

SKY12348-350LF: 0.1-3.0 GHz Four-Bit Digital Attenuator (1 dB LSB)

Applications

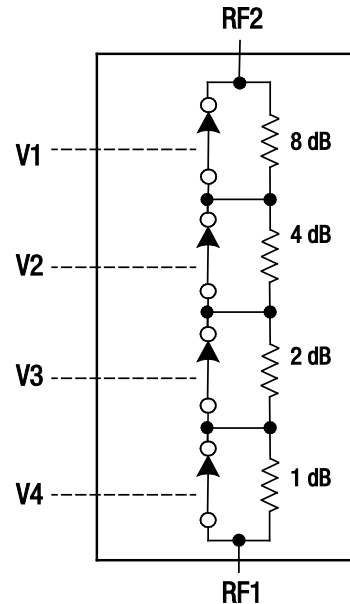
- Cellular, 3G/4G, WiMAX, and LTE Infrastructures
- RF and IF systems

Features

- Broadband operation: 0.1 to 3.0 GHz
- Attenuation: 15 dB with 1 dB LSB
- +5 V supply voltage and +3.3 V control voltage
- Small, QFN (16-pin, 3 x 3 mm) package (MSL1, 260 °C per JEDEC J-STD-020)



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S2242

Figure 1. SKY12348-350LF Block Diagram

Description

The SKY12348-350LF is a GaAs pHEMT four-bit broadband digital attenuator with a 1 dB Least Significant Bit (LSB). The attenuator features low insertion loss, excellent attenuation accuracy, a 15 dB attenuation range, and high linearity performance. The SKY12348-350LF is an ideal choice for a wide variety of cellular 3G and 4G infrastructure applications.

Attenuation is controlled by four DC control pins (V1, V2, V3, and V4). Depending on the control bias, the attenuation state between the RF1 and RF2 pins can vary between a low insertion loss state or up to 15 dB.

The device is provided in a 3 x 3 mm, 16-pin Quad Flat No-Lead (QFN) 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.

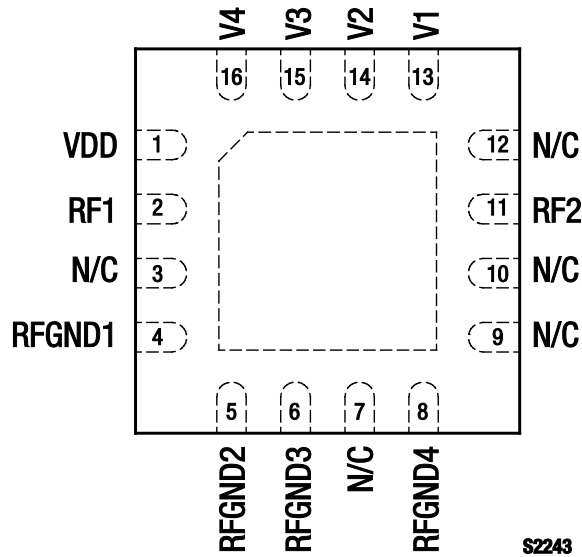


Figure 2. SKY12348-350LF Pinout – 16-Pin QFN (Top View)

Table 1. SKY12348-350LF Signal Descriptions

| Pin # | Name | Description | Pin # | Name | Description |
|-------|--------|---|-------|------|---|
| 1 | VDD | DC power supply | 9 | N/C | No connection. Can be grounded without affecting performance. |
| 2 | RF1 | RF input/output to digital attenuator | 10 | N/C | No connection. Can be grounded without affecting performance. |
| 3 | N/C | No connection. Can be grounded without affecting performance. | 11 | RF2 | RF input/output to digital attenuator |
| 4 | RFGND1 | Connect through external capacitor to ground. Capacitor value determines lower frequency operation of attenuator. | 12 | N/C | No connection. Can be grounded without affecting performance. |
| 5 | RFGND2 | Connect through external capacitor to ground. Capacitor value determines lower frequency operation of attenuator. | 13 | V1 | DC control pin. See Table 4. |
| 6 | RFGND3 | Connect through external capacitor to ground. Capacitor value determines lower frequency operation of attenuator. | 14 | V2 | DC control pin. See Table 4. |
| 7 | N/C | No connection. Can be grounded without affecting performance. | 15 | V3 | DC control pin. See Table 4. |
| 8 | RFGND4 | Connect through external capacitor to ground. Capacitor value determines lower frequency operation of attenuator. | 16 | V4 | DC control pin. See Table 4. |

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY12348-350LF are provided in Table 2. Electrical specifications are provided in Table 3.

Typical performance characteristics of the SKY12348-350LF are illustrated in Figures 5 through 7.

The state of the SKY12348-350LF is determined by the logic provided in Table 4.

Table 2. SKY12348-350LF Absolute Maximum Ratings

| Parameter | Symbol | Minimum | Maximum | Units |
|-----------------------|------------------|---------|-----------------|-------|
| Supply voltage | V _{DD} | 3.3 | 6.0 | V |
| Control voltage | V _{CTL} | 0 | V _{DD} | V |
| RF input power | P _{IN} | | +30 | dBm |
| Operating temperature | T _{OP} | -40 | +85 | °C |
| Storage temperature | T _{STG} | -40 | +125 | °C |

Note: 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.

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.

Table 3. SKY12348-350LF Electrical Specifications (Note 1) (1 of 2)

(V_{DD} = 5 V, V_{CTL} = 5 V, T_{OP} = +25 °C, P_{IN} = 0 dBm, Characteristic Impedance [Z₀] = 50 Ω, , Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units | |
|---|---------|---|------|---------|-----|-------|--|
| RF Specifications | | | | | | | |
| Insertion loss | IL | @ 0.7 GHz | | 0.8 | 1.0 | dB | |
| | | @ 2.1 GHz | | 1.0 | 1.2 | dB | |
| | | @ 2.7 GHz | | 1.2 | 1.4 | dB | |
| Attenuation range | | 0.1 to 3.0 GHz | 1 | | 15 | dB | |
| Return loss | RL | 0.1 to 3.0 GHz | | 15 | | dB | |
| Attenuation accuracy | Attn | 1 dB bit: | | | | | |
| | | 0.7 GHz | 0.8 | 1 | 1.2 | dB | |
| | | 2.1 GHz | 0.8 | 1 | 1.2 | dB | |
| | | 2.7 GHz | 0.8 | 1 | 1.3 | dB | |
| | | 2 dB bit: | | | | | |
| | | 0.7 GHz | 1.8 | 2 | 2.2 | dB | |
| | | 2.1 GHz | 1.8 | 2 | 2.3 | dB | |
| | | 2.7 GHz | 1.8 | 2 | 2.4 | dB | |
| | | 4 dB bit: | | | | | |
| | | 0.7 GHz | 3.8 | 4 | 4.3 | dB | |
| | | 2.1 GHz | 3.8 | 4 | 4.4 | dB | |
| | | 2.7 GHz | 3.8 | 4 | 4.4 | dB | |
| | | 8 dB bit: | | | | | |
| | | 0.7 GHz | 7.8 | 8 | 8.4 | dB | |
| | | 2.1 GHz | 7.8 | 8 | 8.2 | dB | |
| 2.7 GHz | 7.5 | 8 | 8.2 | dB | | | |
| Max. attenuation (15 dB): | | | | | | | |
| 0.7 GHz | 14.8 | 15 | 15.5 | dB | | | |
| 2.1 GHz | 14.4 | 15 | 15.5 | dB | | | |
| 2.7 GHz | 13.8 | 15 | 15.3 | dB | | | |
| 0.1 dB Input Compression Point | IPO.1dB | V _{DD} = 3 V @ 1.8 GHz | | +30 | | dBm | |
| 3 rd Order Input Intercept Point | IIP3 | P _{IN} = +10 dBm/tone @ 1.8 GHz, V _{DD} = 3 V, ΔF = 1 MHz, worst case in 16 states | | +45 | | dBm | |

Table 3. SKY12348-350LF Electrical Specifications (Note 1) (2 of 2)

($V_{DD} = 5\text{ V}$, $V_{CTL} = 5\text{ V}$, $T_{OP} = +25\text{ }^\circ\text{C}$, $P_{IN} = 0\text{ dBm}$, Characteristic Impedance [Z_0] = $50\ \Omega$, , Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|---------------------------------------|-----------|---------------------------------|-----|---------|----------|---------------|
| DC Specifications | | | | | | |
| Control voltage: | V_{CTL} | | 0 | | 0.8 | V |
| | | | 3.3 | | V_{DD} | V |
| Supply voltage | V_{DD} | | 3.3 | 5.0 | 5.5 | V |
| Supply current | I_{DD} | $V_{DD} = 5\text{ V}$ | | 75 | | μA |
| Control current | I_{CTL} | $V_{DD} = 3.3\text{ V}$ | | 5 | | μA |
| Switching Speed Specifications | | | | | | |
| On/rise | | 50% control or 90% RF to 10% RF | | 200 | | ns |
| Off/fall | | 50% control or 10% RF to 90% RF | | 180 | | ns |

Note 1: Performance is guaranteed only under the conditions listed in this Table.

Typical Performance Characteristics

($V_{DD} = 5\text{ V}$, $V_{CTL} = 5\text{ V}$, $T_{OP} = +25\text{ }^\circ\text{C}$, $P_{IN} = 0\text{ dBm}$, Characteristic Impedance [Z_0] = $50\ \Omega$, , Unless Otherwise Noted)

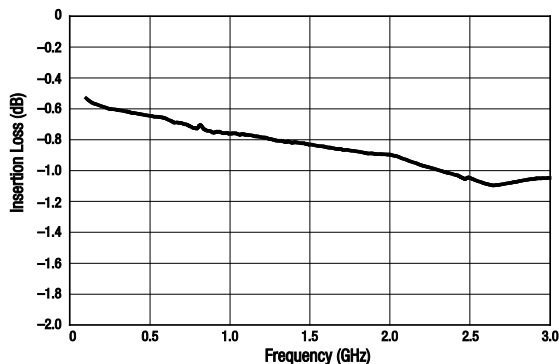


Figure 3. Insertion Loss vs Frequency @ 0 dB

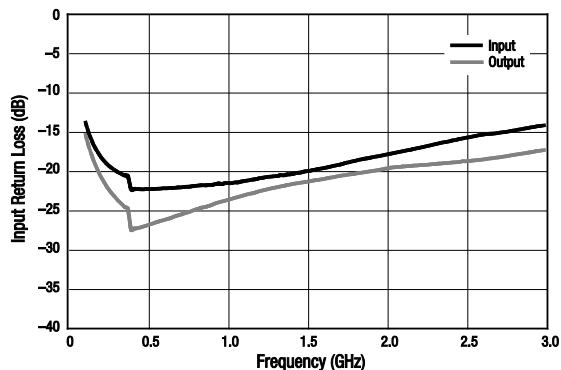


Figure 4. Input Return Loss vs Frequency

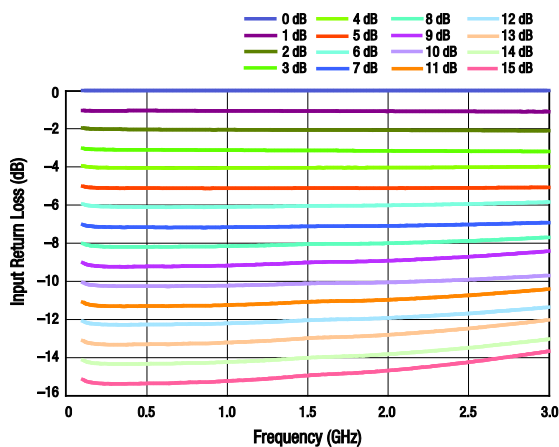


Figure 5. Normalized Attenuation vs Frequency

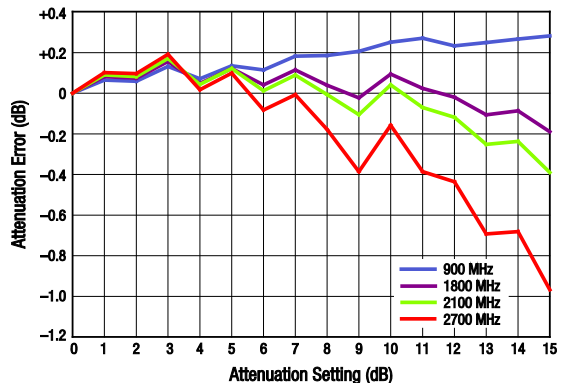


Figure 6. Attenuation Error vs Attenuation Setting

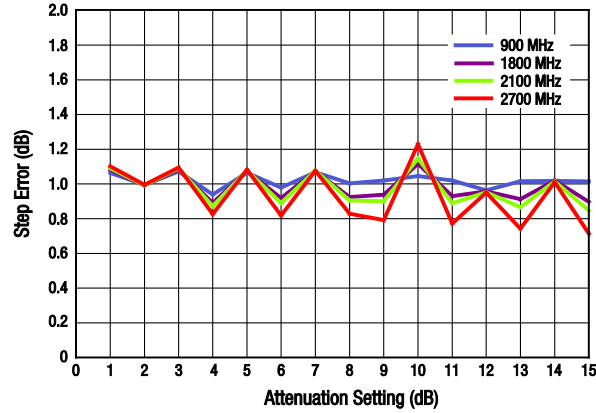


Figure 7. Step Error vs Attenuation Setting

Table 4. SKY12348-350LF Truth Table

| RF1/RF2 (Pins 2 & 11) Attenuation | V4 (Pin 16) | V3 (Pin15) | V2 (Pin 14) | V1 (Pin 13) |
|--------------------------------------|----------------|---------------|----------------|----------------|
| Insertion loss | 1 | 1 | 1 | 1 |
| 1 dB | 0 | 1 | 1 | 1 |
| 2 dB | 1 | 0 | 1 | 1 |
| 4 dB | 1 | 1 | 0 | 1 |
| 8 dB | 1 | 1 | 1 | 0 |
| 15 dB | 0 | 0 | 0 | 0 |

Notes: "1" = high control voltage: +3.3 to V_{DD}.
 "0" = low control voltage: 0 to +0.8 V.

This Table shows the logic required for the major bits and full attenuation. Bit states need to be used in combination to set the sum of the bits selected.

Evaluation Board Description

The SKY12348-350LF Evaluation Board is used to test the performance of the SKY12348-350LF digital attenuator. An assembly drawing for the Evaluation Board is shown in Figure 8 and an Evaluation Board schematic diagram is shown in Figure 9.

Package Dimensions

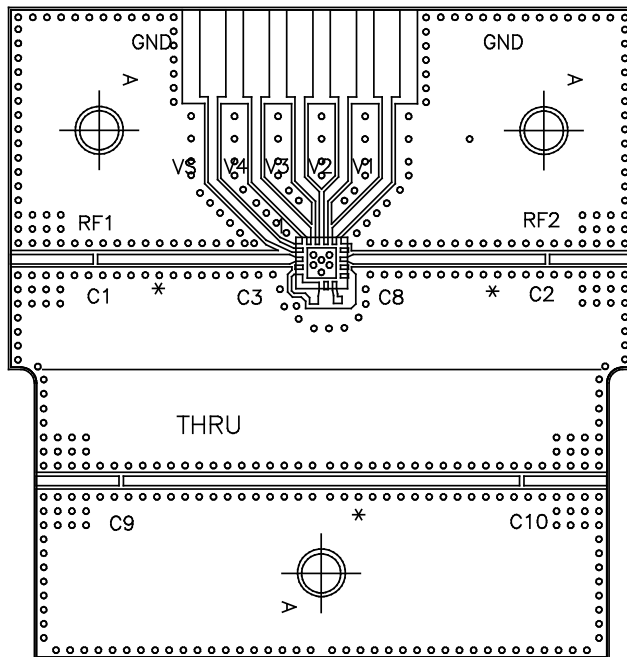
The PCB layout footprint for the SKY12348-350LF is shown in Figure 10. Typical case markings are noted in Figure 11. Package dimensions for the 16-pin QFN are shown in Figure 12, and tape and reel dimensions are provided in Figure 13.

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.

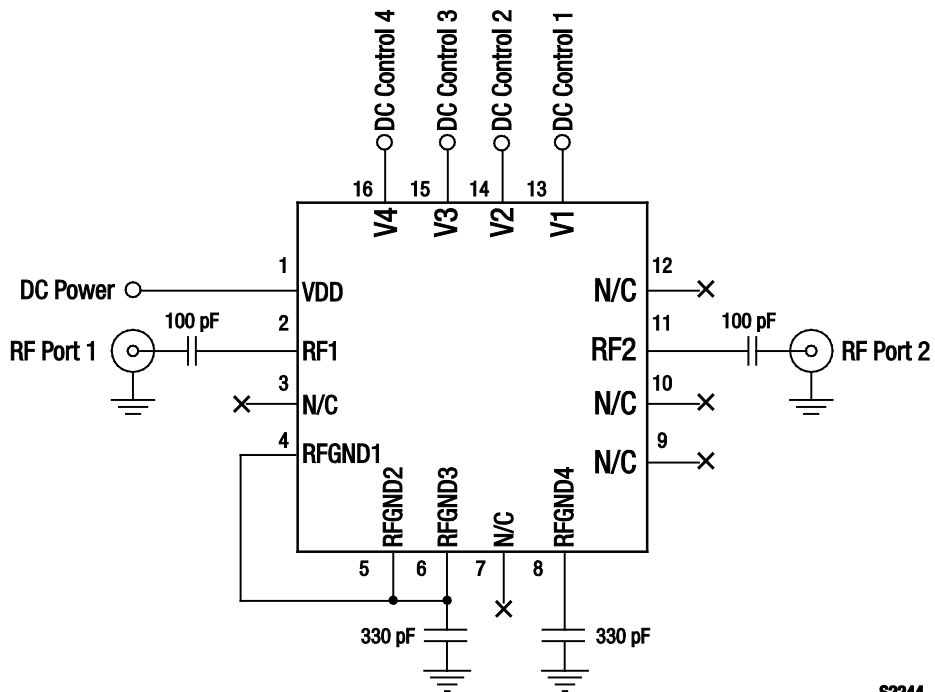
THE SKY12348-350LF is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *Solder Reflow Information*, document number 200164.

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.



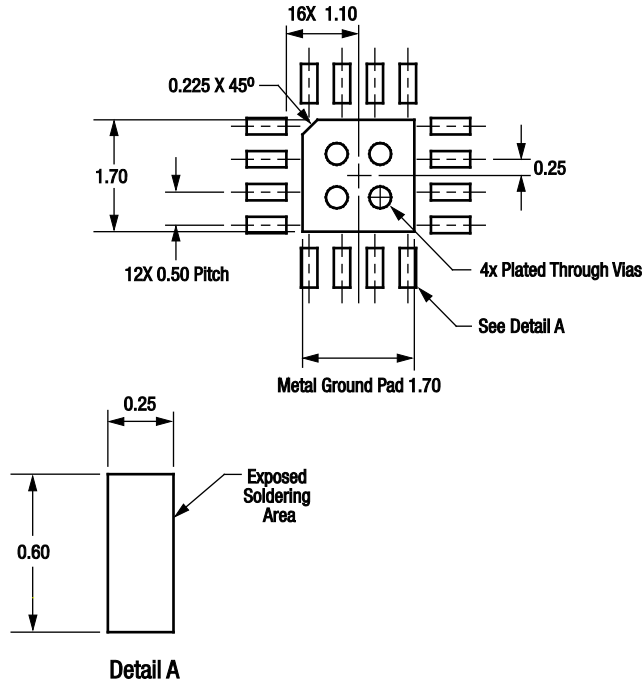
S2245

Figure 8. SKY12348-350LF Evaluation Board Assembly Diagram



S2244

Figure 9. SKY12348-350LF Evaluation Board Schematic Diagram



All dimensions are in millimeters

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Figure 10. SKY12348-350LF PCB Layout Footprint

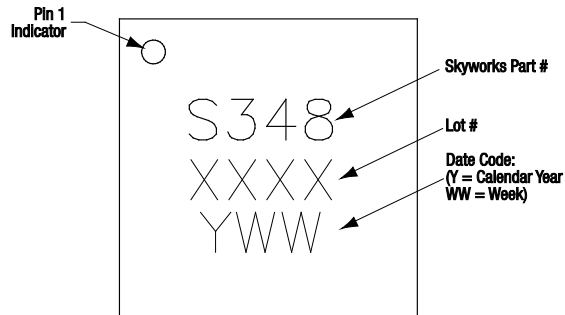
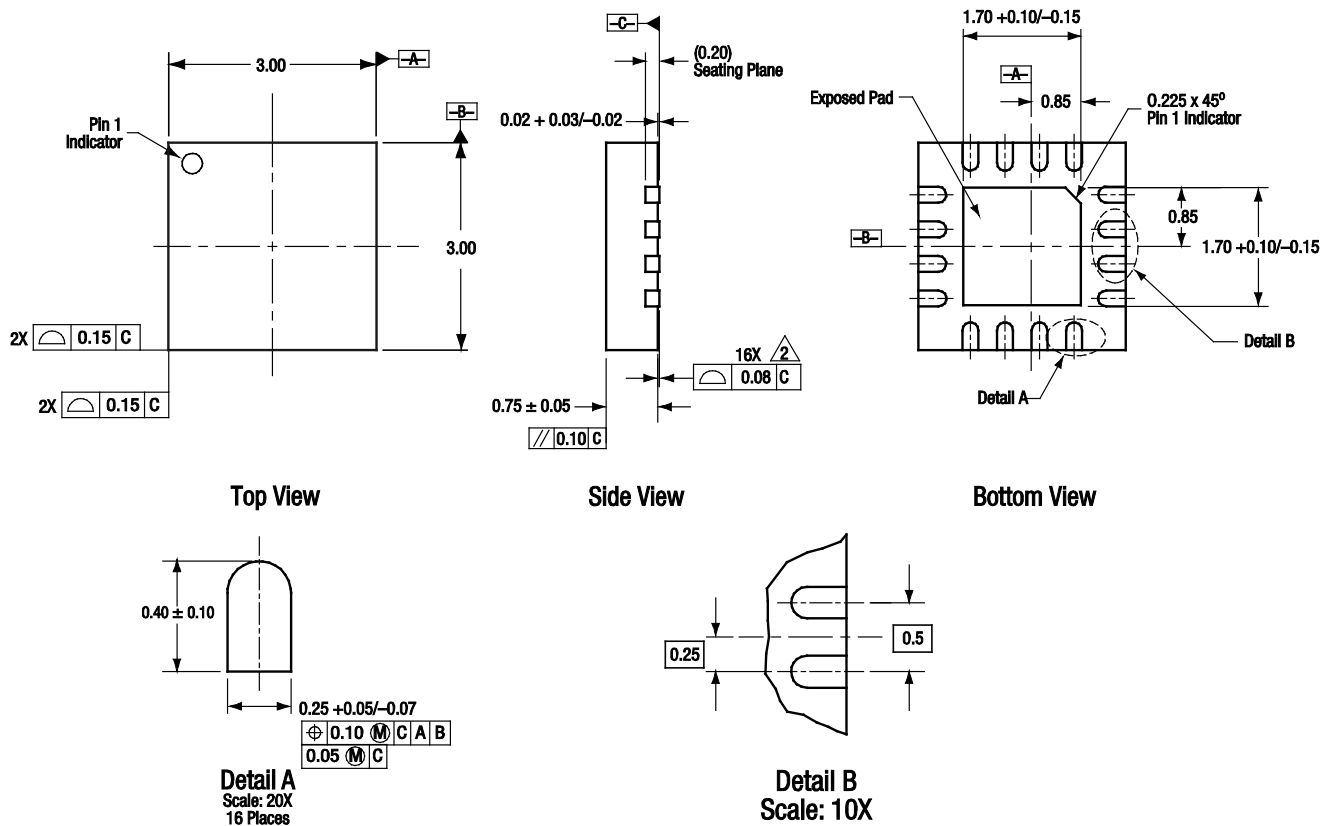


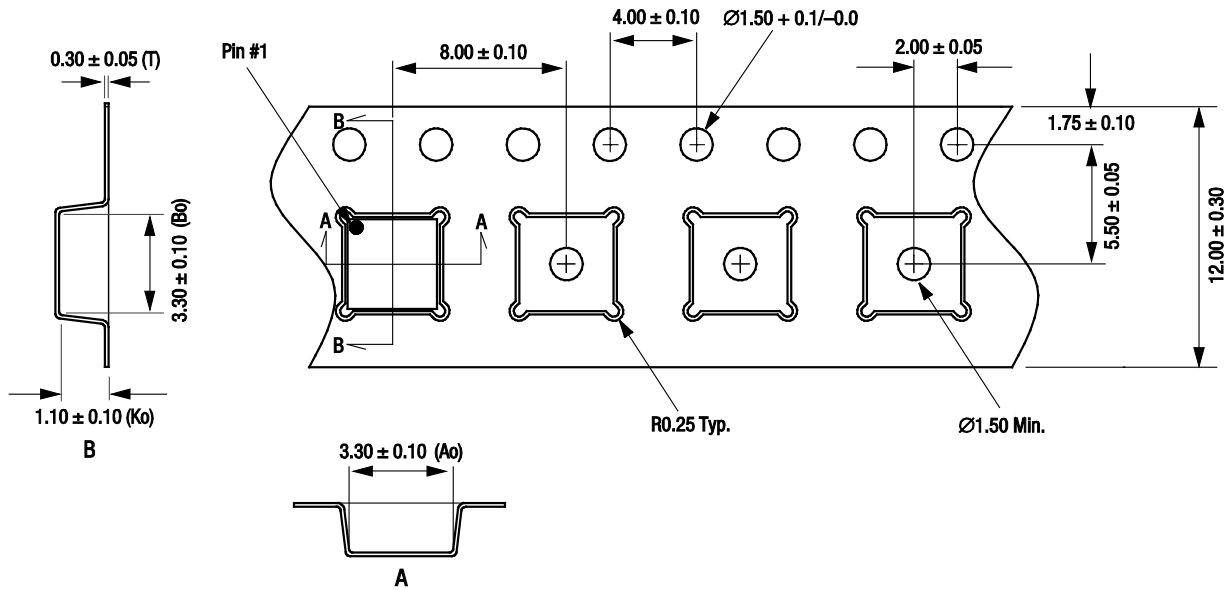
Figure 11. Typical Part Markings



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.

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Figure 12 SKY12348-350LF 16-Pin QFN Package Dimensions



- Notes:
1. Carrier tape: black conductive polystyrene, non-bakeable material.
 2. Cover tape material: transparent conductive HSA.
 3. Cover tape size: 9.20 mm width.
 4. All measurements are in millimeters.

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Figure 13. SKY12348-350LF Tape and Reel Dimensions

Ordering Information

| Model Name | Manufacturing Part Number | Evaluation Board Part Numbers |
|-----------------------------------|---------------------------|-------------------------------|
| SKY12348-350LF Digital Attenuator | SKY12348-350LF | SKY12348-350LF-EVB |

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