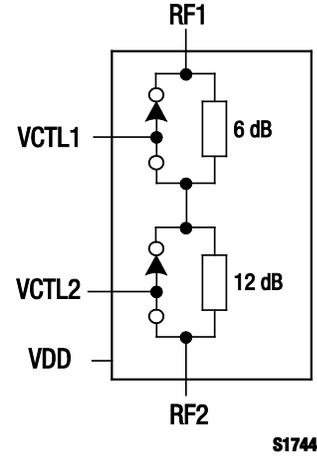# SKY12355-337LF: 0.35-4.0 GHz Two-Bit Digital Attenuator

Applications

- Cellular infrastructure
- Wireless receivers

Features

- Positive voltage operation with integrated decoder
- Broadband operation: 0.35 to 4.0 GHz
- Attenuation: 18 dB with 6 dB LSB
- Low insertion loss: 0.6 dB @ 2 GHz
- Absorptive in 50 Ω systems
- Small, QFN (12-pin, 3 x 3 mm) package (MSL1, 260 °C per JEDEC J-STD-020)

NEW Skyworks Green™ products are RoHS (Restriction of Hazardous Substances)-compliant, conform to the EIA/EICTA/JEITA Joint Industry Guide (JIG) Level A guidelines, are halogen free according to IEC-61249-2-21, and contain <1,000 ppm antimony trioxide in polymeric materials.

Figure 1. SKY12355-337LF Block Diagram

Description

The SKY12355-337LF is a GaAs pHEMT two-bit digital attenuator I/C. The device is provided in a 3 x 3 mm, 12-pin Quad Flat No-Lead (QFN) package.

The SKY12355-337LF is particularly suited for low-cost commercial applications for which high attenuation accuracy, low insertion loss, and low intermodulation products are required.

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.
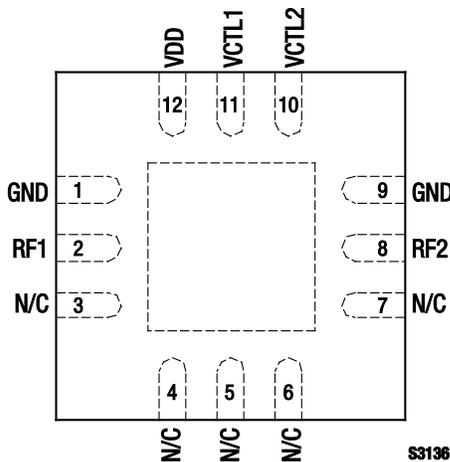
Figure 2. SKY12355-337LF Pinout – 12-Pin QFN (Top View)

Table 1. SKY12355-337LF Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	GND	Ground	7	N/C	No connection required. May be connected to ground with no change in performance.
2	RF1	RF port. Must be DC blocked.	8	RF2	RF port. Must be DC blocked.
3	N/C	No connection required. May be connected to ground with no change in performance.	9	GND	Ground
4	N/C	No connection required. May be connected to ground with no change in performance.	10	VCTL2	DC control voltage. Controls 12 dB attenuation state. Refer to Table 4.
5	N/C	No connection required. May be connected to ground with no change in performance.	11	VCTL1	DC control voltage. Controls 6 dB attenuation state. Refer to Table 4.
6	N/C	No connection required. May be connected to ground with no change in performance.	12	VDD	DC power supply.

Note: Exposed pad must be grounded.

Table 2. SKY12355-337LF Absolute Maximum Ratings

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply voltage	V_{DD}			5.5	V
Control voltage	VCTL1, VCTL2			$V_{DD} + 0.1$	V
RF input power @ 3 V	P_{IN}			+28	dBm
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.

Attention: Observe Precautions for Handling Electrostatic Sensitive Devices
ESD Human Body Model (HBM) = 250 V (Class 1A)
ESD Machine Model (MM) = 100 V (Class A)
ESD Charged Device Model (CDM) = 1000 V (Class 4)

Electrostatic Discharge (ESD) can damage this device, which must be protected from ESD at all times. 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.

Functional Description

This attenuator has a least significant bit (LSB) of 6 dB and a most significant bit (MSB) of 12 dB for a total of 18 dB available attenuation. Pins 10 and 11 (VCTL2 and VCTL1) control the state of the 6 dB and 12 dB attenuation bits, respectively. For each bit, a logic high enables the attenuation state while a logic low enables a low insertion loss state.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY12355-337LF are provided in Table 2. Electrical specifications are provided in Table 3.

The state of the SKY12355-337LF is determined by the logic provided in Table 4. The VCTL1 and VCTL2 signals control the 6 dB and 12 dB attenuation bits, respectively. For each bit, a logic high enables the attenuation state, while a logic low enables the insertion loss state.

Typical performance characteristics are illustrated in Figures 3 to 6.

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Table 3. SKY12355-337LF Electrical Specifications (1 of 2) (Note 1)
(V_{DD} = 3 V, V_{CTL} = 0 to 3 V, T_{OP} = +25 °C, P_{IN} = 0 dBm, Characteristic Impedance [Z_0] = 50 Ω, C1 & C2 = 1000 pF, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Insertion loss	IL	350 to 500 MHz		0.45	0.80	dB
		500 MHz to 2 GHz		0.60	0.80	dB
		2 GHz to 3 GHz		0.65	0.90	dB
		3 GHz to 4 GHz		0.75	1.00	dB
Attenuation accuracy	Att	@ 6 dB:				
		350 MHz to 500 MHz	5.7	6.0	6.3	dB
		500 MHz to 2 GHz	6.0	6.3	6.6	dB
		2 GHz to 3 GHz	6.1	6.4	6.7	dB
		3 GHz to 4 GHz	6.1	6.4	6.7	dB
		@ 12 dB:				
		350 MHz to 500 MHz	11.9	12.2	12.5	dB
		500 MHz to 2 GHz	11.9	12.3	12.6	dB
		2 GHz to 3 GHz	11.9	12.2	12.5	dB
		3 GHz to 4 GHz	11.8	12.1	12.4	dB
		@ 18 dB:				
		350 MHz to 500 MHz	17.9	18.3	18.7	dB
		500 MHz to 2 GHz	18.3	18.7	19.1	dB
		2 GHz to 3 GHz	18.3	18.7	19.1	dB
		3 GHz to 4 GHz	18.2	18.6	19.0	dB
Return loss	|S11|	350 to 500 MHz	10	20		dB
		500 MHz to 2 GHz	14	22		dB
		2 GHz to 3 GHz	12	19		dB
		3 GHz to 4 GHz	12	19		dB
Switching characteristics: Rise/fall time		10% RF to 90% RF or 90% RF to 10% RF		8		ns
On/off time		50% V_{CTL} to 90% RF or 50% V_{CTL} to 10% RF		37		ns
Attenuation amplitude settling		500 ns to 5 ms			0.25	dB
Phase settling (by design)		500 ns to 5 ms	−2		+2	deg
1 dB Input Compression Point	IP1dB	V_{CTL} = 3 V, 500 MHz to 4 GHz, insertion state		+28		dBm
0.1 dB Input Compression Point	IP0.1dB	V_{CTL} = 3 V, 500 MHz to 4 GHz, all states		+19		dBm

Table 3. SKY12355-337LF Electrical Specifications (2 of 2) (Note 1)
(V_{DD} = 3 V, V_{CTL} = 0 to 3 V, T_{OP} = +25 °C, P_{IN} = 0 dBm, Characteristic Impedance [Z_0] = 50 Ω, C1 & C2 = 1000 pF, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
3rd Order Input Intercept Point	IIP3	Tone spacing = 20 MHz, power/tone = +18 dBm, VDD = VCTL1 = VCTL2 = 3.3 V, 500 MHz to 4 GHz:				
		Insertion loss state	+48	+50		dBm
		All attenuation states	+44	+47		dBm
Supply voltage	V_{DD}		3		5	V
Control voltage		V_{DD} V_{CTL} = low V_{CTL} = high	3 0 $0.7 \times V_{DD}$		5 $0.3 \times V_{DD}$ V_{DD}	V V V
Control current		V_{CTL} = low and V_{CTL} = high		10		μA
Supply current	I_{DD}			20	50	μA

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

Table 4. SKY12355-337LF Truth Table

State	VDD	VCTL1	VCTL2
Insertion loss	high	low	low
6 dB	high	high	low
12 dB	high	low	high
18 dB	high	high	high

Note: high = $0.7 \times V_{DD}$ to V_{DD}
low = 0 to $0.3 \times V_{DD}$
Any state other than described in this Table places the attenuator into an undefined state.

Typical Performance Characteristics

(V_{DD} = 3 V, V_{CTL} = 0 to 3 V, T_{OP} = +25 °C, P_{IN} = 0 dBm, Characteristic Impedance [Z_0] = 50 Ω, C1 & C2 = 1000 pF, Unless Otherwise Noted)
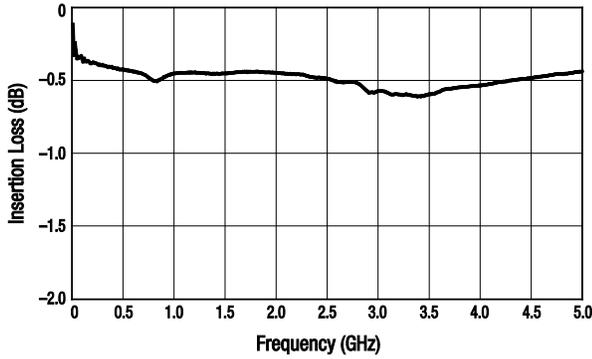
Figure 3. Insertion Loss vs Frequency
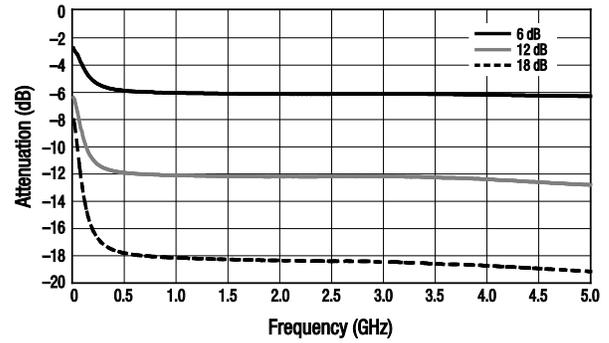
**Figure 4. Attenuation vs Frequency
(Normalized to Insertion Loss)**
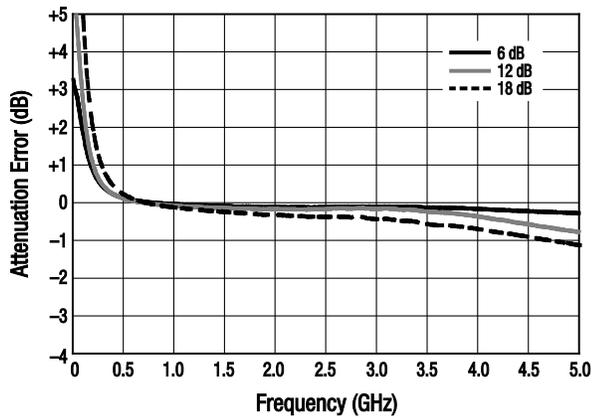
**Figure 5. Attenuation Error vs Frequency
(Normalized to Insertion Loss)**
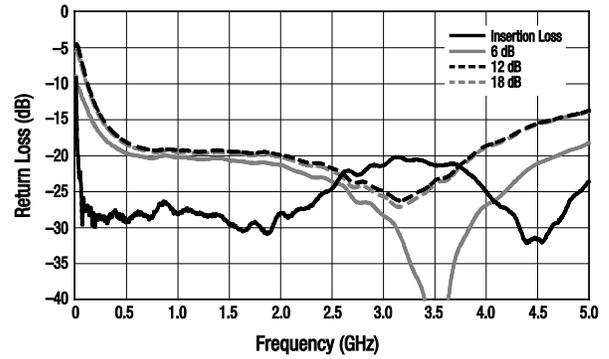
Figure 6. Return Loss vs Frequency

Evaluation Board Description

The SKY12355-337LF Evaluation Board is used to test the performance of the SKY12355-337LF digital attenuator. An Evaluation Board schematic diagram is shown in Figure 7. Table 5 provides the Bill of Materials (BOM) list for Evaluation Board components. An assembly drawing for the Evaluation Board is shown in Figure 8.

Package Dimensions

The PCB layout footprint for the SKY12355-337LF is shown in Figure 9. Typical case markings are noted in Figure 10. Package dimensions for the 12-pin QFN are shown in Figure 11, and tape and reel dimensions are provided 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 SKY12355-337LF 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.
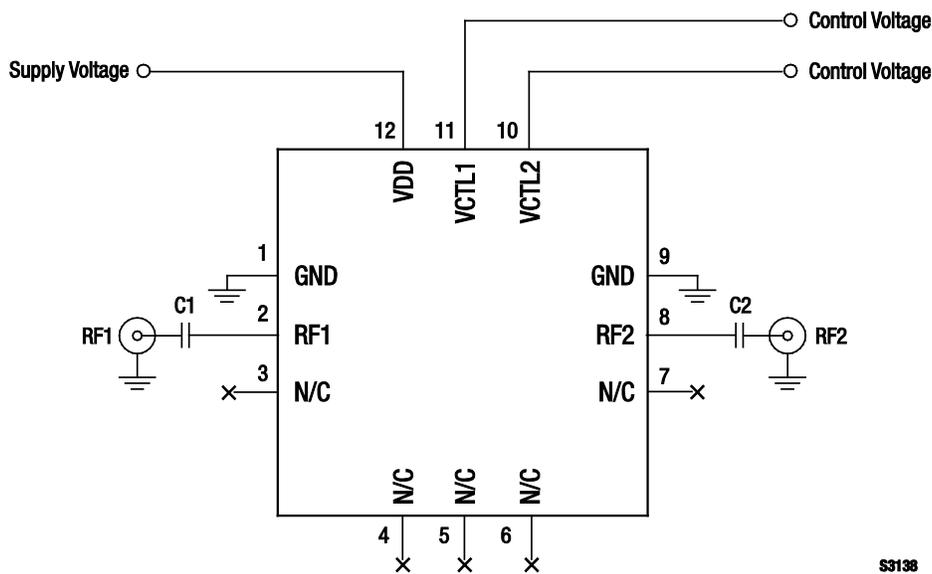
Figure 7. SKY12355-337LF Evaluation Board Schematic Diagram

Table 5. SKY12355-337LF Evaluation Board Bill of Materials

Component	Value	Size	Manufacturer/Part Series
C1, C2	1000 pF	0402	Murata GRM Series

Note: Blocking capacitors are required on both RF ports for proper functionality. Value of DC blocking capacitor determines lower frequency operation.

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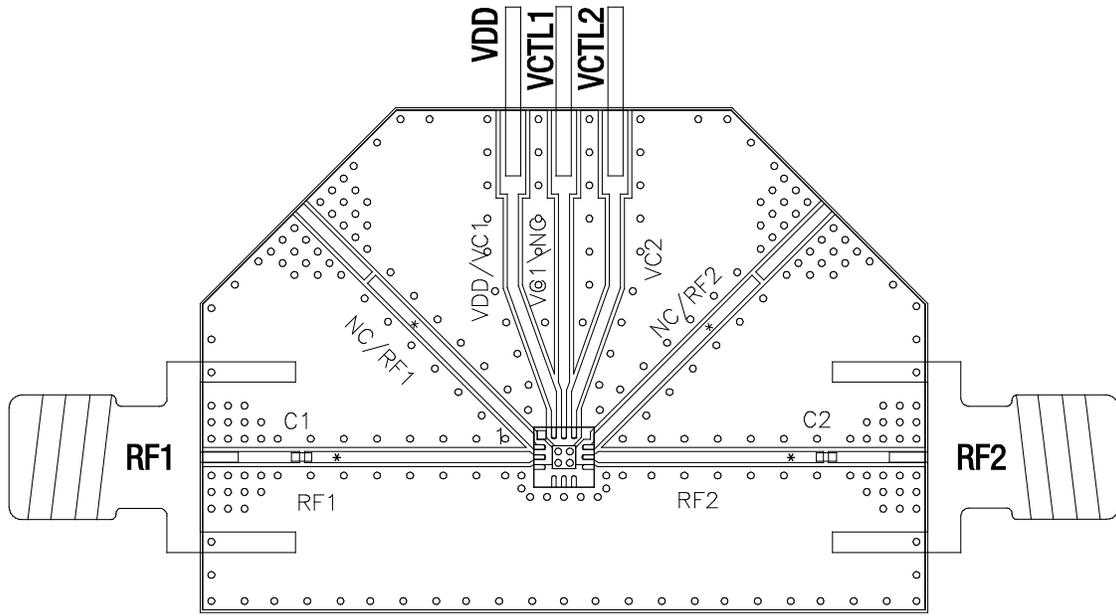
Figure 8. SKY12355-337LF Evaluation Board Assembly Diagram

Figure 9. SKY12355-337LF PCB Layout Footprint
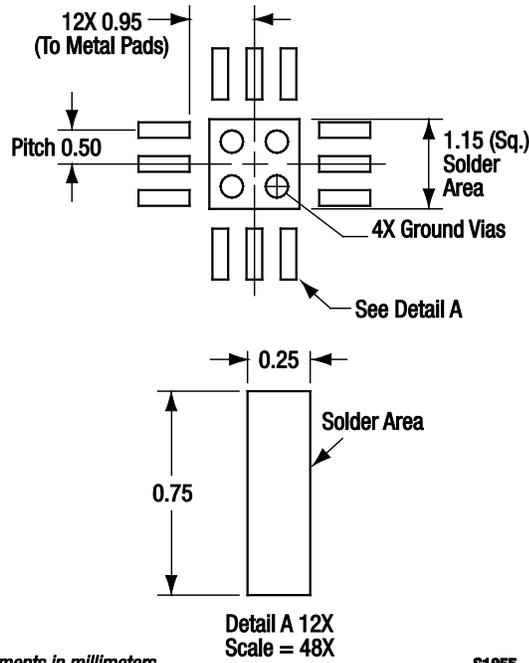
All measurements in millimeters
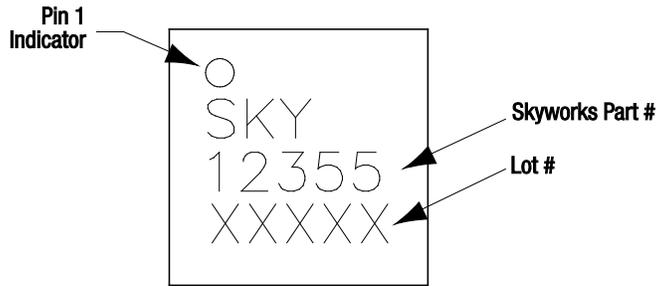
Figure 10. Typical Part Markings

Top View

Side View

Bottom View

Detail A
Scale: 20X

Detail B
Scale: 20X

Detail C
Scale: 40X
12 Places
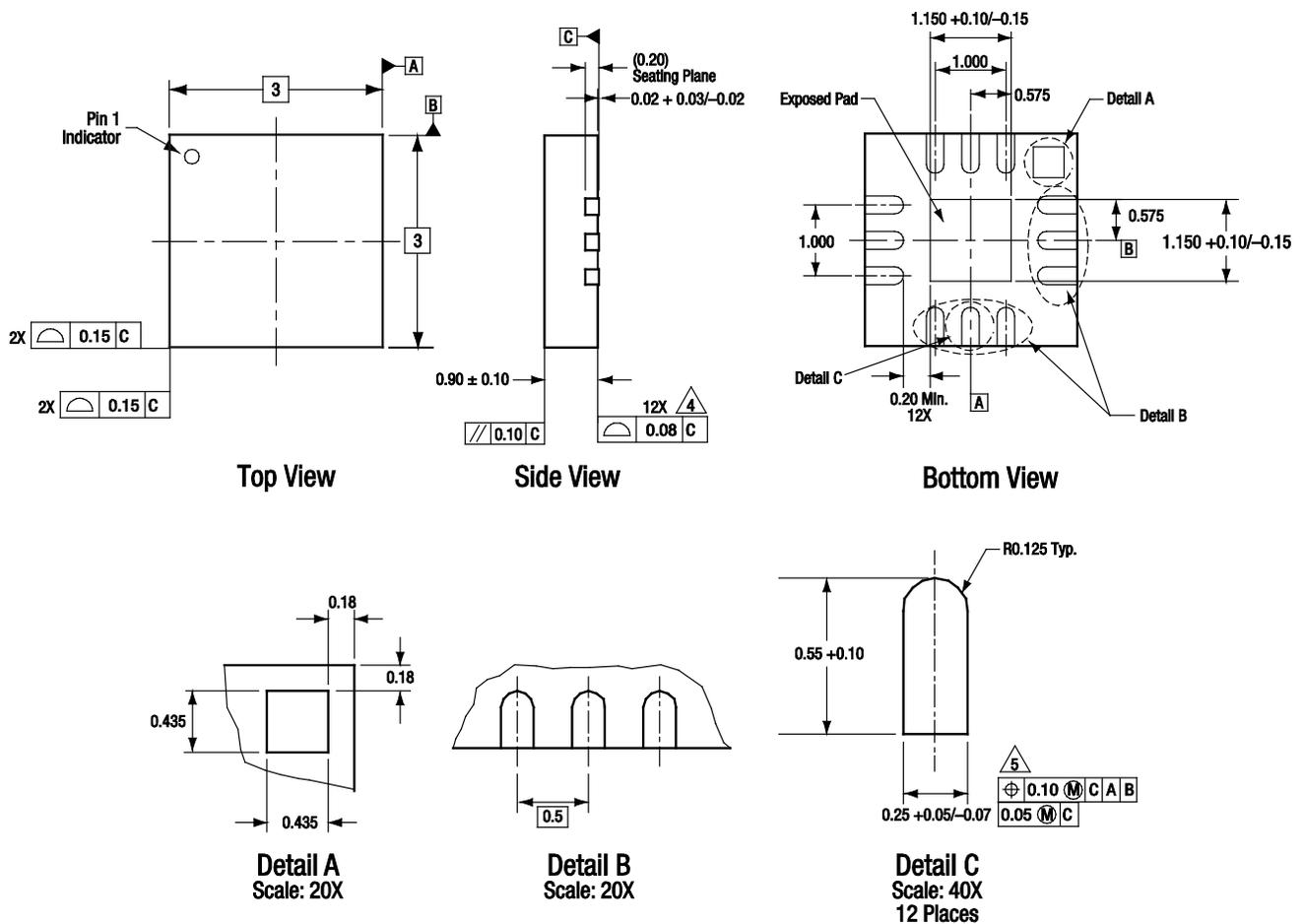
All measurements are in millimeters.
Dimensioning and tolerancing according to ASME Y14.5M-1994.
Unilateral coplanarity applies to the exposed heat sink slug as well as the terminals.
Plating requirement per source control drawing (SCD) 2504.
Dimension applies to metallized terminal and is measured between 0.15 and 0.30 mm
*   from the terminal tip. Do not measure at radius area.*

S1866

Figure 11. SKY12355-337LF 12-Pin QFN Package Dimensions

Figure 12. SKY12355-337LF Tape and Reel Dimensions
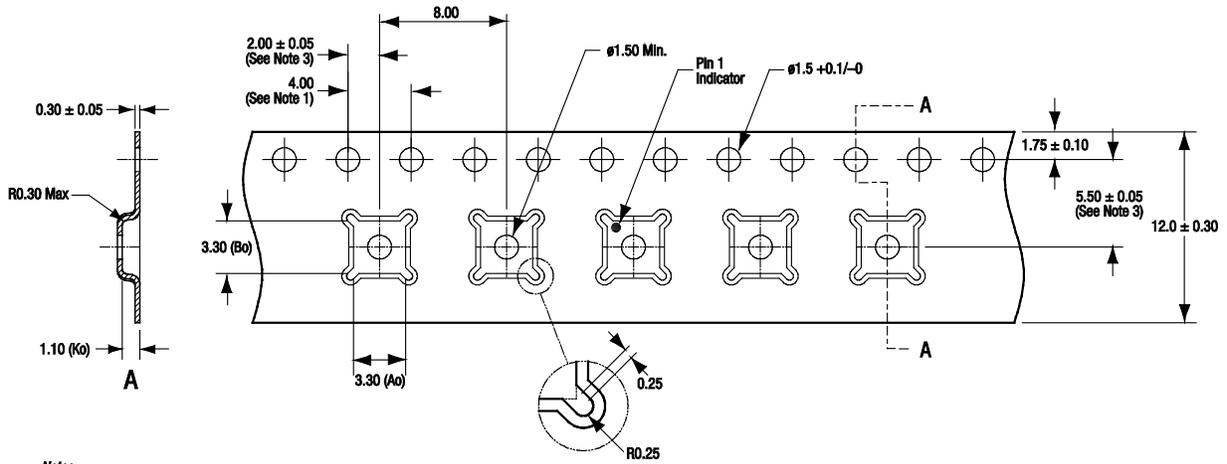
Notes:

1. *Sprocket hole pitch cumulative tolerance: ±0.2.*
2. *Carrier tape: black conductive polystyrene.*
3. *Pocket position relative to sprocket hole, measure as true position of pocket, not pocket hole.*
4. *Cover tape material: transparent conductive PSA, 9.30 mm wide.*
5. *All dimensions are in millimeters.*

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Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Numbers
SKY12355-337LF Digital Attenuator	SKY12355-337LF	SKY12355-337LF-EVB

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