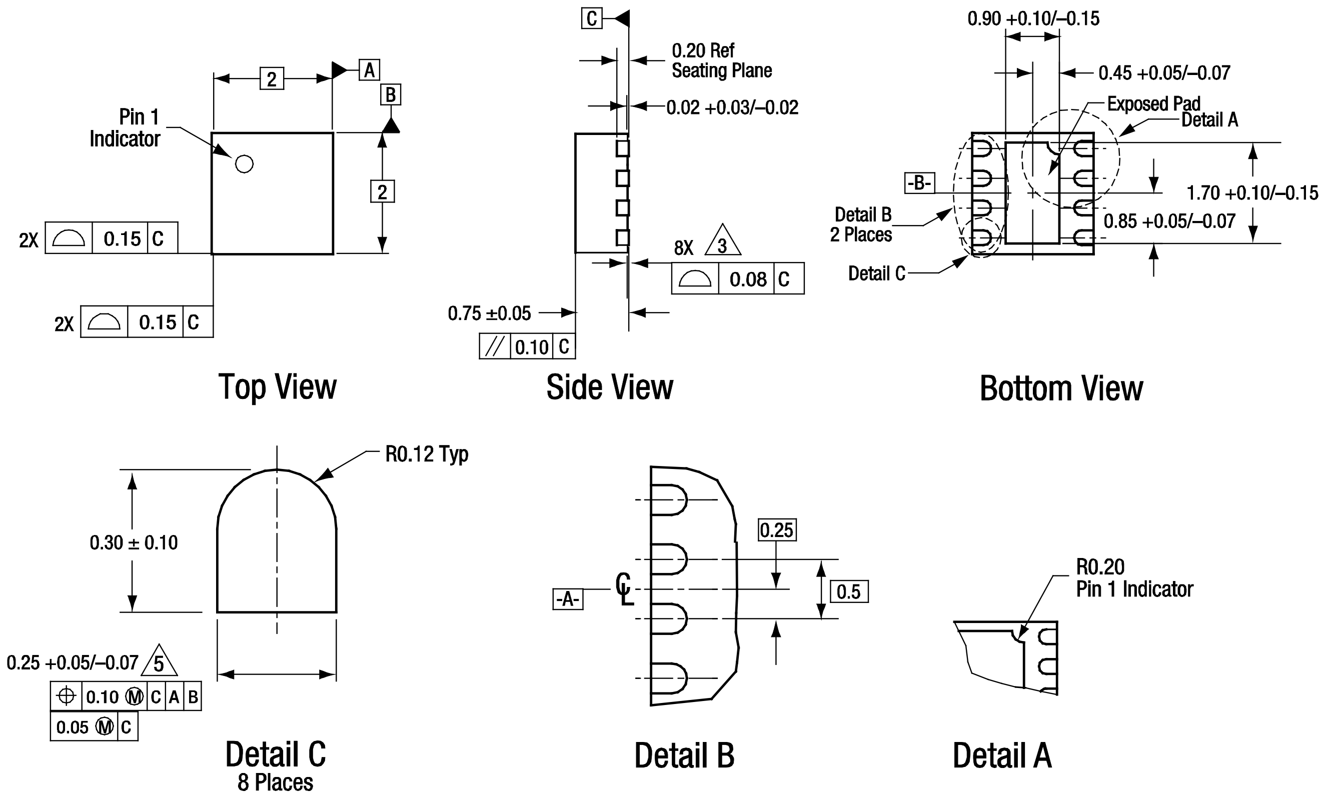



**Figure 27. Typical Case Markings (Top View)**




*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**

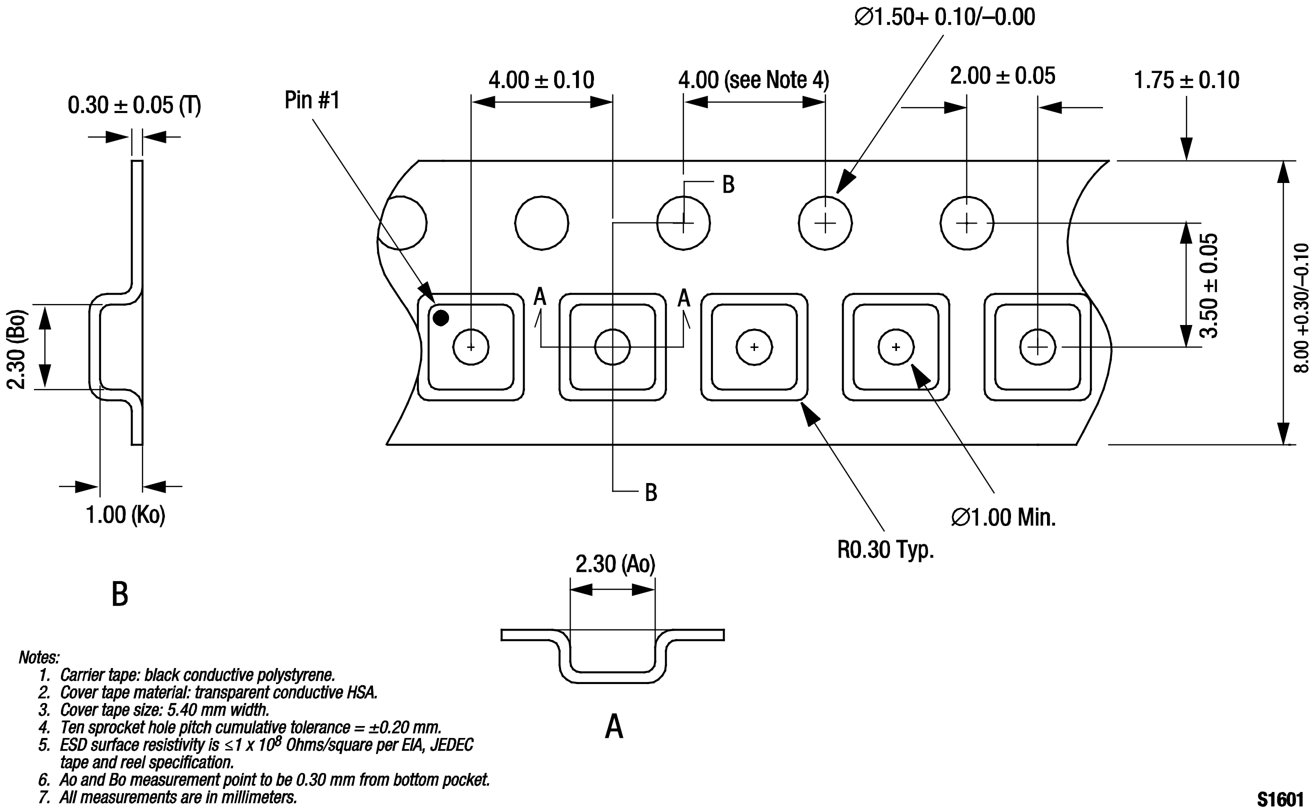


**Figure 29. SKY67002-396LF Tape and Reel Dimensions**

## Ordering Information

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