

DATA SHEET

# SKY12328-350LF: 0.5-4.0 GHz Five-Bit Digital Attenuator (0.5 dB LSB)

## Applications

- Transceiver transmit automatic level control or receive automatic gain control in WiMAX, GSM, CDMA, WCDMA, WLAN, Bluetooth®, or Zigbee® land mobile radio base stations or terminal equipment
- General-purpose signal attenuation in telecommunications and instrumentation applications

## Features

- Broadband operation: 0.5 to 4.0 GHz
- Attenuation range: 15.5 dB
- LSB attenuation: 0.5 dB
- Low insertion loss: 1 dB @ 900 MHz
- Positive voltage operation: 2.7 to 5.5 V
- Low current consumption: <100  $\mu$ A @ 5 V
- Small, QFN (16-pin, 3 x 3 mm) package (MSL1, 260 °C per JEDEC J-STD-020)



Skyworks Pb-free products are compliant with all applicable legislation. For additional information, refer to *Skyworks Definition of Lead (Pb)-Free*, document number SQ04-0073.

## Description

The SKY12328-350LF is a monolithic, GaAs binary-weighted five-bit single positive control voltage digital attenuator. The device operates from 0.5 to 4.0 GHz. DC power consumption is very low, typically 100  $\mu$ A maximum, with a control and supply voltage of 5.5 V.

The SKY12328-350LF has an LSB of 0.5 dB and total attenuation of 15.5 dB. The two RF ports are bilateral; each can be used as the RF input or the RF output. An external supply voltage of 2.7 to 5.5 V is required.

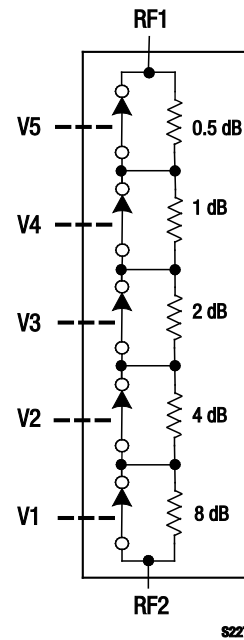


Figure 1. SKY12328-350LF Block Diagram

The SKY12328-350LF is comprised of five cascaded fixed attenuators, each of which has a shunt bypass switch. Beginning at the 0.5 dB LSB, each succeeding fixed attenuator produces twice the attenuation of the preceding stage.

The state of each bypass switch is controlled by the logic level voltage applied to the associated control voltage input. A logic high voltage closes the associated switch, which bypasses that fixed attenuator stage; a logic low opens the switch to force the input signal to that stage through the associated attenuator.

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.

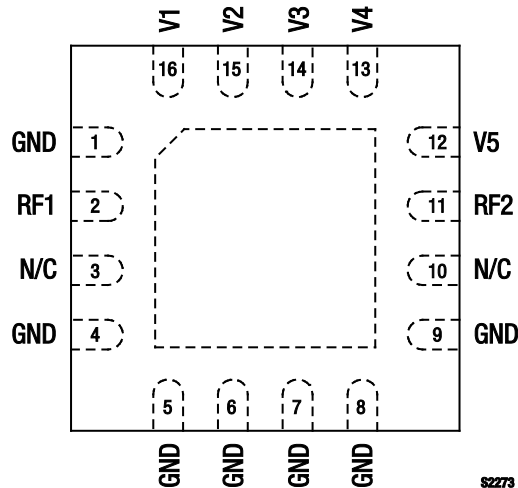


Figure 2. SKY12328-350LF Pinout – 16-Pin QFN (Top View)

Table 1. SKY12328-350LF Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	GND	Ground	9	GND	Ground
2	RF1	RF input or output port. A DC blocking capacitor is required. Supply voltage of 2.7 to 5.5 V is applied to pin 2 through a 10 kΩ resistor (see Figure 10).	10	N/C	No connection
3	N/C	No connection	11	RF2	RF input or output port. A DC blocking capacitor is required.
4	GND	Ground	12	V5	High impedance control voltage input for 0.5 dB weighted bit (LSB)
5	GND	Ground	13	V4	High impedance control voltage input for 1 dB weighted bit
6	GND	Ground	14	V3	High impedance control voltage input for 2 dB weighted bit
7	GND	Ground	15	V2	High impedance control voltage input for 4 dB weighted bit
8	GND	Ground	16	V1	High impedance control voltage input for 8 dB weighted bit (MSB)

**Electrical and Mechanical Specifications**

The absolute maximum ratings of the SKY12328-350LF are provided in Table 2. Electrical specifications are provided in Table 3.

Typical performance characteristics of the SKY12328-350LF are illustrated in Figures 3 through 8.

The state of the SKY12328-350LF is determined by the logic provided in Table 4.

**Table 2. SKY12328-350LF Absolute Maximum Ratings**

Parameter	Symbol	Minimum	Typical	Maximum	Units
RF input power ( $V_{CTL} = 0/8\text{ V}$ )	$P_{IN}$	+33 dBm for $f > 500\text{ MHz}$			
Control voltage	$V_{CTL}$	-0.2		+8	V
Operating temperature	$T_{OP}$	-40		+85	°C
Storage temperature	$T_{STG}$	-65		+150	°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. SKY12328-350LF Electrical Specifications (Note 1)**

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

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Insertion loss	IL	0.5 to 1.0 GHz		1.1	1.3	dB
		1.0 to 2.0 GHz		1.3	1.5	dB
		2.0 to 3.0 GHz		1.6	1.9	dB
		3.0 to 4.0 GHz		2.3	2.5	dB
Attenuation range			15.5			dB
Attenuation accuracy		0.5 to 1.0 GHz, attenuation referred to insertion loss	$\pm(0.2 + 3\%$ of attenuation setting)			dB
		1.0 to 4.0 GHz, all attenuation states	$\pm(0.3 + 3\%$ of attenuation setting)			dB
Return loss	RL	0.5 to 1.0 GHz		15		dB
		1.0 to 4.0 GHz		20		dB
Switching characteristics: Rise/fall time On/off time		10/90% or 90/10% RF 50% $V_{CTL}$ to 90/10% RF		150		ns
				300		ns
Input power for 1 dB compression	IP1dB	@ 0.9 GHz, $V_{CTL} = 0\text{ to }5\text{ V}$		+30		dBm
3 <sup>rd</sup> Order Input Intercept Point	IIP3	For two-tone input power, +5 dBm/tone, 1 to 4 GHz:  $V_{CTL} = 0\text{ to }3\text{ V}$ , $V_{CTL} = 0\text{ to }5\text{ V}$		+40		dBm
				+42		dBm
Thermal resistance	$\Theta_{JC}$	Junction to package terminal		45		°C/W
Supply voltage	$V_S$		$V_{HIGH} - 0.2$		$V_{HIGH} + 0.2$	V
Control voltage: High Low	$V_{CTL}$		2.7		5.5	V
			-0.2		+0.2	V
Control port current	$I_{CTL}$	$V_{CTL} = V_{HIGH}$ $V_{CTL} = V_{LOW}$		15	100	$\mu\text{A}$
				5	20	$\mu\text{A}$

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

### Typical Performance Characteristics

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

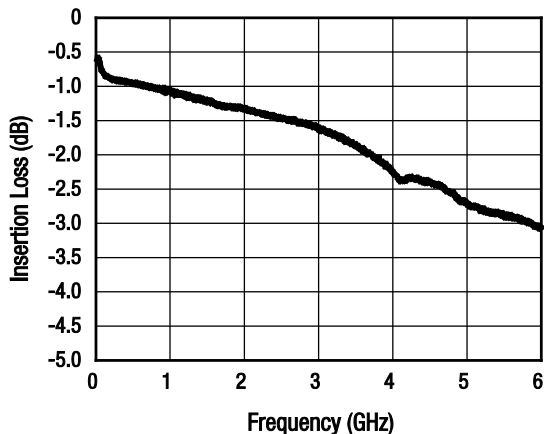


Figure 3. Insertion Loss vs Frequency

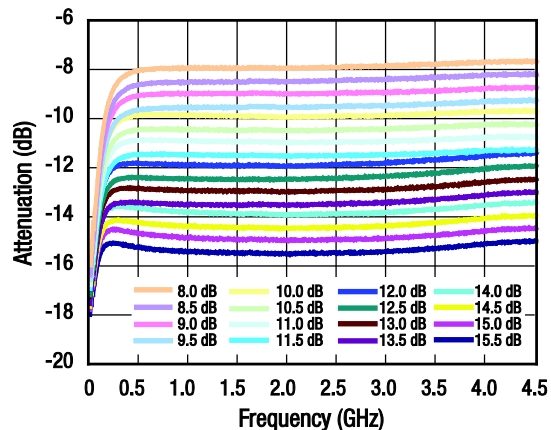


Figure 4. Attenuation vs Frequency (8 dB to 15.5 dB, Normalized to Insertion Loss)

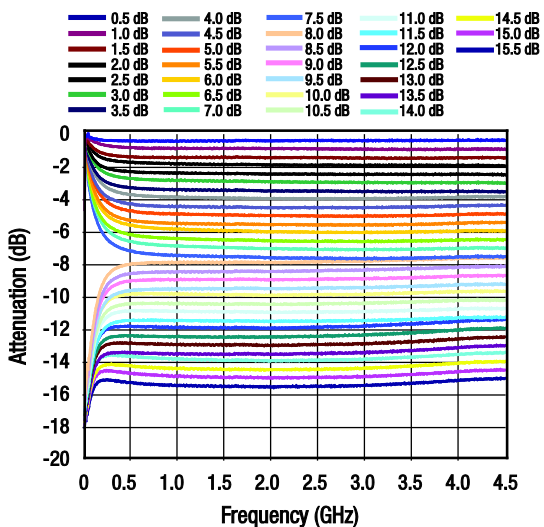


Figure 5. Attenuation vs Frequency (Normalized to Insertion Loss)

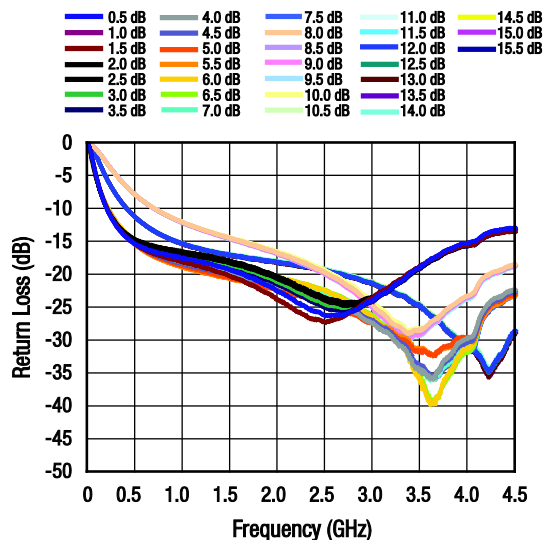
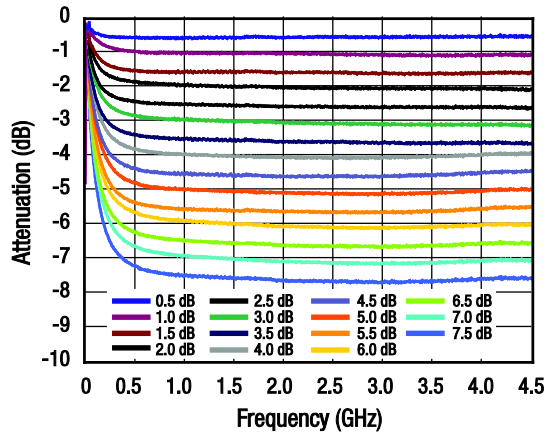
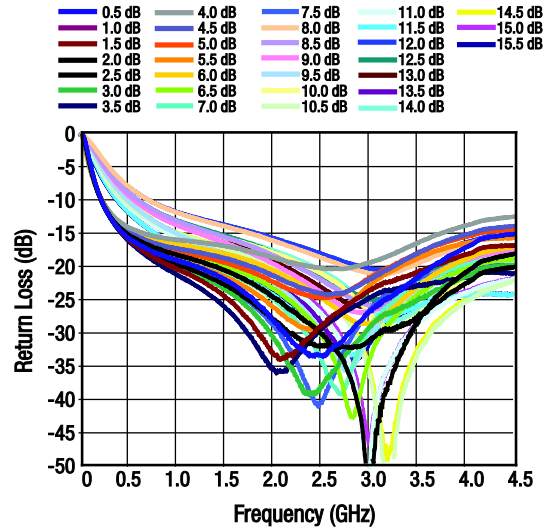


Figure 6. Input Return Loss vs Frequency



**Figure 7. Attenuation vs Frequency (0.5 dB to 7.5 dB, Normalized to Insertion Loss)**



**Figure 8. Output Return Loss vs Frequency**

**Table 4. SKY12328-350LF Truth Table**

Nominal Attenuation	V1 (Pin 1)	V2 (Pin 2)	V3 (Pin 3)	V4 (Pin 4)	V5 (Pin 5)
Reference insertion loss	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>
0.5 dB	V <sub>LOW</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>
1.0 dB	V <sub>HIGH</sub>	V <sub>LOW</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>
2.0 dB	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>LOW</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>
4.0 dB	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>LOW</sub>	V <sub>HIGH</sub>
8.0 dB	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>HIGH</sub>	V <sub>LOW</sub>
15.5 dB	V <sub>LOW</sub>	V <sub>LOW</sub>	V <sub>LOW</sub>	V <sub>LOW</sub>	V <sub>LOW</sub>

**Note:** V<sub>HIGH</sub> = +3 V to 5 V. V<sub>LOW</sub> = 0 V to +0.2 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 SKY12328-350LF Evaluation Board is used to test the performance of the SKY12328-350LF digital attenuator. An assembly drawing for the Evaluation Board is shown in Figure 9 and an Evaluation Board schematic diagram is shown in Figure 10.

### Package Dimensions

Typical case markings are shown 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 SKY12328-350LF 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.

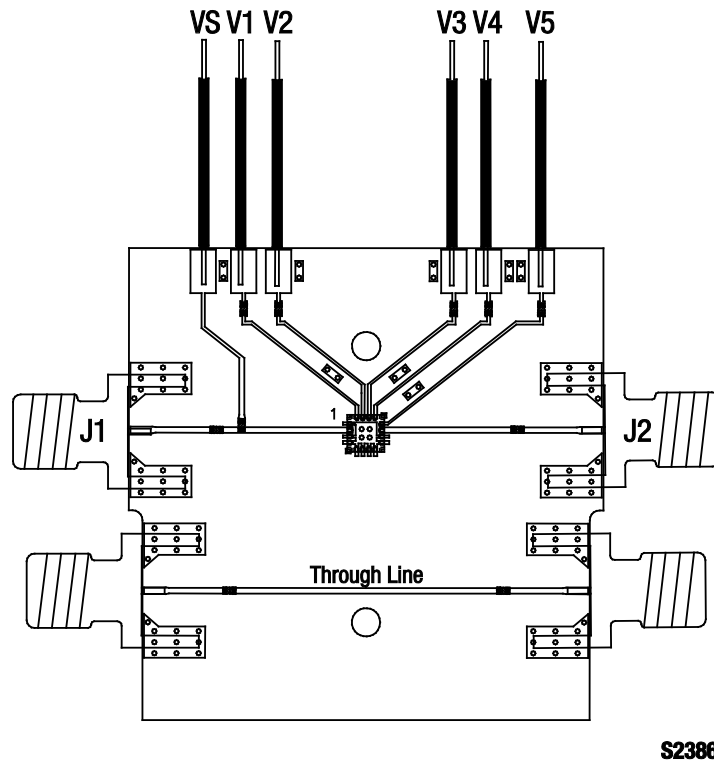


Figure 9 SKY12328-350LF Evaluation Board Assembly Diagram

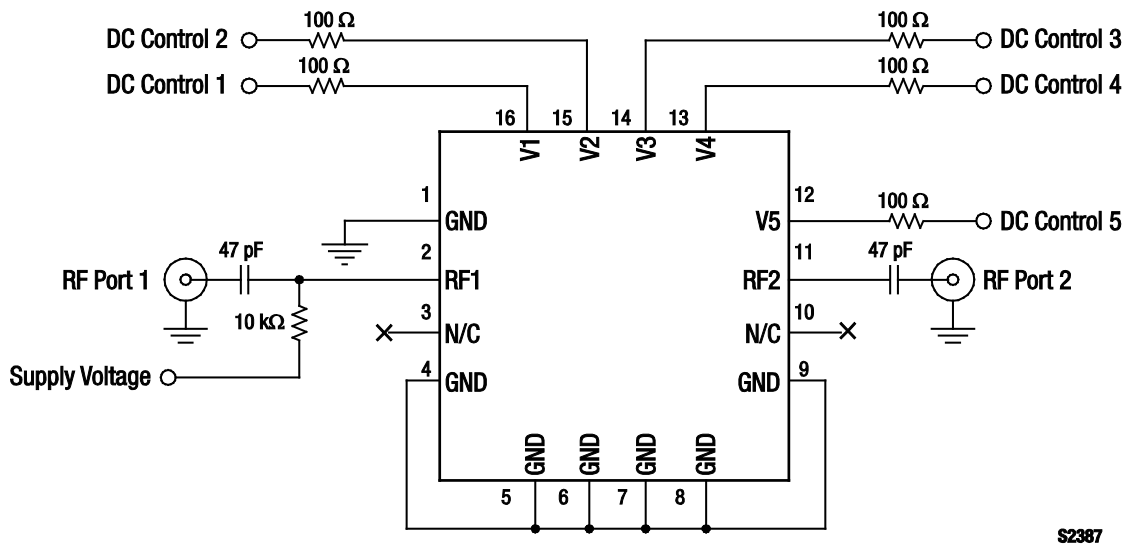


Figure 10. SKY12328-350LF Evaluation Board Schematic Diagram

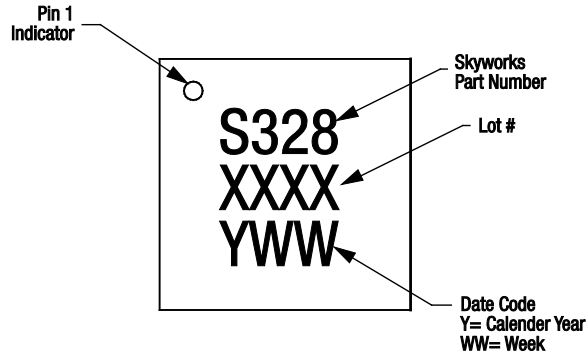
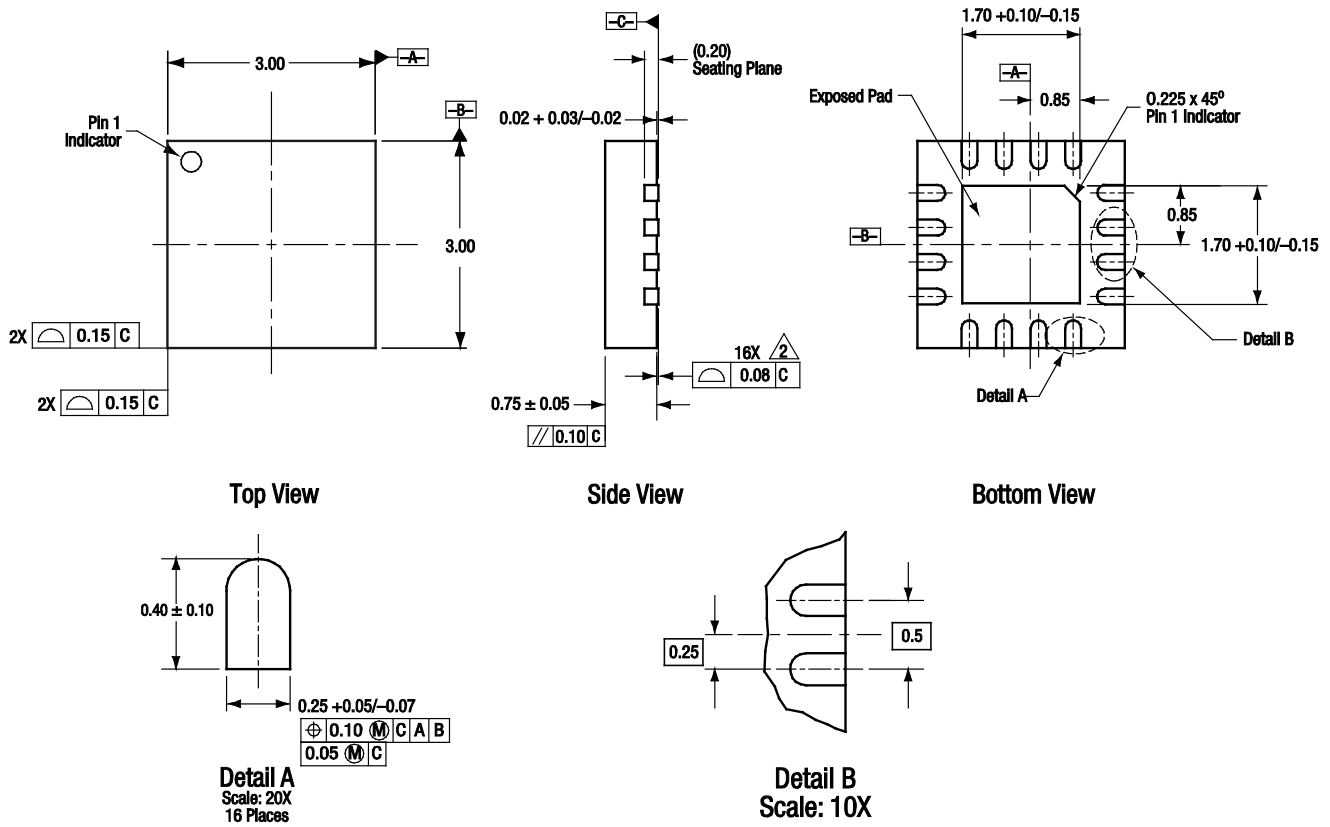


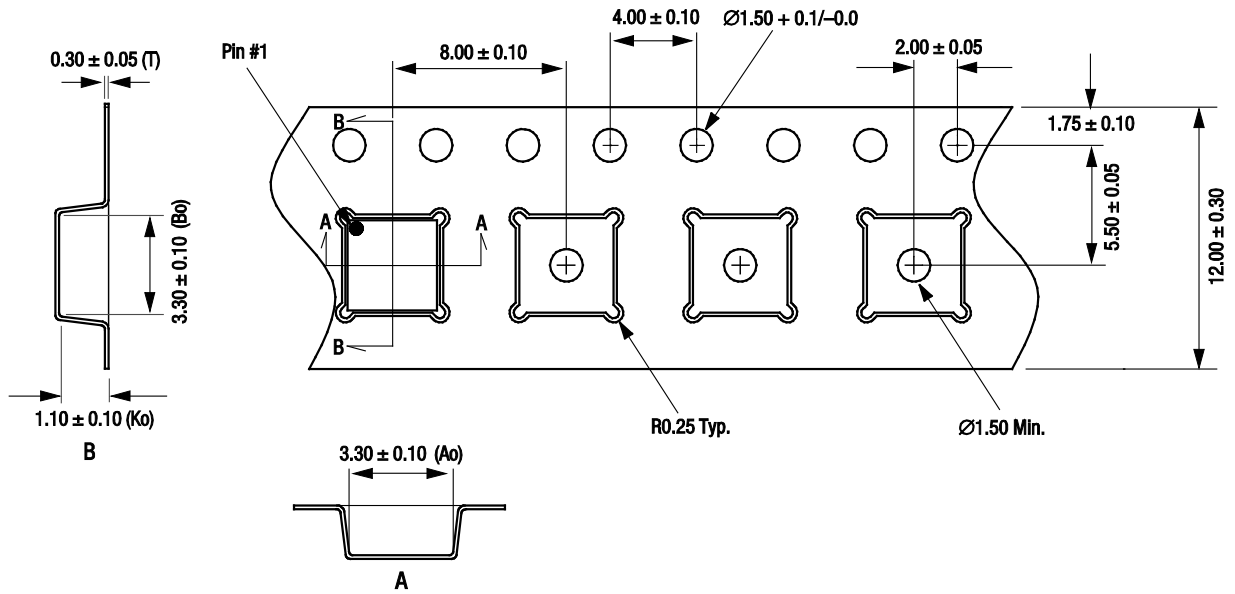
Figure 11. Typical Case Markings (Top View)



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.

S1692

Figure 12. SKY12328-350LF 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: 0.20 mm width.
  4. All measurements are in millimeters.

S1688

Figure 13. SKY12328-350LF Tape and Reel Dimensions



**Ordering Information**

Model Name	Manufacturing Part Number	Evaluation Board Part Numbers
SKY12328-350LF Digital Attenuator	SKY12328-350LF	SKY12328-350LF-EVB

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