

DATA SHEET

SKY67159-396LF: 200 to 3800 MHz Broadband Low-Noise Amplifier

Applications

- FDD and TDD 2G/3G/4G LTE systems
- Receive LNA for micro-cell, macro-cell, and small-cell base stations
- Active antenna array and massive MIMO
- Land mobile radios and military communications
- Low-noise broadband gain block and driver amplifier

Features

- Excellent broadband flat gain performance
- Low noise figure
- High IP3 performance over voltage
- Single matching circuit for 200 to 3800 MHz
- Adjustable supply current from 30 to 100 mA
- Flexible bias voltage: 3 to 5 V
- Fast rise/fall time ENABLE function suitable for TDD application
- Temperature and process-stable active bias up to +105 °C
- 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.

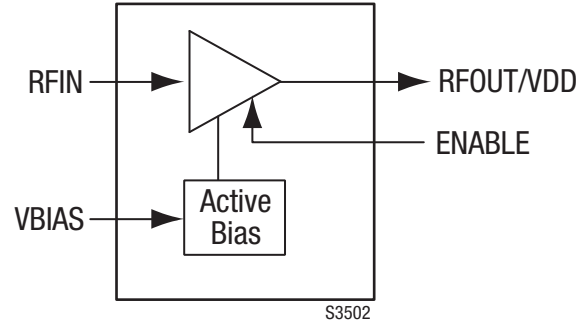


Figure 1. SKY67159-396LF Block Diagram

Description

The SKY67159-396LF is an ultra-broadband low-noise amplifier with superior gain flatness and exceptional linearity.

The compact 2 x 2 mm, 8-pin Dual Flat No Lead packaged LNA is designed for FDD and TDD 2G/3G/4G LTE small-cell base stations operating from 200 to 3800 MHz.

The internal active bias circuitry provides stable performance over temperature and process variation. The device offers the ability to externally adjust supply current.

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.

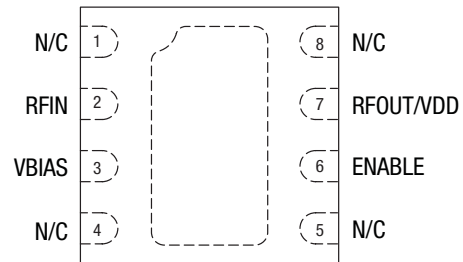


Figure 2. SKY67159-396LF Pinout (Top View)

Table 1. SKY67159-396LF Signal Descriptions

| Pin | Name | Description | Pin | Name | Description |
|-----|-------|--|-----|-----------|---|
| 1 | N/C | No connection. May be left open, connected to VDD, or 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 = amplifier ON state |
| 3 | VBIAS | Bias voltage for input gate. 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. |

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY67159-396LF are provided in Table 2. Electrical specifications are provided in Tables 3 through 5.

Typical performance characteristics are illustrated in Figures 3 through 27.

Table 2. SKY67159-396LF Absolute Maximum Ratings¹

| Parameter | Symbol | Minimum | Maximum | Units |
|-------------------------------------|------------------|---------|---------|-------|
| Supply voltage | VDD | | 5.5 | V |
| Quiescent supply current | I _{CC} | | 100 | mA |
| RF input power (C/W) | P _{IN} | | +21 | dBm |
| Storage temperature | T _{STG} | -40 | +150 | °C |
| Operating temperature | T _A | -40 | +105 | °C |
| Junction temperature | T _J | | +150 | °C |
| Electrostatic discharge: | ESD | | | |
| Charged Device Model (CDM), Class 4 | | | 1000 | V |
| Human Body Model (HBM), Class 1A | | | 250 | V |
| Machine Model (MM), Class A | | | 30 | V |

¹ 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.

ESD HANDLING: *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 when handling or transporting. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD handling precautions should be used at all times.*

Table 3. SKY67159-396LF Electrical Specifications: Thermal Data¹

(VDD = 3.3 V, Enable = GND, TA = +25 °C, PIN = -20 dBm, Characteristic Impedance [Zo] = 50 Ω, Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|--|--------|--|-----|---------|-----|-------|
| Thermal resistance | θJC | | | 40 | | °C/W |
| Channel temperature @ +85 °C reference (package heat slug) | | VDD = 3.3 V, Ico = 45 mA, no RF applied, dissipated power = 0.15 W | | 90.9 | | °C |

¹ Performance is guaranteed only under the conditions listed in this table.

Table 4. SKY67159-396LF Electrical Specifications: 700 to 2700 MHz Optimized Tuning¹ (1 of 2)

(VDD = 3.3 V, Enable = GND, TA = +25 °C, PIN = -20 dBm, Characteristic Impedance [Zo] = 50 Ω, Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|------------------------------------|--------|---|----------------|------------------------------|-----|----------------------|
| RF Specifications | | | | | | |
| Noise figure ² | NF | @ 700 MHz @ 1200 MHz @ 2100 MHz @ 2700 MHz | | 0.95 0.97 0.98 1 | | dB dB dB dB |
| Small signal gain | IS21l | @ 700 MHz @ 1200 MHz @ 2100 MHz @ 2700 MHz | | 17.8 17.5 17.3 17.1 | | dB dB dB dB |
| Input return loss | IS11l | @ 700 MHz @ 1200 MHz @ 2100 MHz @ 2700 MHz | | 18 20 20 18 | | dB dB dB dB |
| Output return loss | IS22l | @ 700 MHz @ 1200 MHz @ 2100 MHz @ 2700 MHz | | 22 19 19 22 | | dB dB dB dB |
| Reverse isolation | IS12l | @ 700 MHz @ 1200 MHz @ 2100 MHz @ 2700 MHz | | 22 22 22 23 | | dB dB dB dB |
| Third order input intercept point | IIP3 | @ 700 MHz, Δf = 1 MHz, PIN = -20 dBm/tone @ 2700 MHz, Δf = 1 MHz, PIN = -20 dBm/tone | 12 10 | 14.2 12.4 | | dBm dBm |
| Third order output intercept point | OIP3 | @ 700 MHz, Δf = 1 MHz, PIN = -20 dBm/tone @ 2700 MHz, Δf = 1 MHz, PIN = -20 dBm/tone | 30 27.5 | 32 29.5 | | dBm dBm |
| 1 dB input compression point | IP1dB | @ 700 MHz @ 2700 MHz | -1 -2 | +1 0 | | dBm dBm |
| 1 dB output compression point | OP1dB | @ 700 MHz @ 2700 MHz | +16 +14 | +18 +16 | | dBm dBm |

Table 4. SKY67159-396LF Electrical Specifications: 700 to 2700 MHz Optimized Tuning¹ (2 of 2)
(V_{DD} = 3.3 V, Enable = GND, 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 |
|-------------------------------|-------------------|--|-----|---------|-----|-------|
| DC Specifications | | | | | | |
| Supply voltage | V _{DD} | | | 3.3 | | V |
| Quiescent current | I _{DD} | Set with external resistor (R _{BIAS} = 4.7 kΩ) | | 45 | | mA |
| Bias current | I _{BIAS} | | | | | μA |
| Enable voltage: Gain mode | V _{EN} | | 0 | | 0.2 | V |
| Power-down mode | | | 1.5 | | 5.5 | V |
| Enable rise time ³ | t _{ON} | @ 2700 MHz | | 400 | | ns |
| Enable fall time ³ | t _{OFF} | @ 2700 MHz | | 150 | | ns |

¹ Performance is guaranteed only under the conditions listed in this table.

² Connector and board loss are de-embedded.

³ Tested with a 100 kHz square wave, 1000 pF capacitance-to-ground on the ENABLE pin. Switching time can be improved by reducing the value of, or eliminating, the 1000 pF capacitor on pin 6 (component M17 in Figure 19).

Table 5. SKY67159-396LF Electrical Specifications: 3400 to 3800 MHz Optimized Tuning (1 of 2)
(V_{DD} = +3.3 V, ENABLE = LOW, I_{cq} = 45 mA, T_{OP} = +25 °C, P_{IN} = -20 dBm, Optimized for 3400 to 3800 MHz Operation, Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|--------------------------|--------|----------------|-----|---------|-----|-------|
| RF Specifications | | | | | | |
| Noise figure | NF | @ 3400 MHz | | 1.2 | | dB |
| | | @ 3600 MHz | | 1.25 | | dB |
| | | @ 3800 MHz | | 1.3 | | dB |
| Small signal gain | IS21I | @ 3400 MHz | | 16.8 | | dB |
| | | @ 3600 MHz | | 16.7 | | dB |
| | | @ 3800 MHz | | 16.5 | | dB |
| Input return loss | IS11I | @ 3400 MHz | | 24 | | dB |
| | | @ 3600 MHz | | 30 | | dB |
| | | @ 3800 MHz | | 30 | | dB |
| Output return loss | IS22I | @ 3400 MHz | | 22 | | dB |
| | | @ 3600 MHz | | 21 | | dB |
| | | @ 3800 MHz | | 22 | | dB |
| Reverse isolation | IS12I | @ 3400 MHz | | 23 | | dB |
| | | @ 3600 MHz | | 23 | | dB |
| | | @ 3800 MHz | | 23 | | dB |

Table 5. SKY67159-396LF Electrical Specifications: 3400 to 3800 MHz Optimized Tuning (2 of 2)
(VDD = +3.3 V, ENABLE = LOW, Icq = 45 mA, Top = +25 °C, PIN = -20 dBm, Optimized for 3400 to 3800 MHz Operation, Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|------------------------------------|--------|---|-----|---------|-----|-------|
| <i>RF Specifications</i> | | | | | | |
| Third order input intercept point | IIP3 | @ 3400 MHz, $\Delta f = 1$ MHz, PIN = -20 dBm/tone | 9 | 11.4 | | dBm |
| | | @ 3800 MHz, $\Delta f = 1$ MHz, PIN = -20 dBm/tone | 8 | 10.9 | | dBm |
| Third order output intercept point | OIP3 | @ 3400 MHz, $\Delta f = 1$ MHz, PIN = -20 dBm/tone | 25 | 28.2 | | dBm |
| | | @ 3800 MHz, $\Delta f = 1$ MHz, PIN = -20 dBm/tone | 24 | 27.4 | | dBm |
| 1 dB input compression point | IP1dB | @ 3400 MHz | -3 | -1 | | dBm |
| | | @ 3800 MHz | -3 | -1 | | dBm |
| 1 dB output compression point | OP1dB | @ 3400 MHz | 12 | 14.8 | | dBm |
| | | @ 3800 MHz | 12 | 14.5 | | dBm |

Typical Performance Characteristics, 700 to 2700 MHz

(VDD = 3.3 V, Enable = GND, ICQ = 45 mA, TA = +25 °C, PIN = -20 dBm, Characteristic Impedance [Zo] = 50 Ω, Unless Otherwise Noted)

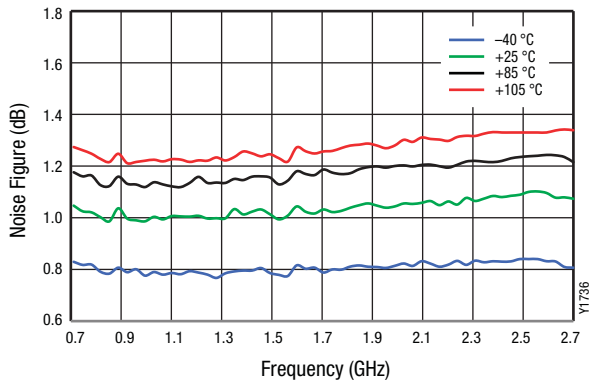


Figure 3. Evaluation board NF vs Frequency over Temperature

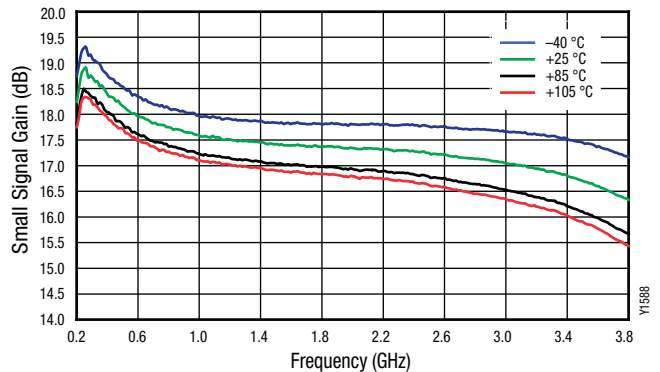


Figure 4. Narrow Band Gain vs Frequency over Temperature

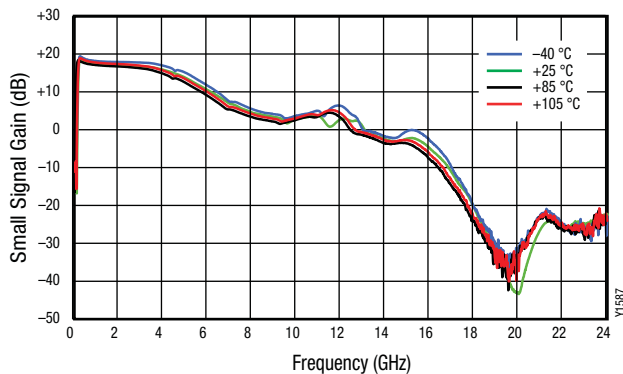


Figure 5. Broadband Gain vs Frequency over Temperature

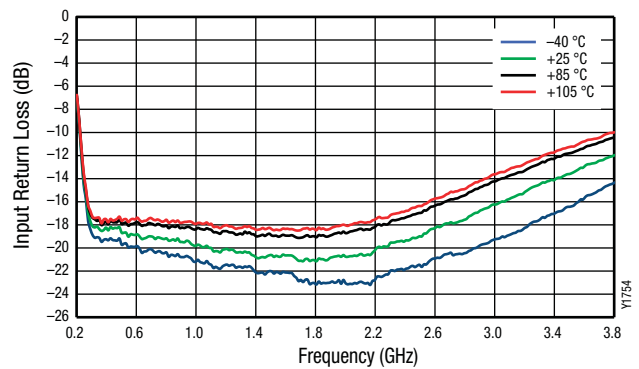


Figure 6. Narrowband Input Return Loss vs Frequency over Temperature

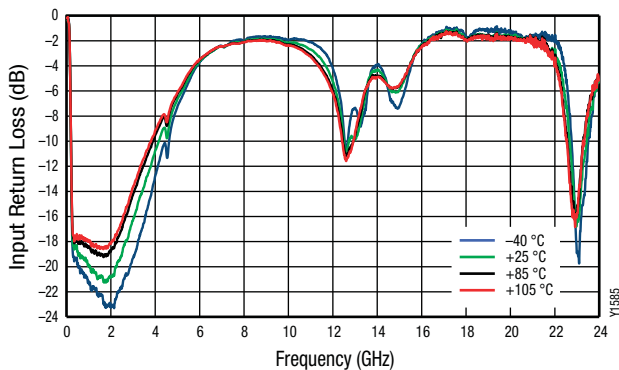


Figure 7. Broadband Input Return Loss vs Frequency over Temperature

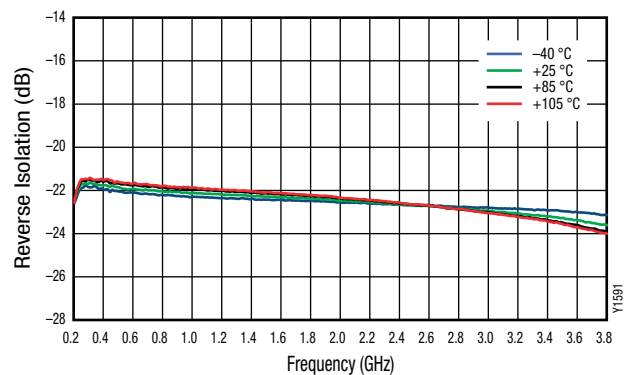


Figure 8. Narrowband Reverse Isolation vs Frequency over Temperature

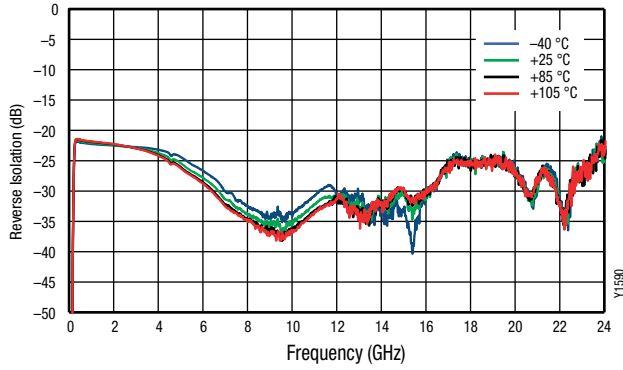


Figure 9. Broadband Reverse Isolation vs Frequency over Temperature

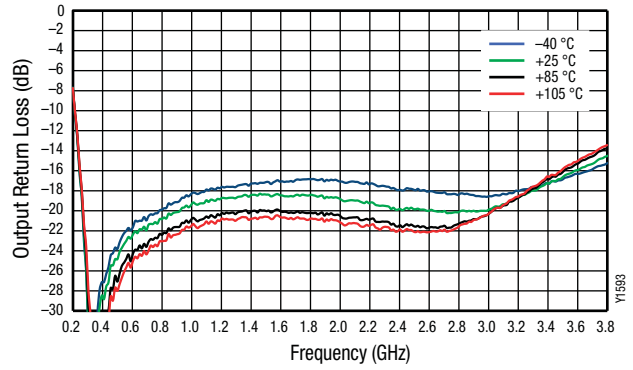


Figure 10. Narrowband Output Return Loss vs Frequency over Temperature

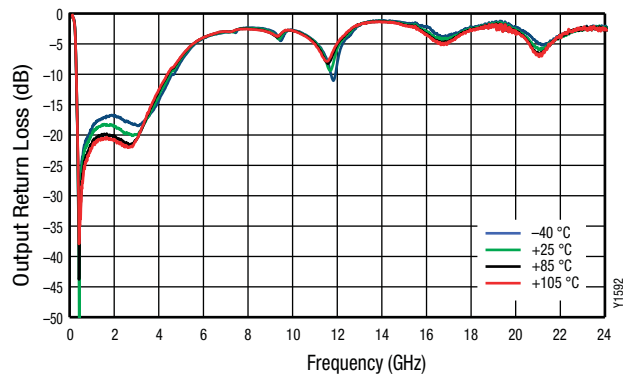


Figure 11. Broadband Output Return Loss vs Frequency over Temperature

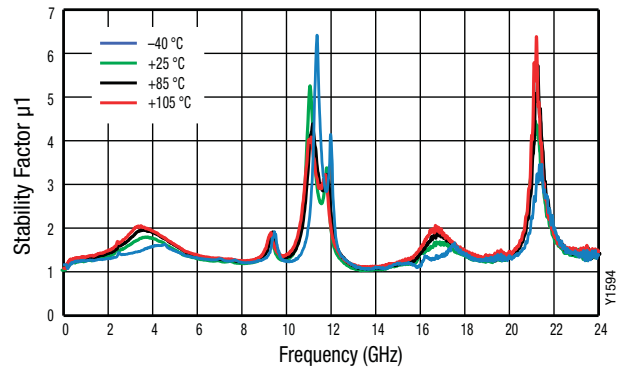


Figure 12. Stability Factor (μ_1) vs Frequency over Temperature

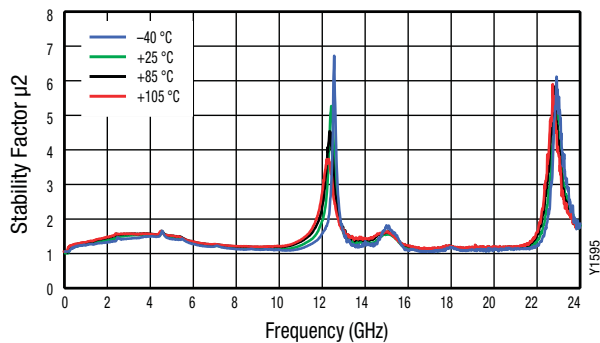


Figure 13. Stability Factor (μ_2) vs Frequency over Temperature

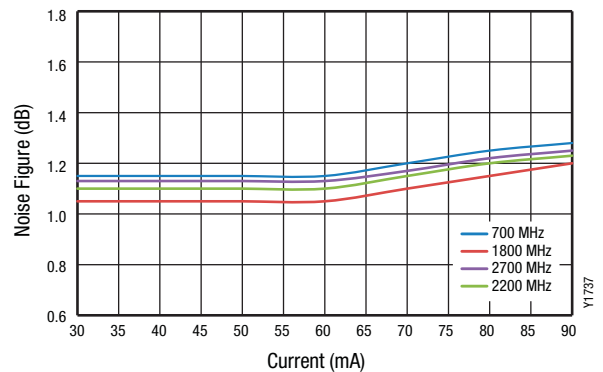


Figure 14. Evaluation Board Noise Figure vs Quiescent Current over Frequency

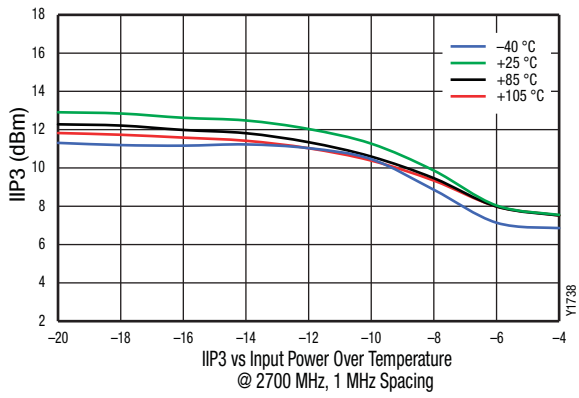


Figure 15. OIP3 vs Input Power over Temperature (@ 2700 MHz, 1 MHz Spacing)

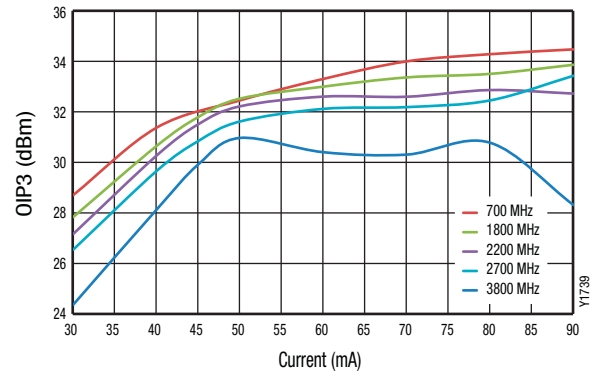


Figure 16. OIP3 vs Quiescent Current over Frequency

Typical Performance Characteristics, 3400 to 3800 MHz Optimized Tuning

(V_{DD} = 3.3 V, Enable = GND, I_{CQ} = 45 mA, T_A = +25 °C, P_{IN} = -20 dBm, Characteristic Impedance [Z₀] = 50 Ω, Unless Otherwise Noted)

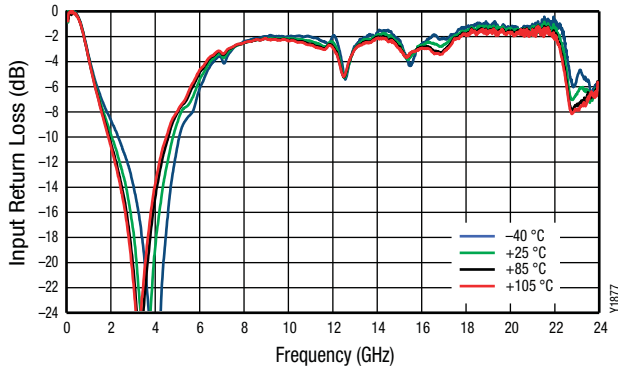


Figure 17. Broadband Input Return Loss vs Frequency over Temperature

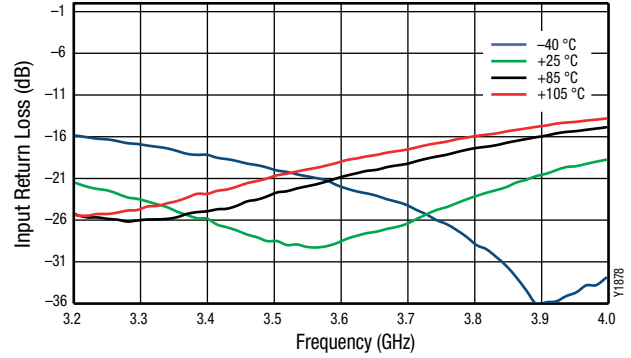


Figure 18. Narrowband Input Return Loss vs Frequency over Temperature

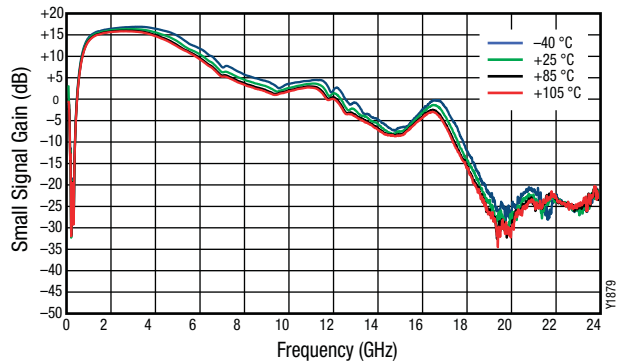


Figure 19. Broadband Gain vs Frequency over Temperature

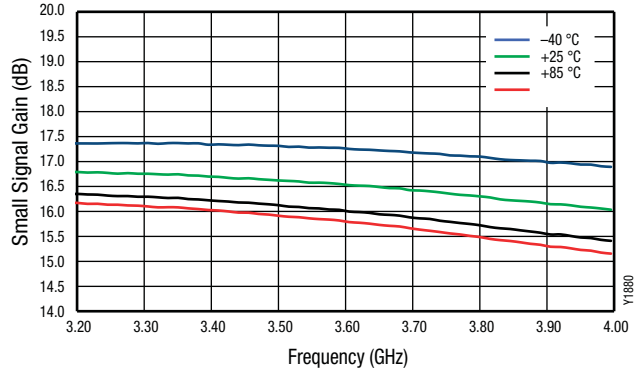


Figure 20. Narrow Band Gain vs Frequency over Temperature

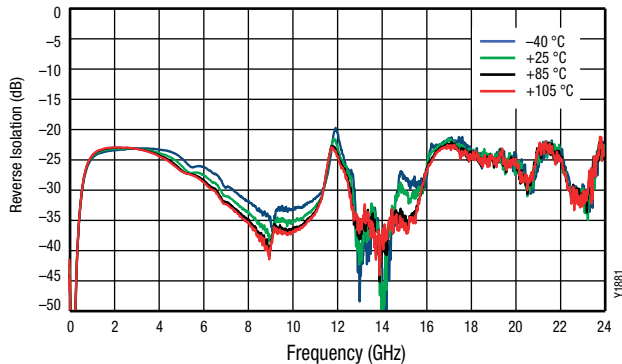


Figure 21. Broadband Reverse Isolation vs Frequency over Temperature

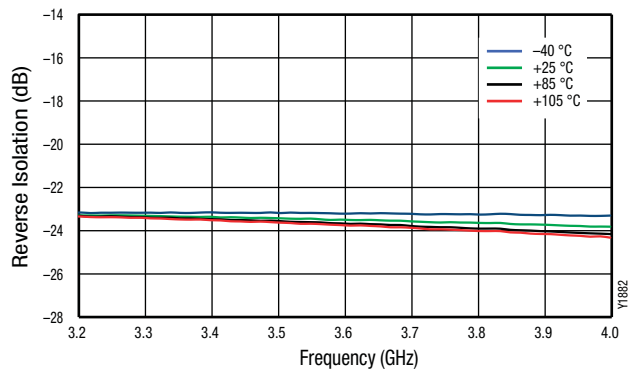


Figure 22. Narrowband Reverse Isolation vs Frequency over Temperature

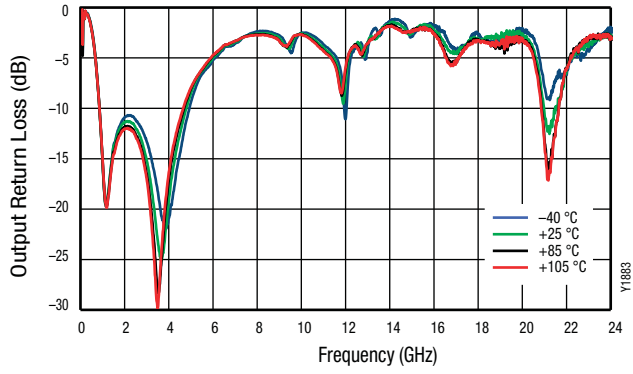


Figure 23. Broadband Output Return Loss vs Frequency over Temperature

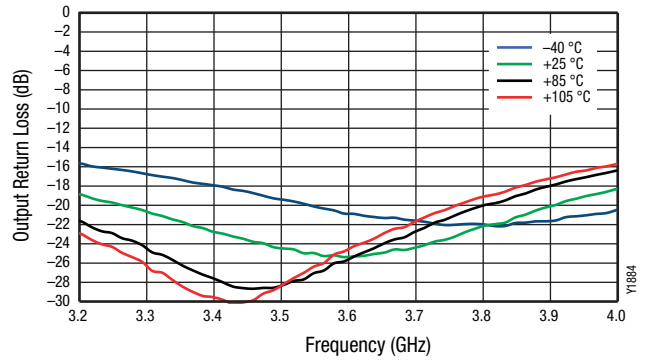


Figure 24. Narrowband Output Return Loss vs Frequency over Temperature

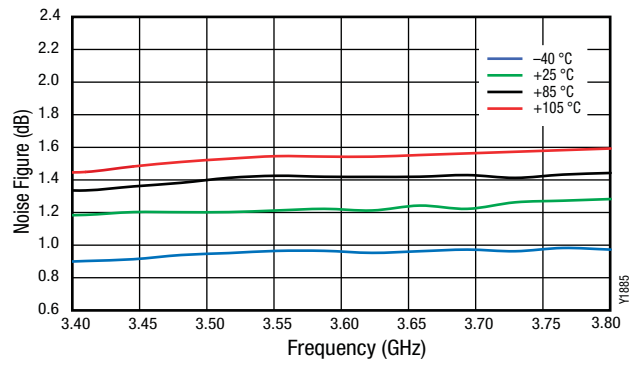


Figure 25. Noise Figure vs Frequency

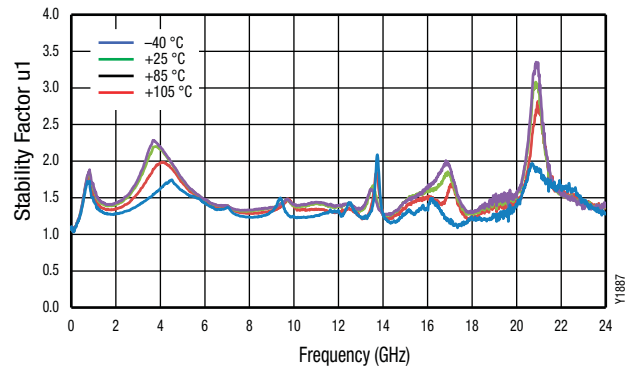


Figure 26. Stability Factor u1 vs Frequency

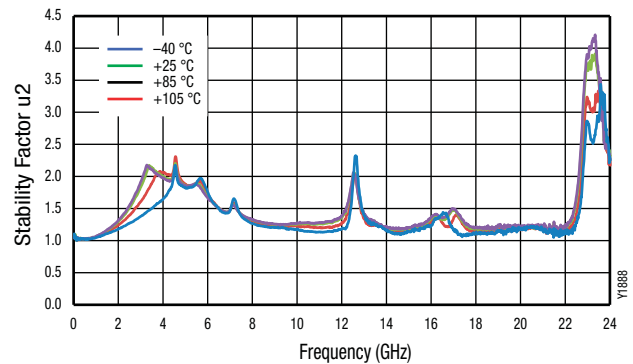


Figure 27. Stability Factor u2 vs Frequency

Evaluation Board Description

The SKY67159-396LF Evaluation Board is used to test the performance of the SKY67159-396LF LNA.

An assembly drawing for the Evaluation Board is shown in Figure 28. The layer detail is provided in Figure 29. An Evaluation Board schematic (optimized for 700 to 2700 MHz) diagram is provided in Figure 30. Table 6 provides the Bill of Materials (BOM) list for the optimized frequency band (700 to 2700 MHz). An Evaluation Board schematic (optimized for 3400 to 3800 MHz) diagram is provided in Figure 31. Table 7 provides the Bill of Materials (BOM) list for the optimized frequency band (3400 to 3800 MHz).

Package Dimensions

The PCB layout footprint for the SKY67159-396LF is provided in Figure 32. Typical part markings are shown in Figure 33. Package dimensions 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 SKY67159-396LF 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.

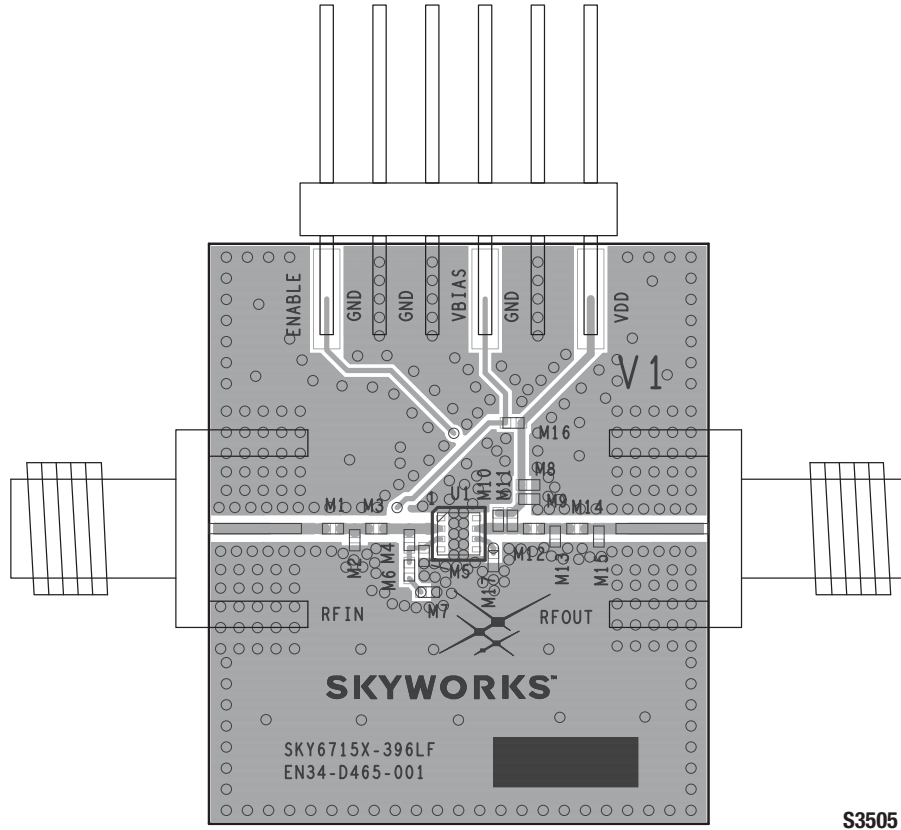


Figure 28. SKY67159-396LF Evaluation Board Assembly Diagram

| Cross Section | Name | Thickness (mm) | Material |
|---------------|----------|----------------|----------------------|
| | MSK-NS | | |
| | TRA-NS | 0.03556 | 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, $\epsilon_r = 3.66$
 Layer 1 thickness: 0.254 mm
 Overall board thickness: 1.575 mm
 50 Ω transmission line width: 0.522 mm
 Coplanar ground spacing: 0.394 mm
 Via diameter: 0.254 mm

S2530

Figure 29. Layer Detail Physical Characteristics

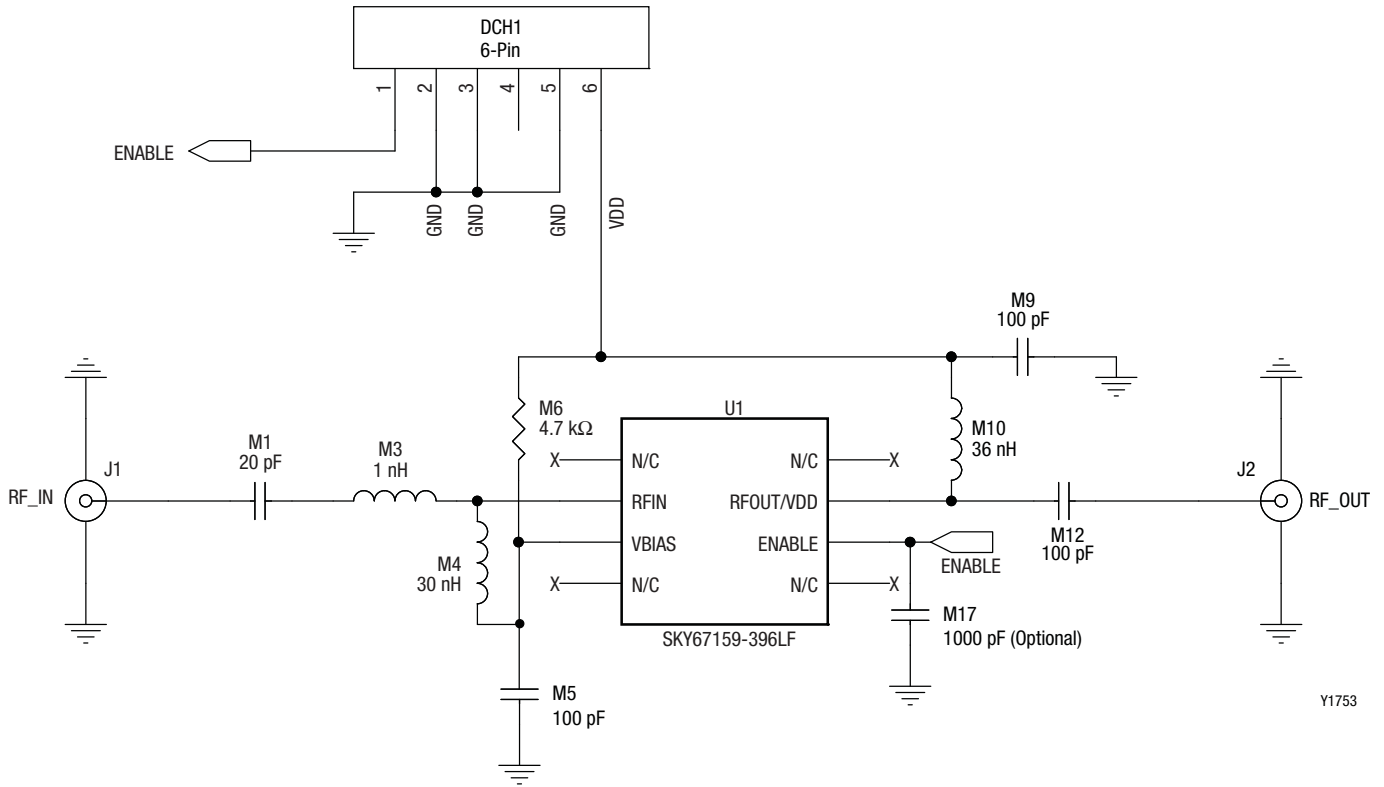


Figure 30. SKY67159-396LF Evaluation Board Schematic (Optimized for 700 to 2700 MHz)

Table 6. SKY67159-396LF Evaluation Board Bill of Materials (700 to 2700 MHz)

| Component | Description | Value | Size | Manufacturer | Mfr Part Number |
|---|-------------|--------|------|--------------|--------------------|
| M1 | Capacitor | 20 pF | 0402 | Murata GJM | GJM1555C1H200JB01 |
| M3 | Inductor | 1 nH | 0402 | Coilcraft HP | 0402HP-1N0XJL |
| M4 | Inductor | 30 nH | 0402 | Coilcraft HP | 0402HP-30NX_L_ |
| M5, M9, M12 | Capacitor | 100 pF | 0402 | Murata GRM | GRM1555C1H101JA01D |
| M6 (RBIAS) | Resistor | 4.7 kΩ | 0402 | Panasonic | ERJ-2RKF4701X |
| M10 | Inductor | 36 nH | 0402 | Coilcraft HP | 0402HP-36NX_L_ |
| M14, M16 | Jumper | 0 Ω | 0402 | Panasonic | ERJ-2GE0R00X |
| M2, M7, M8, M11, M13, M15, M17 ¹ | DNP | | | | |

¹ M17 is optional. It is only needed if the control signal is noisy.

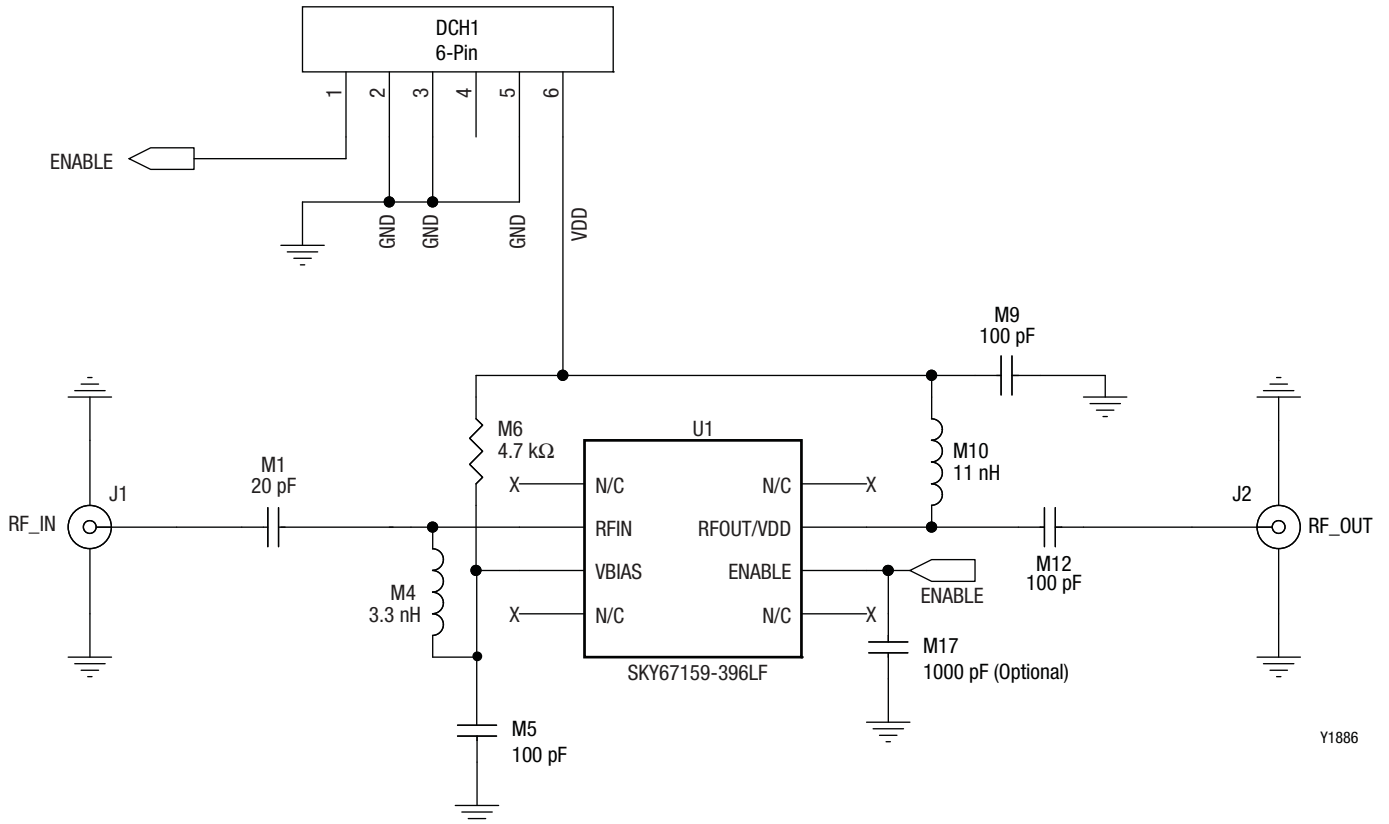


Figure 31. SKY67159-396LF Evaluation Board Schematic (Optimized for 3400 to 3800 MHz)

Table 7. SKY67159-396LF Evaluation Board Bill of Materials (3400 to 3800 MHz)

| Component | Description | Value | Size | Manufacturer | Part Number |
|---|-------------|--------|------|--------------|--------------------|
| M1 | Capacitor | 20 pF | 0402 | Murata GJM | GJM1555C1H200JB01 |
| M4 | Inductor | 3.3 nH | 0402 | Coilcraft HP | 0402HP-3N3X_L_ |
| M5, M9, M12 | Capacitor | 100 pF | 0402 | Murata GRM | GRM1555C1H101JA01D |
| M6 (RBIAS) | Resistor | 4.7 kΩ | 0402 | Panasonic | ERJ-2RKF4701X |
| M10 | Inductor | 11 nH | 0402 | Coilcraft HP | 0402HP-11NX_L_ |
| M3, M14, M16 | Jumper | 0 Ω | 0402 | Panasonic | ERJ-2GE0R00X |
| M2, M7, M8, M11, M13, M15, M17 ¹ | DNP | | | | |

¹ M17 is optional. It is only needed if the control signal is noisy.

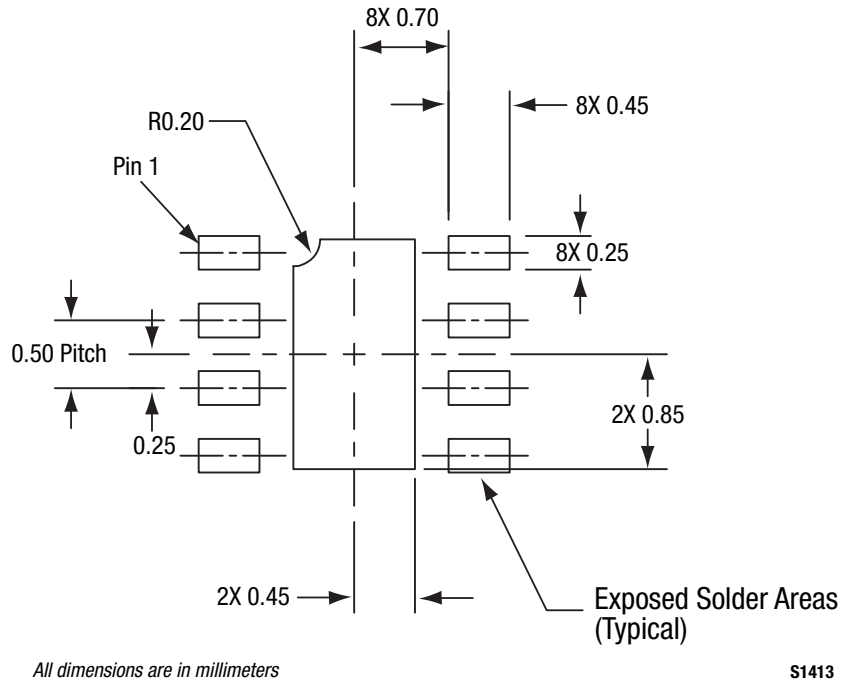


Figure 32. SKY67159-396LF PCB Layout Footprint (Top View)

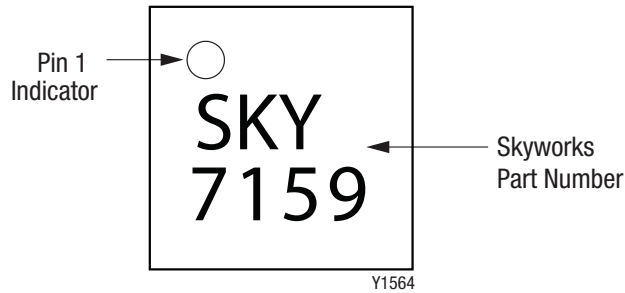
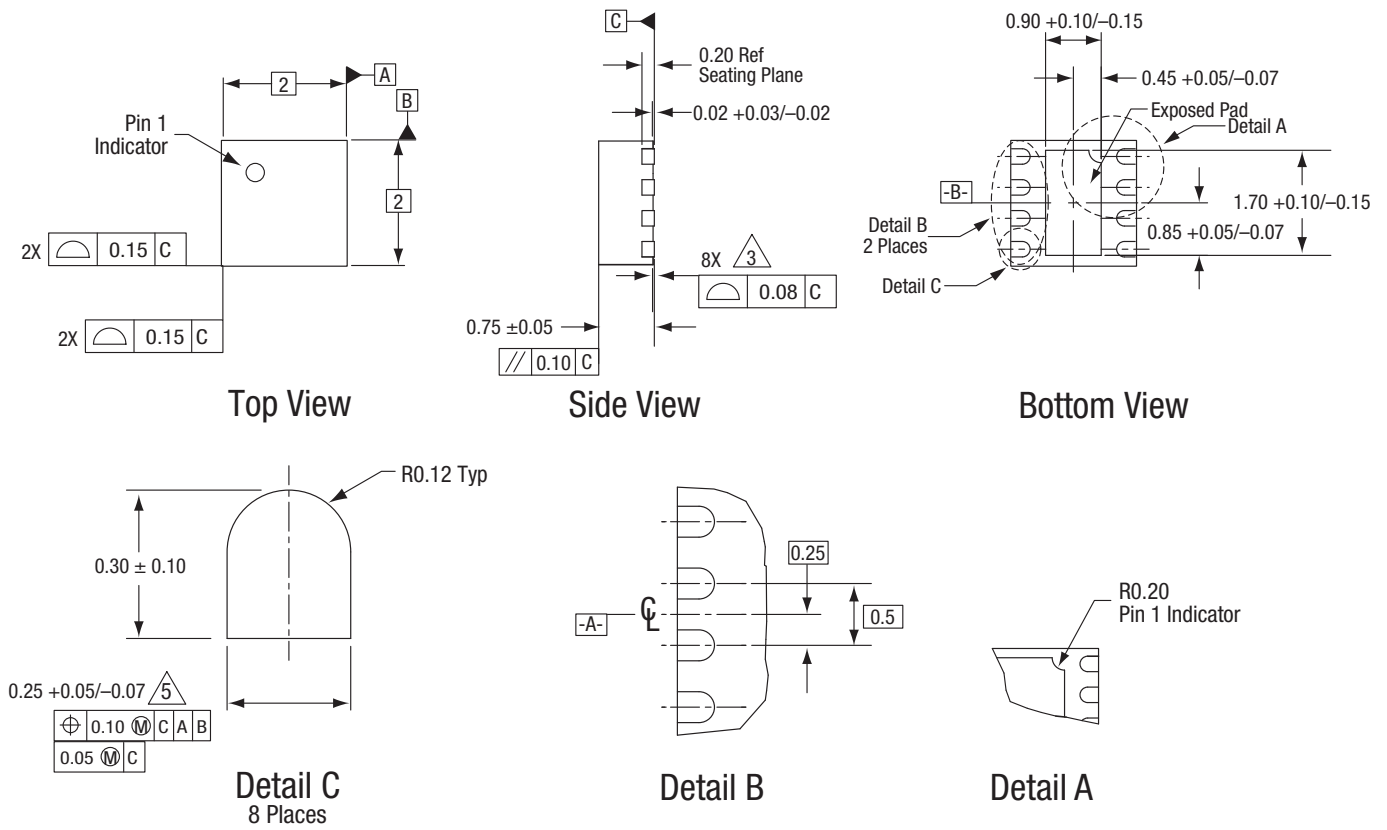


Figure 33. Typical Part Markings (Top View)

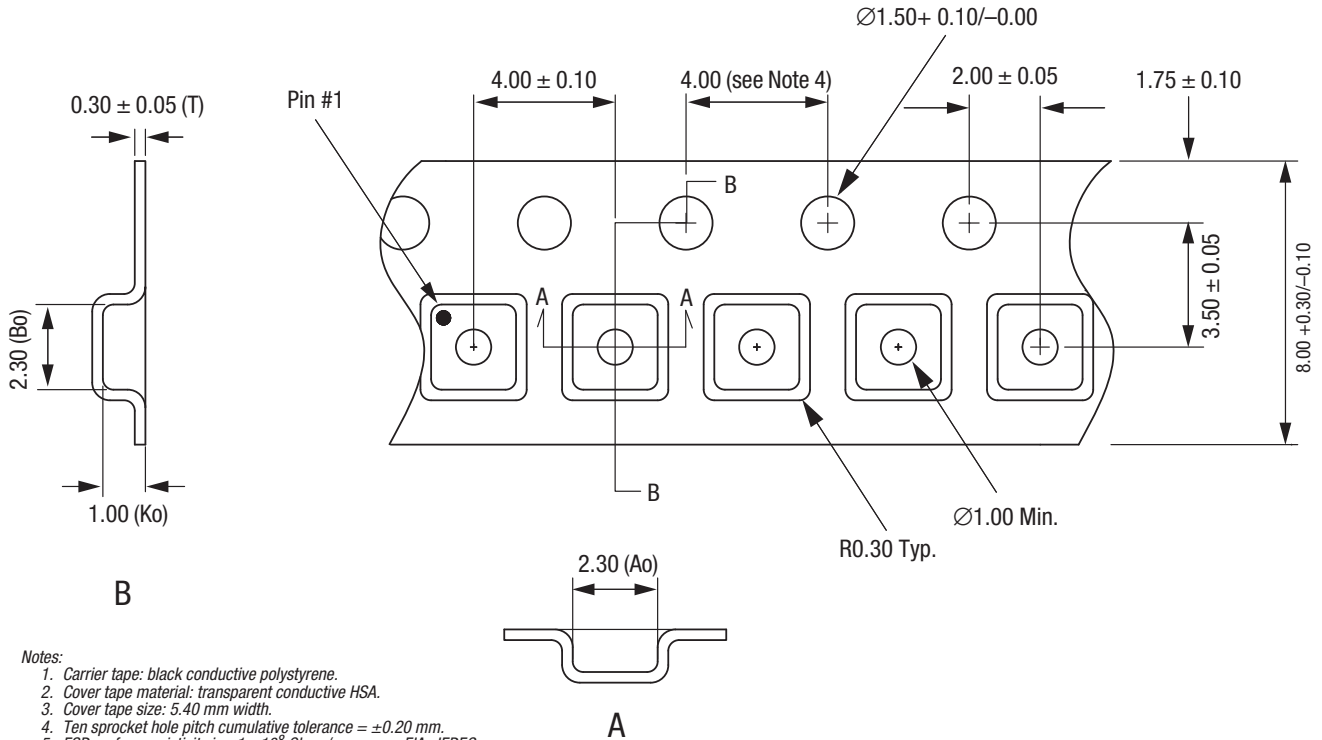


Notes:

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

Figure 34. SKY67159-396LF Package Dimensions

S1945



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 $\leq 1 \times 10^8$ 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.

S1601

Figure 35. SKY67159-396LF Tape and Reel Dimensions

Ordering Information

| Part Number | Product Description | Evaluation Board Part Number |
|--------------------|---|--|
| SKY67159-396LF LNA | 200 to 3800 MHz Broadband Low-Noise Amplifier | SKY67159-396EK1 (700 to 2700 MHz low frequency range) SKY67159-396EK2 (3400 to 3800 MHz next frequency range) |

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