



SKY16602-632LF: 0.2 to 4.0 GHz Low-Threshold PIN Diode Limiter

Applications

- Cellular infrastructure
- WLAN, WiMAX
- Receiver LNA protection
- Test instruments

Features

- Optimized for 0.2 to 4.0 GHz operation
- Low limiting threshold (+5 dBm typical)
- Low insertion loss
- Low distortion
- Integrated PIN limiter, Schottky diodes, and DC blocks
- Dual Flat No Lead (DFN), 2-pin, 2.3 x 2.3 mm Pb-free package, (MSL1, 260 °C per JEDEC J-STD-020)

Description

The SKY16602-632LF is a fully-integrated PIN diode low-threshold limiter module in a surface-mount package. It is designed for use as a passive receiver protector in wireless or other RF systems for frequencies up to 4 GHz. It features a low limiting threshold, low-insertion loss, and low distortion in a DFN package.

The SKY16602-632LF is comprised of a PIN limiter diode, a Schottky diode, and two DC blocking capacitors at the RF ports.

The small package design reduces printed circuit board area. The module can be tuned using external surface mount technology (SMT) components for optimal narrow band performance over the 0.2 to 4.0 GHz operating range.

The module can operate over the temperature range of -40 °C to +125 °C.

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.

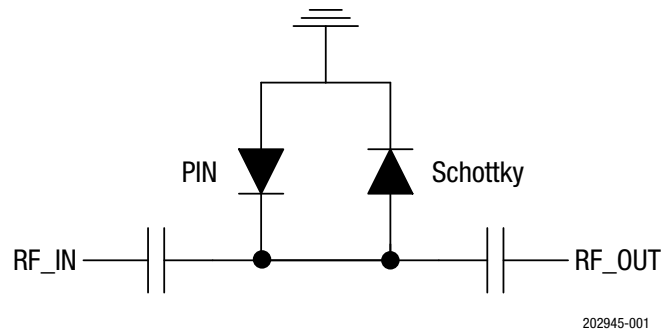


Figure 1. SKY16602-632LF Block Diagram



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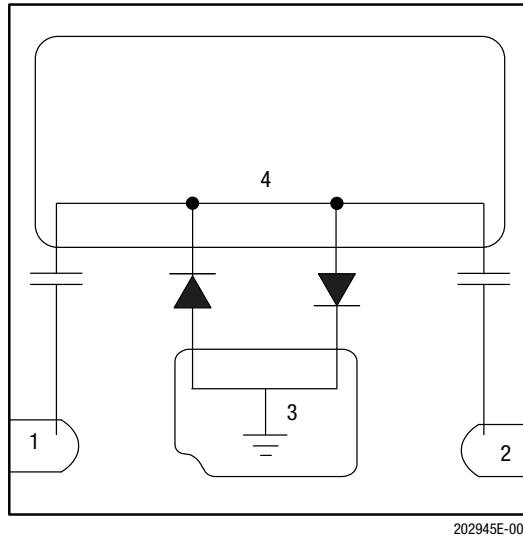


Figure 2. SKY16602-632LF Pinout (Top View)

Table 1. SKY16602-632LF Signal Descriptions

| Pin | Name | Description |
|-----|--------|--|
| 1 | RF_IN | RF input, AC coupled |
| 2 | RF_OUT | RF output, AC coupled |
| 3 | GND | Must be connected to chassis ground |
| 4 | PAD | Exposed pad (must be isolated from ground) |

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY16602-632LF are provided in Table 2. Electrical specifications for the un-tuned limiter module are provided in Table 3, and typical performance characteristics start at Figure 4. Electrical specifications for the 2.45 GHz tuned limiter module are provided in Table 4.

Figure 8 shows the power de-rating curve for the limiter. The temperature is referenced to the bottom of the DFN package.

Table 2. SKY16602-632LF Absolute Maximum Ratings¹

| Parameter | Symbol | Minimum | Maximum | Unit |
|--|------------------|---------|--------------------|-------------|
| RF input power (CW) at TCASE = 120°C, without external tune | P _{IN} | | 1 | W |
| RF input power (1 ms pulse, 10% duty cycle) at TCASE = 120°C, without external tune | P _{IN} | | 10 | W |
| CW power dissipation at TCASE = 120°C | P _{DIS} | | 0.4 | W |
| Storage temperature | T _{STG} | -65 | +150 | °C |
| Operating temperature | T _{OP} | -40 | +125 | °C |
| Electrostatic discharge: Charged-Device Model (CDM), Class 4 Human Body Model (HBM), Class 1B Machine Model (MM), Class A | ESD | | 1000 250 150 | V V 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: Industry-standard ESD handling precautions must be adhered to at all times to avoid damage to this device.

Table 3. SKY16602-632LF Electrical Specifications (Untuned Circuit, Reference Figure 1)

(T_{OP} = 25 °C, Z_O = 50 Ohms, as Measured on Skyworks Evaluation Board Optimized for 0.2 to 4.0 GHz, Unless Otherwise Noted)

| Parameter | Symbol | Condition | Frequency | Min | Typ | Max | Units |
|---------------------------------------|--------------------|------------------|-----------|-----|-----|-----|-------|
| Reverse voltage | V _R | | | | | 20 | V |
| Forward current | I _F | | | | | 50 | mA |
| Insertion loss | I _L | PIN = 0 dBm | 0.90 GHz | | 0.3 | 0.5 | dB |
| Return loss | R _L | PIN = 0 dBm | 0.90 GHz | | 14 | | dB |
| Threshold level | TL | P1dB | 0.90 GHz | 5.3 | 6.0 | 6.7 | dBm |
| Saturated CW input power ¹ | P _{IN_CW} | | 0.90 GHz | | 30 | | dBm |
| Flat leakage power ² | F _L | PIN = +10 dBm | 0.90 GHz | | 6 | | dBm |
| Recovery time ³ | t _R | | 0.90 GHz | | 5 | | ns |
| Thermal resistance | Θ _{JC} | Junction-to-case | | | 55 | | °C/W |

1. Saturated CW input power is defined as the point where the diode series resistance does not change with the rectified current. As the input power increases past this point, output power will increase until the diode reaches its max power limit.
2. Flat leakage power is defined as the power level after the limiter has fully turned on and the output pulse reaches a constant level.
3. Recovery time represents the transition time from the high-loss to low-loss state following the removal of high-power input. RF pulse modulation: 1 ms pulse width and 0.1% duty factor.

Theory of Operation

A limiter prevents overload by allowing RF signals that are below a certain threshold to pass through, but larger signals exceeding the threshold are increasingly attenuated. The SKY16602-632LF has a lower threshold level over a traditional self-bias limiter circuit with an inductor for a ground return. It accomplishes this by adding a basic PIN limiter diode (pin 1) in parallel to a Schottky diode (pin 2). The low turn on voltage of the Schottky diode reduces the threshold level while the PIN limiter diode protects the Schottky diode at higher power levels. Therefore, for maximum RF power handling, the RF input signal is required to be connected to Pin 1. The two internal DC input/output capacitors provide DC blocking needed for most applications.

Tuned Circuit

The module may be RF tuned for optional RF match and insertion loss centered at a target frequency within its normal band of operation. This is done with the use of external surface mount components. The schematic diagram in Figure 3 shows the SKY16602-632LF limiter with a shunt connected capacitor and inductor tuned for 2.45 GHz. The Bill of Materials for the 2.45 GHz tuned circuit is shown in Table 4.

Electrical specifications for the 2.45 GHz tuned limiter module are provided in Table 5.

For additional target frequencies, refer to Table 6 for inductor and capacitor values.

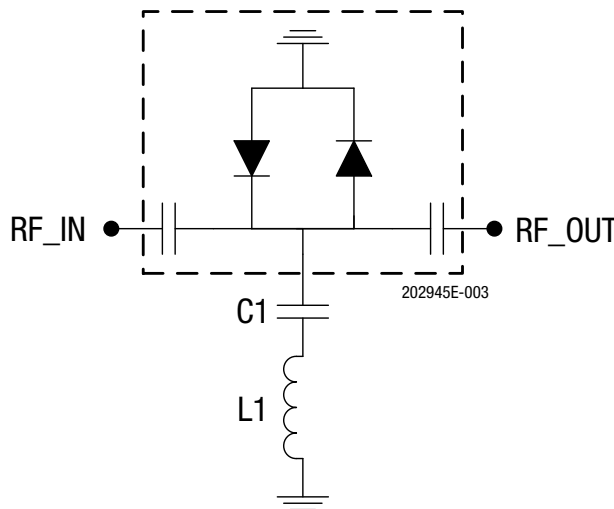


Figure 3. SKY16602-632LF with External Tuning Networks Optimized for 2.45 GHz

Table 4. Evaluation Board Bill of Materials for EN33-D946-001 (2.45 GHz Tuned Circuit)

| Component | Value | Size | Manufacturer | Mfr. Part Number | Characteristics |
|-----------|--------|------|--------------|------------------|------------------|
| C1 | 15 pF | 0402 | Murata | GRM1555C1H150J | COG, 50 V |
| L1 | 2.2 nH | 0402 | Taiyo Uden | HK10052N2S | 300 mA, R = 0.13 |

Table 5. SKY16602-632LF Electrical Specifications (Tuned to 2.45 GHz Operation, Reference Figure 3)
 ($T_{OP} = 25\text{ }^{\circ}\text{C}$, $Z_0 = 50\text{ Ohms}$, as Measured on Skyworks Evaluation Board Optimized for 2.45 GHz, Unless Otherwise Noted)

| Parameter | Symbol | Condition | Frequency | Min | Typ | Max | Units |
|---------------------------------------|---------------|--------------------------------------|-----------|-----|-----|-----|-----------------------------|
| Insertion loss | I_L | PIN= 0 dBm | 2.45 GHz | | 0.5 | | dB |
| Return loss | R_L | PIN= 0 dBm | 2.45 GHz | | 25 | | dB |
| Threshold level | T_L | P1dB | 2.45 GHz | | 5 | | dBm |
| Saturated CW input power ¹ | P_{IN_CW} | | 2.45 GHz | | 23 | | dBm |
| Flat leakage power ² | F_L | PIN = +10 dBm | 2.45 GHz | | 4 | | dBm |
| Input third order intercept | IIP3 | PIN = -10 dBm/tone, spacing = 10 MHz | 2.45 GHz | | 21 | | dBm |
| Recovery time ³ | t_R | | 2.45 GHz | | 5 | | ns |
| Thermal resistance | θ_{JC} | Junction to case | | | 55 | | $^{\circ}\text{C}/\text{W}$ |

1. Saturated CW input power is defined as the point where the diode series resistance does not change with the rectified current. As the input power increases past this point, output power will increase until the diode reaches its max power limit.
2. Saturated CW input power is defined as the point where the diode series resistance does not change with the rectified current. As the input power increases past this point, output power will increase until the diode reaches its max power limit.
3. Recovery time represents the transition time from the high-loss to low-loss state following the removal of high-power input. RF pulse modulation: 1 s pulse width and 0.1% duty factor.

Table 6. Bill of Materials for EN33-D946-001 Tuned Circuit

| Frequency (GHz) | L (nH) | C (pF) | Frequency (GHz) | L (nH) | C (pF) | Frequency (GHz) | L (nH) | C (pF) |
|-----------------|--------|--------|-----------------|--------|--------|-----------------|--------|--------|
| 1.06 | 12 | 15 | 1.55 | 5.6 | 10 | 2.50 | 1.8 | 15 |
| 1.16 | 12 | 4.7 | 1.57 | 6.8 | 4.7 | 2.60 | 1.8 | 9 |
| 1.22 | 10 | 15 | 1.68 | 4.7 | 47 | 2.90 | 1.5 | 5.6 |
| 1.22 | 10 | 12 | 1.70 | 4.7 | 22 | 2.95 | 1.5 | 5 |
| 1.23 | 10 | 12 | 1.75 | 4.7 | 10 | 3.05 | 1.4 | 5 |
| 1.29 | 10 | 10 | 1.85 | 4.7 | 5.6 | 3.50 | 1 | 4.7 |
| 1.35 | 9 | 10 | 1.90 | 4.7 | 4.7 | 3.63 | 1 | 3.6 |
| 1.40 | 8 | 13 | 2.40 | 2 | 15 | 4.30 | 0.7 | 1.8 |
| 1.45 | 6.8 | 10 | 2.45 | 2.2 | 15 | 4.50 | 0.3 | 1.8 |

Typical Performance Characteristics, $T_{OP} = 25\text{ }^{\circ}\text{C}$, Characteristic Impedance = 50 Ohms

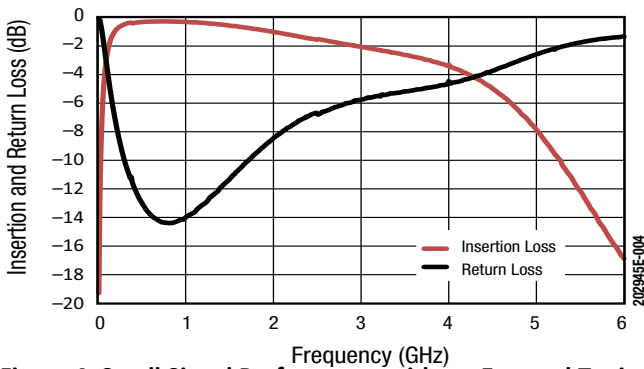


Figure 4. Small Signal Performance without External Tuning

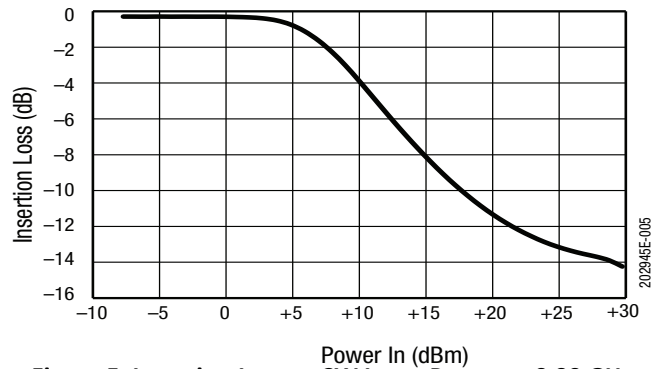


Figure 5. Insertion Loss vs CW Input Power at 0.90 GHz without External Tuning

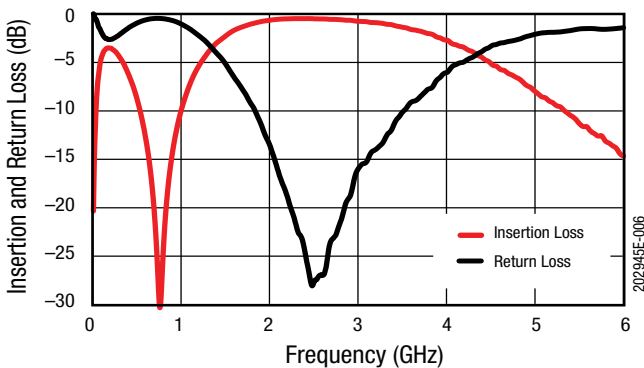


Figure 6. Small Signal Performance Optimized for 2.45 GHz

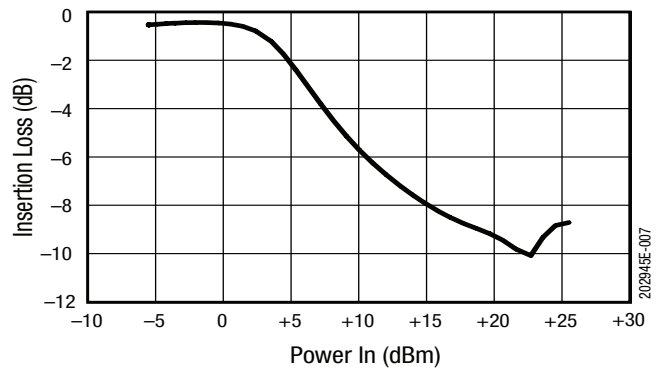


Figure 7. Insertion Loss vs CW Input Power at 2.45 GHz (Tuned Circuit)

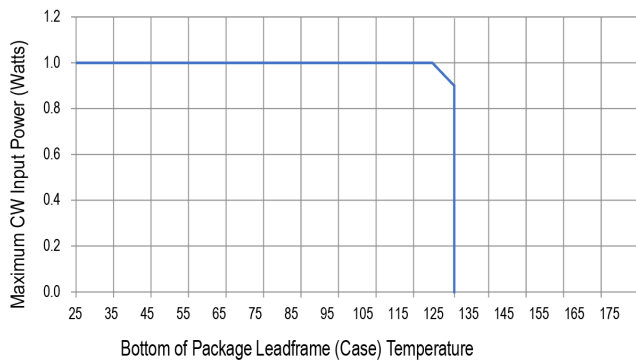


Figure 8. Power Derating Curve ($P_{diss} = 0.95\text{ W}$) vs Temperature on Bottom of Package Leadframe Without External Tune

Evaluation Board Description

Evaluation Boards are used to test the performance of the SKY16602-632LF limiter. Assembly drawings for the Evaluation Boards are shown in Figures 9 and 10. The Evaluation Board layer detail is provided in Figure 11.

Package Dimensions

The PCB layout footprint for the SKY16602-632LF is shown in Figure 12. Typical part markings are noted in Figure 13. Package dimensions are shown in Figure 14, and tape and reel dimensions are provided in Figure 15.

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 SKY16602-632LF 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.

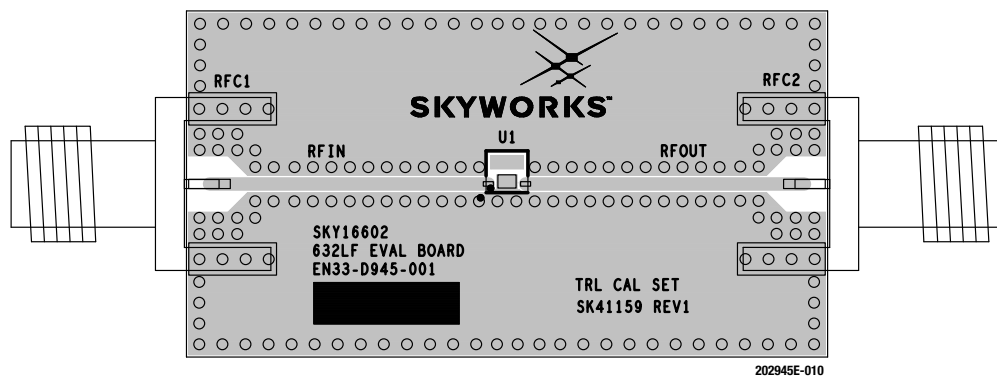


Figure 9. SKY16602-632LF Evaluation Board Assembly Diagram

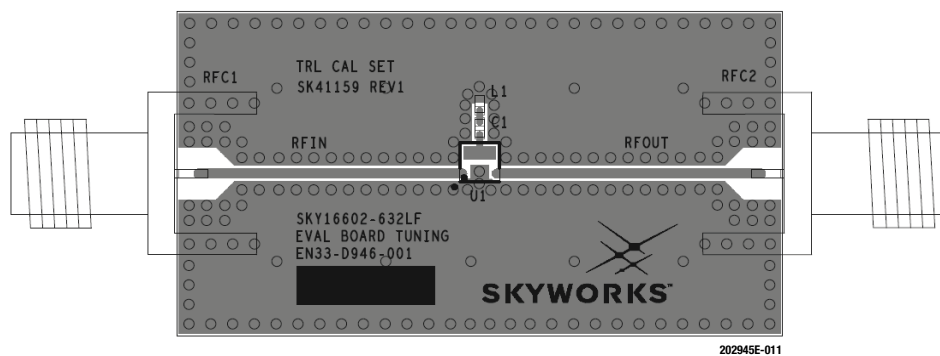


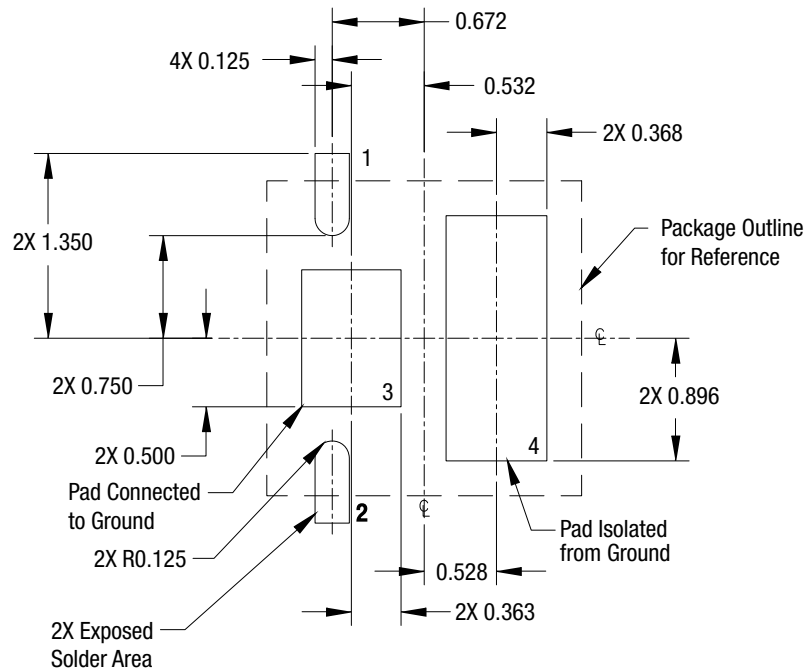
Figure 10. SKY16602-632LF Evaluation Board Assembly Diagram (Tuned Circuit)

| Cross Section | Name | Thickness (in) | Material |
|---------------|--------------------|----------------|---------------------|
| | Top Solder mask | | |
| | L1 | (0.0028) | Cu foil |
| | Laminate | 0.012 ± 0.0006 | Rogers R04003C Core |
| | L2 | (0.0014) | Cu foil |
| | Laminate | (Note 1) | FR4 Prepreg |
| | L3 | (0.0014) | Cu foil |
| | Laminate | 0.010 ± 0.0006 | FR4 Core |
| | L4 | (0.0028) | Cu foil |
| | Bottom Solder mask | | |

Note 1: Adjust this thickness to meet total thickness goal of 0.062 ± 0.005 inches.

202945E-012

Figure 11. SKY16602-632LF Board Layer Detail



All dimensions are in millimeters

202945E-013

Figure 12. SKY16602-632LF PCB Layout Footprint

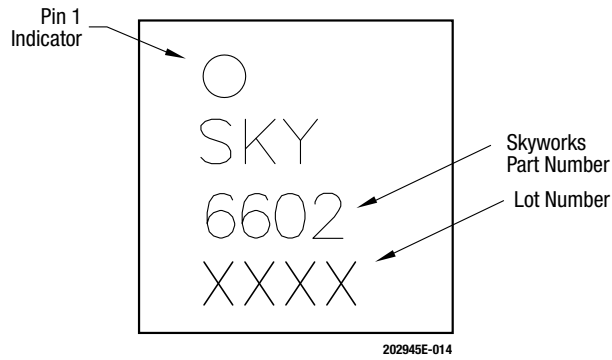
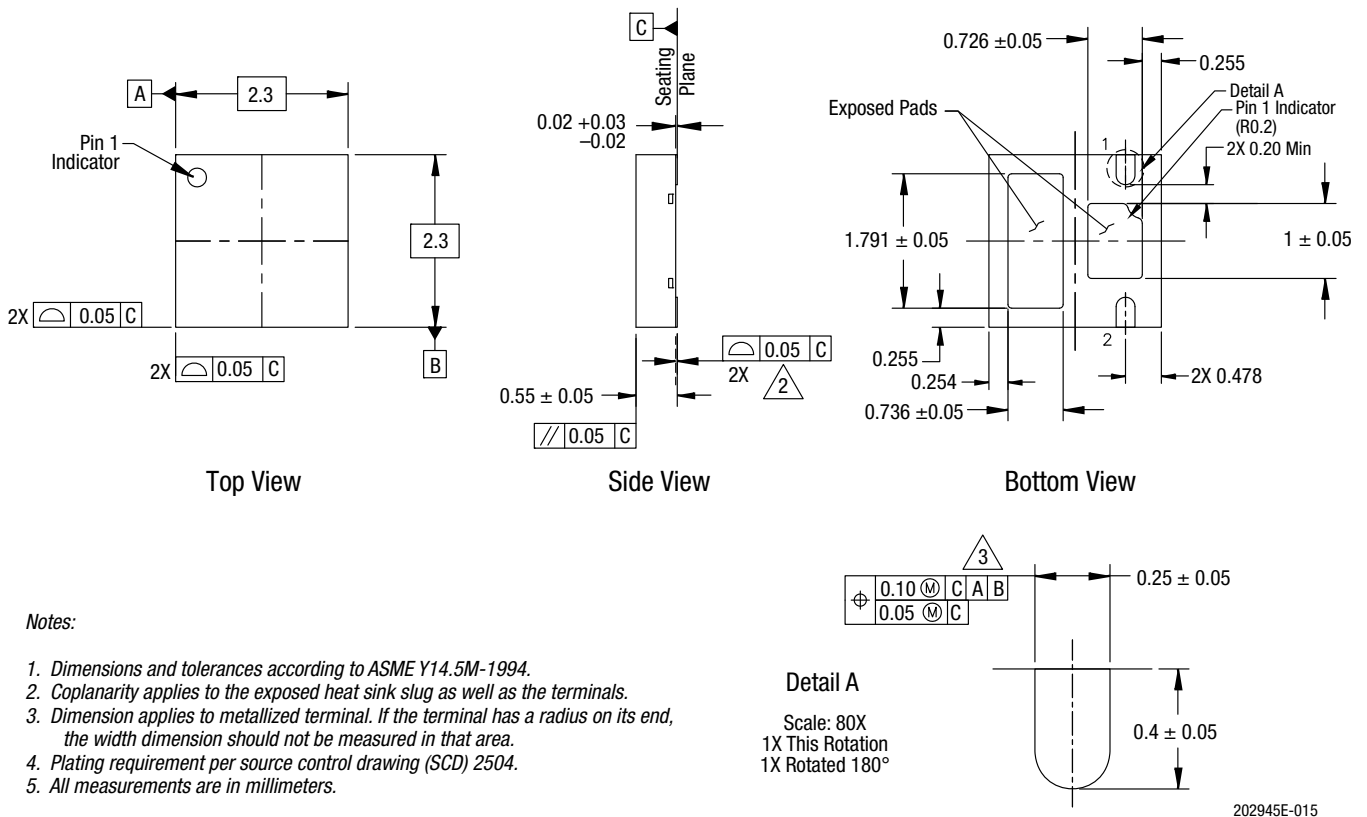


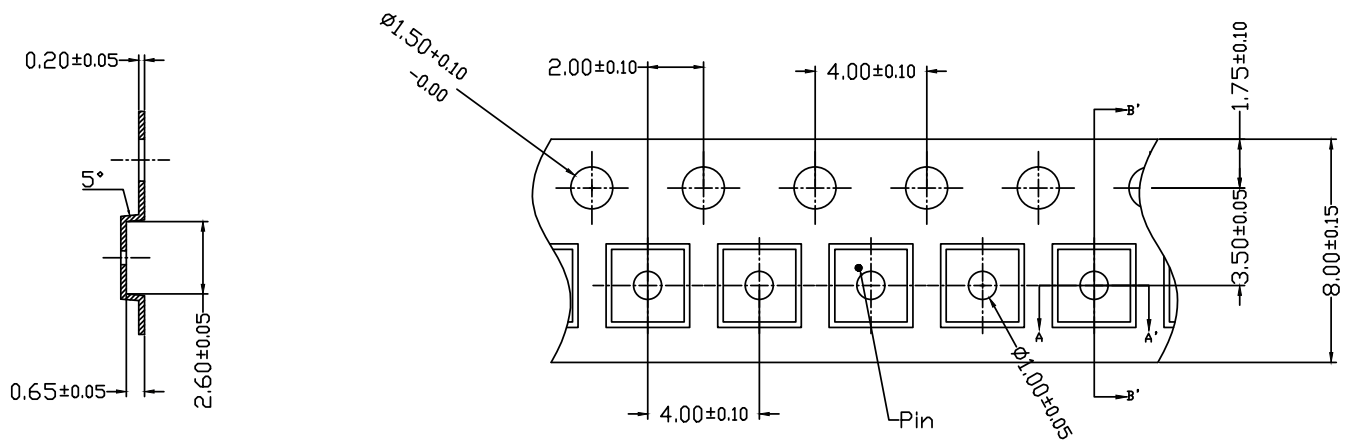
Figure 13. SKY16602-632LF Typical Part Marking



Notes:

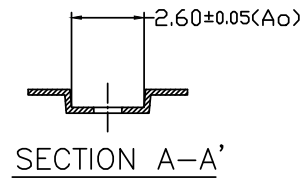
1. Dimensions and tolerances according to ASME Y14.5M-1994.
2. Coplanarity applies to the exposed heat sink slug as well as the terminals.
3. Dimension applies to metallized terminal. If the terminal has a radius on its end, the width dimension should not be measured in that area.
4. Plating requirement per source control drawing (SCD) 2504.
5. All measurements are in millimeters.

Figure 14. SKY16602-632LF Package Dimensions



SECTION B-B'

1. CARRIER TAPE MUST MEET ALL SKYWORKS REQUIREMENTS OF GP01-D233 PROCUREMENT SPEC FOR TAPE AND REEL
- ② CARRIER TAPE SHALL BE BLACK CONDUCTIVE POLYCARBONATE NON BAKEABLE.
3. COVER TAPE SHALL BE TRANSPARENT CONDUCTIVE MATERIAL
4. ESD-SURFACE RESISTIVITY SHALL MEET GP01-D233
5. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE : $\pm 0.20\text{mm}$
6. A_0 & B_0 MEASURED ON PLANE 0.30mm ABOVE THE BOTTOM OF THE POCKET.
7. ALL DIMENSIONS ARE IN MILLIMETERS.



SECTION A-A'

202945E-016

Figure 15. SKY16602-632LF Tape and Reel Dimensions

Ordering Information

| Part Number | Part Description | Evaluation Board Part Number |
|----------------|---|------------------------------|
| SKY16602-632LF | Low-Threshold PIN Diode Limiter EVB | SKY16602-632EK1 |
| | Low-Threshold PIN Diode Limiter Tunable EVB | SKY16602-632EK2 |

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