

## DATA SHEET

# SKY65016-70LF: 0.1 to 3.0 GHz InGaP Cascadable Amplifier

## Applications

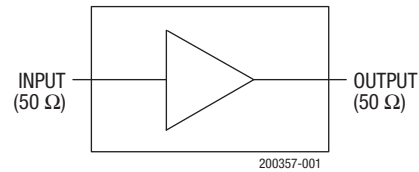
- Wireless infrastructure: WLAN, HLAN, DBS, broadband, cellular base stations
- Test instrumentation
- Cable television

## Features

- Broadband frequency range: 0.1 to 3.0 GHz
- Small signal gain = 20 dB typical @ 2 GHz
- High OIP3: +27 dBm typical
- OP1dB = +14 dBm typical @ 2 GHz
- Input and output impedance: 50  $\Omega$  nominal
- Single, positive DC supply voltage
- SOT-89 (4-pin, 1.5 x 4.0 mm) package (MSL1, 260 °C per JEDEC J-STD-020)



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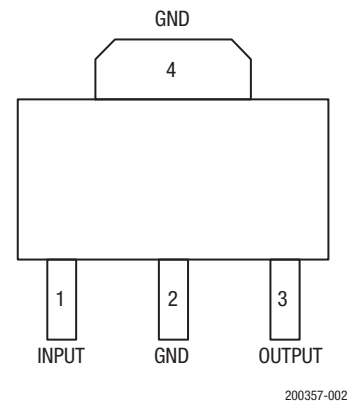
**Figure 1. SKY65016-70LF Functional Block Diagram**

## Description

Skyworks SKY65016-70LF is a general purpose, broadband amplifier. The device is fabricated from Skyworks InGaP HBT process and packaged in a miniature Small Outline Transistor (SOT-89) package.

The device's 50  $\Omega$  input and output impedance allow it to be easily cascaded without external impedance matching networks. The typical -3 dB bandwidth of the SKY65016-70LF is 0.1 to 3.0 GHz.

A functional block diagram is provided in Figure 1. The device package and pinout are shown in Figure 2.



**Figure 2. SKY65016-70LF Pinout (Top View)**

## Electrical and Mechanical Specifications

Signal pin assignments and functional pin descriptions are described in Table 1. The absolute maximum ratings of the SKY65016-70LF are provided in Table 2. Electrical specifications are provided in Table 3.

Typical performance characteristics of the SKY65016-70LF are illustrated in Figures 3 through 6.

**Table 1. SKY65016-70LF Signal Descriptions**

| Pin | Name   | Description   |
|-----|--------|---|
| 1   | INPUT  | RF input with 50 $\Omega$ nominal input impedance. An internally generated DC voltage is present at this pin, so an external DC block should be used to connect this pin to the external circuit.   |
| 2   | GND    | Ground  |
| 3   | OUTPUT | RF output. DC supply voltage input and RF output with 50 $\Omega$ nominal output impedance. The nominal voltage required at this pin is listed in Table 3. Supply current is determined by an external resistor connected between the DC power supply and this pin. |
| 4   | GND    | Ground  |

**Table 2. SKY65016-70LF Absolute Maximum Ratings<sup>1</sup>**

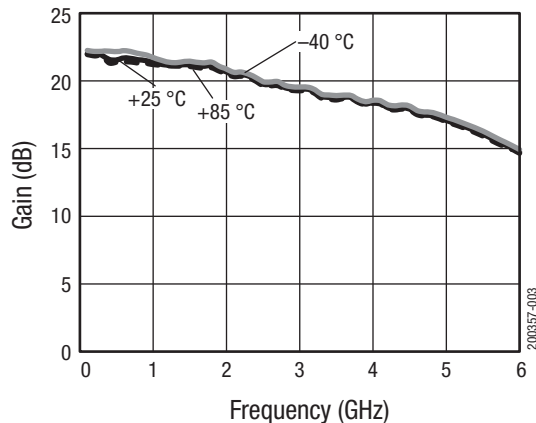
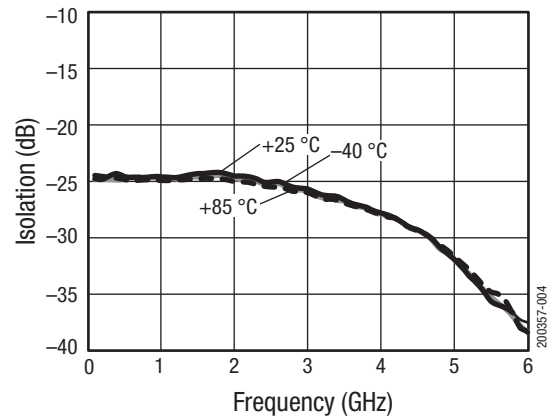
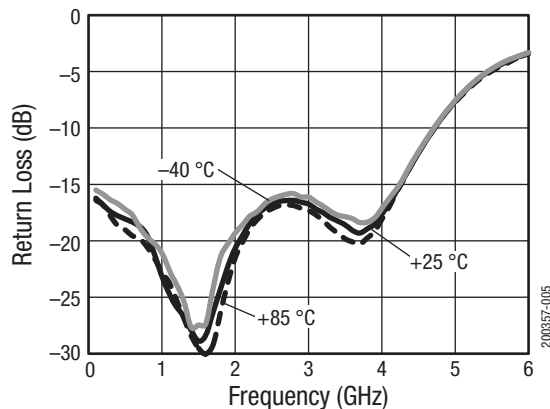
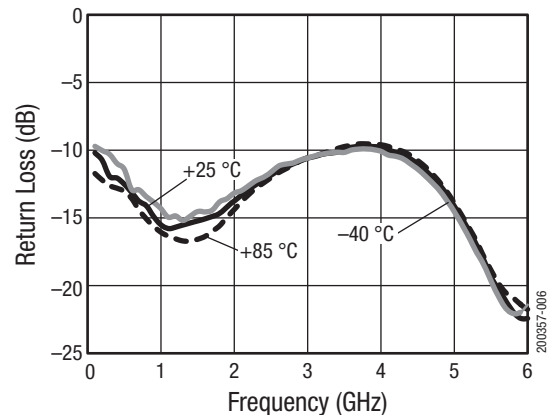
| Parameter                                  | Symbol          | Minimum | Maximum | Units |
|--|-----------------|---------|---------|-------|
| Supply voltage                             | V <sub>S</sub>  |         | 5       | V     |
| RF input power                             | P <sub>IN</sub> |         | +15     | dBm   |
| Supply current                             | I <sub>S</sub>  |         | 120     | mA    |
| Power dissipation @ T <sub>c</sub> = 25 °C | P <sub>D</sub>  |         | 500     | mW    |
| Operating case temperature                 | T <sub>C</sub>  | −40     | +85     | °C    |
| Storage temperature                        | T <sub>ST</sub> | −65     | +125    | °C    |
| Junction temperature                       | T <sub>J</sub>  |         | +150    | °C    |
| Thermal resistance                         | $\Theta_{JC}$   |         | 70      | °C/W  |
| Electrostatic discharge:                   | ESD             |         |         |       |
| Charged Device Model (CDM), Class III      |                 |         |         | 500   |
| Human Body Model (HBM), Class 1B           |                 |         |         | 500   |
| Machine Model (MM), Class A                |                 |         |         | 100   |

<sup>1</sup> 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 values. 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. SKY65016-70LF Electrical Specifications<sup>1</sup>****( $I_s = 40$  mA,  $T_c = 25$  °C,  $P_{IN} = -10$  dBm, Characteristic Impedance [ $Z_0$ ] = 50  $\Omega$ , Unless Otherwise Noted)**

| Parameter                        | Symbol            | Test Conditions   | Min | Typ       | Max   | Units |
|----------------------------------|-------------------|---|-----|-----------|-------|-------|
| Small signal gain                | S <sub>21</sub>   | @ 2 GHz   | 19  | 20        | 21    | dB    |
| 3 dB gain bandwidth              | BW <sub>3dB</sub> |   | 2.5 | 3.0       |       | GHz   |
| Noise Figure                     | NF                | @ 2 GHz   |     | 4.8       |       | dB    |
| 1 dB Output Compression Point    | OP1dB             | @ 2 GHz   | +13 | +14       |       | dBm   |
| Input and output VSWR            | VSWR              | 0.1 to 5.0 GHz  |     | 1.9:1     | 2.0:1 | –     |
| 3rd Order Output Intercept Point | OIP3              | @ 2 GHz,<br>$P_{IN} = 0$ dBm/tone,<br>$\Delta f = 10$ MHz |     | +27       |       | dBm   |
| Operating voltage                | $V_D$             | Measured @ pin 3  | 3.2 | 3.5       | 3.7   | V     |
| Reverse isolation                | S <sub>12</sub>   | 0.1 to 6.0 GHz  |     | 20        |       | dB    |
| Gain flatness                    |                   | 10 MHz to 3 GHz   |     | $\pm 1.5$ |       | dB    |

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.**Typical Performance Characteristics****( $I_s = 40$  mA, Characteristic Impedance [ $Z_0$ ] = 50  $\Omega$ , Unless Otherwise Noted)****Figure 3. Small Signal Gain vs Frequency****Figure 4. Isolation vs Frequency****Figure 5. Input Return Loss vs Frequency****Figure 6. Output Return Loss vs Frequency**

## Theory of Operation

The SKY65016-70LF is a Darlington feedback amplifier that features a constant gain-bandwidth product for use as an RF gain block. It uses a circuit topology where two transistors are combined to form a configuration known as a Darlington pair. This transistor pair behaves like a single transistor with a current gain equivalent to the product of the current gain of the two transistors. Darlington transistors are connected in an emitter-follower configuration, while sharing the same collector contact.

The current amplified by the first transistor is amplified further by the second. This gives a high current gain (written  $\beta$  or  $h_{FE}$ ), and takes less space than two discrete transistors in the same configuration. As RF gain blocks, Darlington pairs are offered as integrated packaged devices, usable DC to over 10 GHz. They exhibit good broadband matching into 50  $\Omega$  and tight performance distributions. The power supply for this amplifier should be a fixed current,  $I_s$ , rather than a fixed voltage. Due to the I-V characteristics of the base-emitter junction of each HBT, a small change in voltage or temperature can result in a large change in current. Therefore, it is better to supply the Darlington pair with a fixed current, rather than a fixed voltage to properly set the base voltages and the collector currents of each transistor in the Darlington pair. The values of resistors R2 and R3 are selected to set the base voltages and currents of the Darlington pair, as well as to establish the necessary feedback to set the input and output impedances of the amplifier.

## Evaluation Board Description

The Skyworks SKY65016-70LF Evaluation Board is used to test the performance of the SKY65016-70LF cascable amplifier. The Evaluation Board is shown in Figure 7. An Evaluation Board schematic is shown in Figure 8. Table 4 provides the Bill of Materials (BOM) for Evaluation Board components.

The input and output of the SKY65016-70LF are connected using 50  $\Omega$  microstrip transmission lines with DC blocking capacitors, C1 and C2, to the input and output SMA connectors, respectively.

The positive supply voltage,  $V_D$ , is connected to pin 3 (OUTPUT) of the amplifier using the decoupling network that consists of C4, L1, L2, and R1. The power supply current,  $I_s$ , must be limited

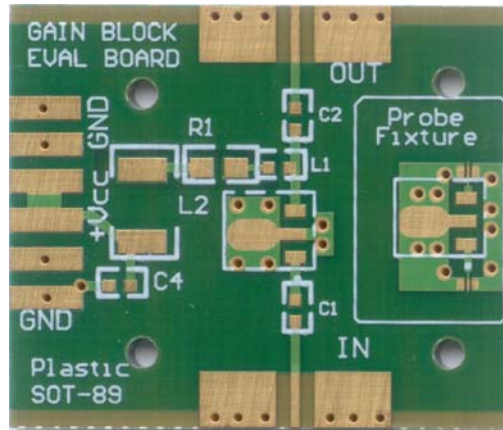
either by the current limit function of an external bench power supply or by replacing L3 with resistor R1, the value of which is given in shown in Table 5. The Evaluation Board is shipped with L3 in place, which shifts an in-band series resonance of the supply decoupling network out of band. For low frequency applications, R1 may be used to conveniently limit supply current on the Evaluation Board.

The Evaluation Board also contains a probe fixture that facilitates the direct measurement of the S-parameters. The probe fixture comprises a very short Co-Planar Waveguide (CPW) transmission line to pin 1 and an identical line to pin 3. The other two pins of the amplifier are grounded. The CPW transmission lines are compatible with ground-signal-ground wafer probe tips, which can be connected to the RF ports of a Vector Network Analyzer (VNA) using coaxial cables. The very small electrical length of these CPW transmission lines obviates the need to de-embed their effects from the S-parameters that are measured. The supply constant current must be applied using the bias tee, which is typically integrated into the VNA, and cascaded with the OUTPUT pin of the amplifier.

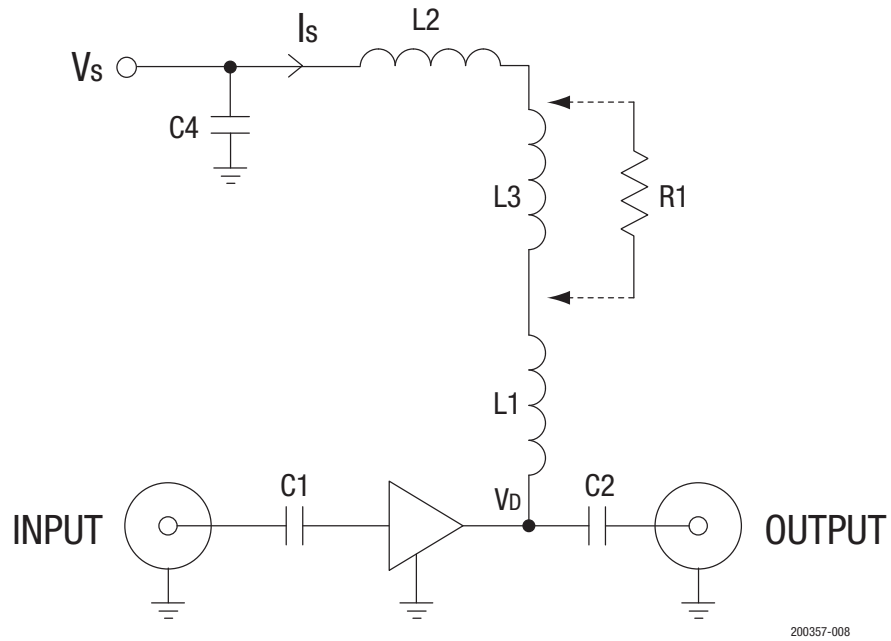
## Evaluation Board Test Procedure

Use the following procedure to set up the SKY65016-70LF Evaluation Board for testing:

1. Option 1: Connect a 70 mA current supply to  $V_s$ . ( $V_s$  is labeled “Vcc” on the Evaluation Board)
- Option 2: Connect a 5 V voltage supply to  $V_s$ , use the appropriate R1 value to set the supply current limit to 70 mA. See Current Limiting Resistor Values tables for other values of  $V_s$ .
2. Connect a signal generator to the RF signal input port. Set it to the desired RF frequency at a power level of -15 dBm or less to the Evaluation Board but do NOT enable the RF signal.
3. Connect a spectrum analyzer to the RF signal output port.
4. Enable the power supply.
5. Enable the RF signal.
6. Take measurements.



**Figure 7. SKY65016-70LF Evaluation Board**



**Figure 8. SKY65016-70LF Evaluation Board Schematic**

**Table 4. SKY65016-70LF Evaluation Board Bill of Materials (BOM)**

| Component  | Value         | Size | Part Number      | Manufacturer |
|------------|---------------|------|------------------|--------------|
| C1, C2, C4 | 47 nF         | 0603 | GRM188R71E473K   | Murata       |
| L1         | 33 nH         | 0603 | 0603CS-33NX_LU   | Coilcraft    |
| L2         | 1600 $\Omega$ | 1810 | FBMH4525HM162N-T | Taiyo-Yuden  |
| L3         | 110 nH        | 0805 | 0805CS-111X_L    | Coilcraft    |
| R1         | See Table 5   | 0603 | Variable         | Variable     |

**Table 5. Current Limiting Resistor Values**

| Supply Voltage<br>Vs (V) | Value of R1<br>( $\Omega$ ) | Minimum Power Dissipation Rating<br>(mW) |
|--------------------------|-----------------------------|--|
| 4.0                      | 13                          | 125                                      |
| 4.6                      | 28                          | 125                                      |
| 5.0                      | 38                          | 125                                      |
| 6.0                      | 63                          | 125                                      |
| 8.0                      | 113                         | 250                                      |
| 9.0                      | 138                         | 500                                      |
| 10.0                     | 163                         | 500                                      |
| 12.0                     | 213                         | 500                                      |

## Package Dimensions

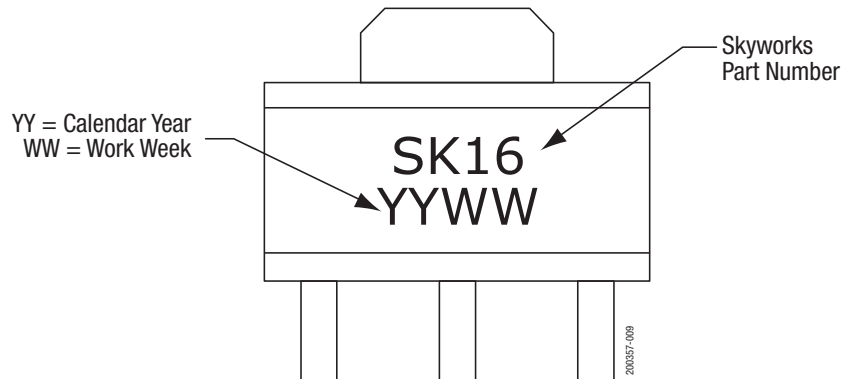
Typical part markings for the SKY65016-70LF are shown in Figure 9. The PCB layout footprint for the SKY65016-70LF is provided in Figure 10. Package dimensions are provided in Figure 11, and tape and reel dimensions are shown in Figure 12.

## Package and Handling Information

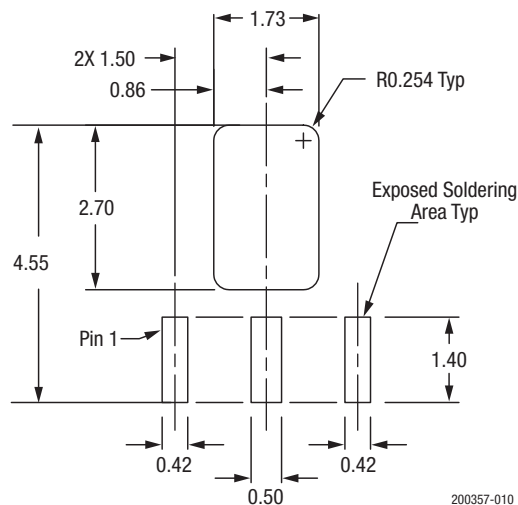
Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The SKY65016-70LF 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.

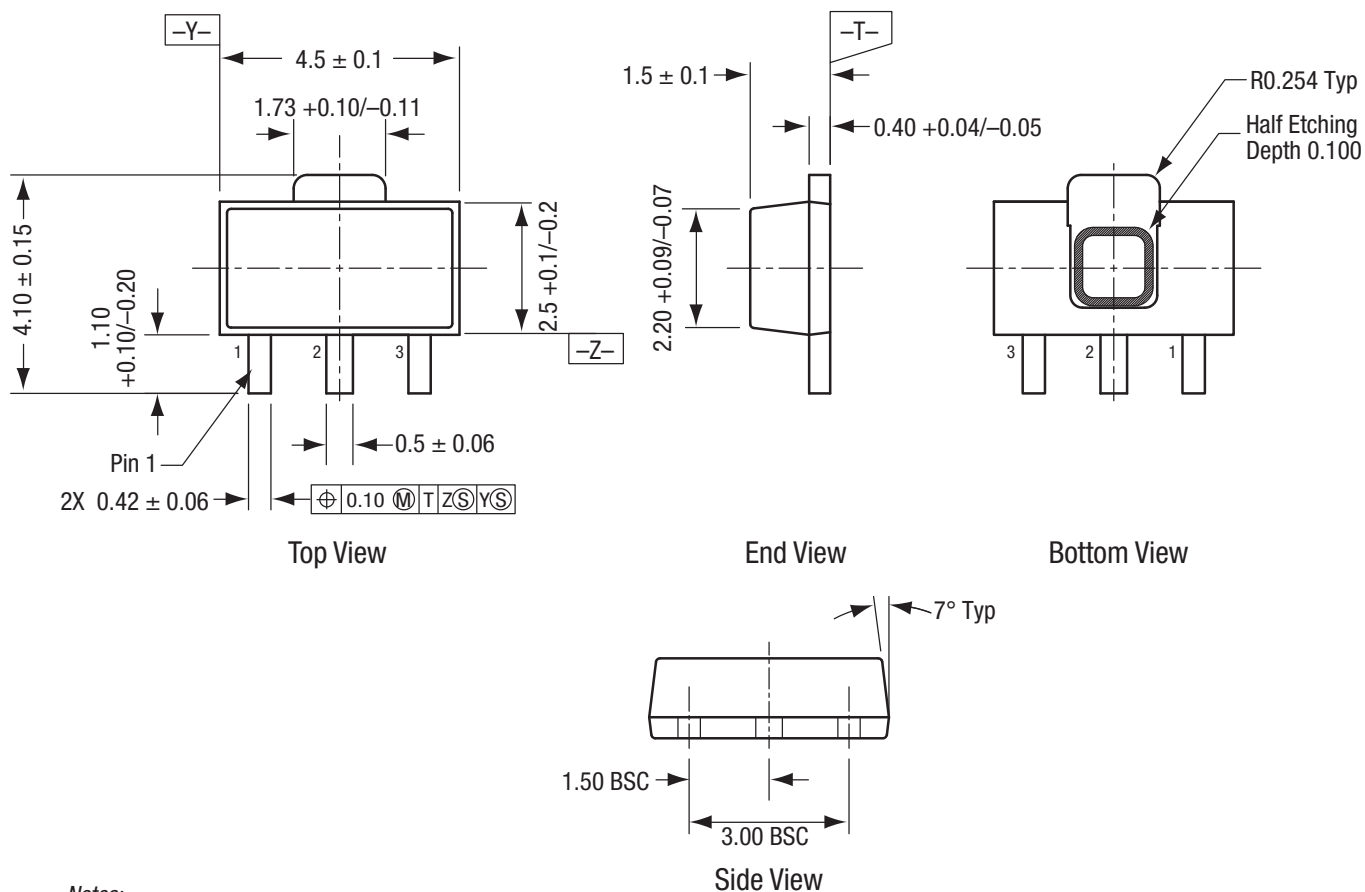
Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format.



**Figure 9. SKY65016-70LF Typical Part Markings**



**Figure 10. SKY65016-70LF PCB Layout Footprint**



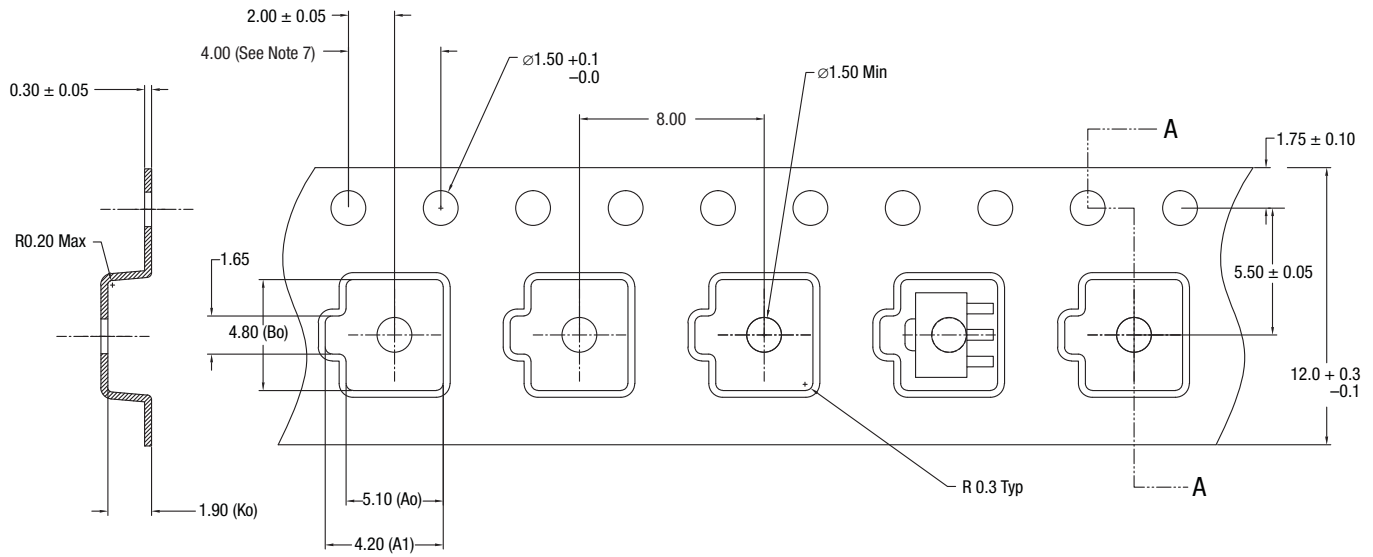
Notes:

1. All measurements are in millimeters.
2. Dimensions and tolerances according to ASME Y14.5M-1994.
3. Package dimension does not include mold protrusions or gate burrs.  
Mold protrusions and gate burrs do not exceed 0.005" per end.  
Body width dimension does not include interlead mold protrusions.  
Interlead protrusions do not exceed 0.005" per side.
4. Leadwidth dimension does not include dambar protrusions.  
Allowable protrusion does not exceed 0.002" total in excess of lead width dimension at maximum material condition.

200357-011

Figure 11. SKY65016-70LF Package Dimensions





Notes:

1. Carrier tapes must meet all requirements of Skyworks GP01-D233 procurement spec for tape and reel shipping.
2. Carrier tape material: black conductive polycarbonate or polystyrene.
3. Cover tape material: transparent conductive PSA.  
Cover tape size: 9.2 mm width.
4. Typical ESD surface resistivity must meet all ESD requirements of Skyworks specified in GP01-D233.
5. Ao and Bo measurement point to be 0.30 mm from bottom pocket.
6. All measurements are in millimeters.
7. 10-sprocket hole pitch cumulative tolerance 0.2 mm.

200357-012

**Figure 12. SKY65016-70LF Tape and Reel Dimensions**

## Ordering Information

| Model Name                        | Ordering Part Number | Evaluation Board Part Number |
|-----------------------------------|----------------------|------------------------------|
| SKY65016-70LF Low-Noise Amplifier | SKY65016-70LF        | SKY65016-70EK1               |

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