

DATA SHEET

# SKY12239-11: High IIP3 10 MHz to 1.5 GHz Voltage-Controlled Variable Attenuator

## Applications

- Automatic power leveling/gain control circuits in cellular base stations and point-to-point radio IF chains
- General wireless systems including WiMAX, LTE, WCDMA, VSAT, and military communications

## Features

- 10 MHz to 1.5 GHz broadband operating range
- Low insertion loss: 2.5 dB @ 700 MHz
- Maximum attenuation level: 40 dB @ 700 MHz
- Control voltage range: 1 to 5 V
- High IIP3: +50 dBm
- Low current consumption: < 2 mA @ maximum attenuation
- Small MCM (8-pin, 3.8 x 3.8 x 1 mm) package (MSL3, 260 °C per JEDEC J-STD-020)

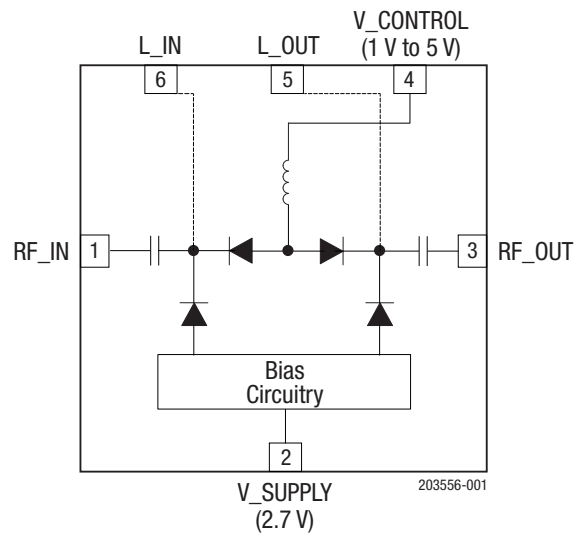


Figure 1. SKY12239-11 Block Diagram



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## Description

The SKY12239-11 is a voltage-controlled variable attenuator from Skyworks series of broadband, flat attenuation, high third order input intercept point (IIP3) components. The device has been designed to operate over the 10 MHz to 1.5 GHz frequency band, and is specifically optimized for use as a wide dynamic range, low distortion attenuator.

The SKY12239-11 provides monotonic attenuation performance over its entire control voltage range. This attenuator is comprised of four matched PIN diodes that are biased using an external control voltage signal. The attenuator requires no external components. It operates with a control voltage range of 1 to 5 V and a 2 mA typical control current at maximum attenuation.

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.

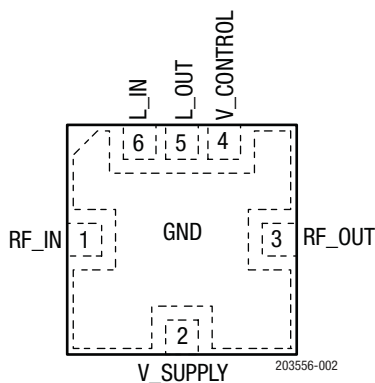


Figure 2. SKY12239-11 Pinout (Top View)

**Table 1. SKY12239-11 Signal Descriptions**

Pin	Name	Description	Pin	Name	Description
1	RF_IN	RF input, AC coupled. No external components required.	5	L_OUT	Phase compensation inductor output
2	V_SUPPLY	Fixed reference supply, 2.7 Vdc.	6	L_IN	Phase compensation inductor input
3	RF_OUT	RF output, AC coupled. No external components required.	7	GND	Paddle of the device. Ground to the Applications Board. Provides thermal contact and RF ground.
4	V_CONTROL	Variable reference supply, 1.0 V to 5.0 Vdc.			

### Technical Description

The SKY12239-11 is a 50 Ω matched voltage controlled variable attenuator with monotonic attenuation performance from 10 MHz to 1.5 GHz over its entire control voltage range. This attenuator requires no external biasing or RF matching components.

Monotonic performance means the attenuation increases or decreases as the applied DC voltage increases or decreases. This attenuator is comprised of four matched PIN diodes that terminate two ports of an internal matching network.

The diodes are biased using an external control voltage signal that sets the bias current through a resistive network. The attenuator operates with a control voltage range of 1 to 5 V and a 2 mA typical control current at maximum attenuation. As the control voltage increases, the bias current through each of the PIN diodes also increases.

This increased bias current lowers the resistance of the PIN diodes. Maximum attenuation occurs when the resistance of the PIN diodes is at maximum (control voltage of approximately 1 VDC).

### Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY12239-11 are provided in Table 2. Electrical specifications are provided in Table 3.

Performance characteristics for the SKY12239-11 are illustrated in Figures 3 through 8.

**Table 2. SKY12239-11 Absolute Maximum Ratings<sup>1</sup>**

Parameter	Symbol	Minimum	Maximum	Units
Control voltage	VCTRL	0	5.5	V
Reference voltage	VSUPPLY		5.5	V
RF input power (CW)	PIN		1	W
Control current	ICC		50	mA
Thermal impedance (VCTRL = 5 V, VSUPPLY = 2.7 V, PIN = +21 dBm)	θJC		+94	°C/W
Storage temperature	TSTG	-55	+125	°C
Operating temperature	TOP	-40	+105	°C
Electrostatic discharge:	ESD			
Charged Device Model (CDM), Class C3			1000	V
Human Body Model (HBM), Class 2			3000	V

<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 value. 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. SKY12239-11 Electrical Specifications<sup>1</sup>**

(TOP = +25 °C, VCTRL = 1 to 5 V, VSUPPLY = 2.7 V, PIN = 0 dBm, Characteristic Impedance [Zo] = 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min <sup>2</sup>	Typ	Max	Units
<b>RF Specifications</b>						
Insertion loss (VCTRL = 5 V)	IS21I	100 MHz		2		dB
		700 MHz		2.5	3.5	dB
		1500 MHz		3		dB
Maximum attenuation (VCTRL = 1 V)	IS21I	100 MHz		51		dB
		700 MHz	35	40		dB
		1500 MHz		33		dB
IRL maximum attenuation (VCTRL = 1 V)	IS11I	100 MHz		29		dB
		700 MHz		28		dB
		1500 MHz		22		dB
ORL maximum attenuation (VCTRL = 1 V)	IS22I	100 MHz		29		dB
		700 MHz		27		dB
		1500 MHz		21		dB
IRL minimum attenuation (VCTRL = 5 V)	IS11I	100 MHz		37		dB
		700 MHz		19		dB
		1500 MHz		13		dB
ORL minimum attenuation (VCTRL = 5 V)	IS22I	100 MHz		37		dB
		700 MHz		19		dB
		1500 MHz		13		dB
Third order input intercept point (VCTRL = 5 V)	IIP3	100 MHz, 1 MHz tone spacing, +22 dBm/tone		50		dBm
		700 MHz, 1 MHz tone spacing, +22 dBm/tone		50		dBm
		1500MHz, 1 MHz tone spacing, +22 dBm/tone		50		dBm
1 dB input compression point (VCTRL = 5 V)	IP1dB	12.5% duty cycle		34		dBm
				40		dBm
				40		dBm
Phase shift @ 150 nH <sup>3</sup>	φ	700 MHz		15		degree
<b>DC Specifications</b>						
Control voltage (VCTRL)	VCTRL	1.0 to 5.0 V nominal	1	5	5.5	V
Control current (ICTRL)	ICTL	5.0 V, VCTRL; 2.7 V, VSUPPLY		20		mA
Supply voltage (VSUPPLY)	VSUPPLY	Fixed supply		2.7		V
Supply current (ISUPPLY)	ISUPPLY			2		mA
Settling time @ 700 MHz	tSETTLE	VSUPPLY = 2.7 V, VCTRL change from 5 V to 1 V, settled within 0.2 dB of respective state, 10 KHz repetitive rate, 50% duty cycle		8		μs

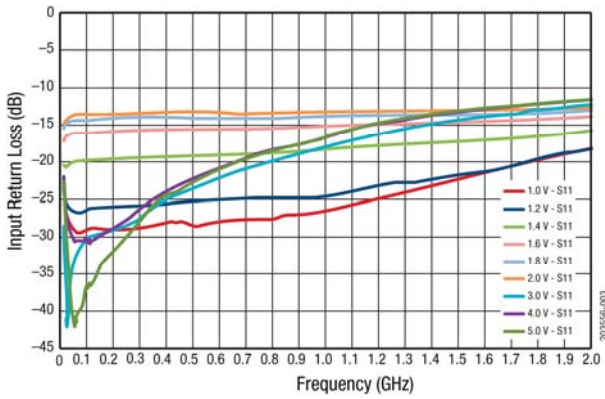
<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.

<sup>2</sup> Minimum specification is guaranteed by design and is not 100% production tested.

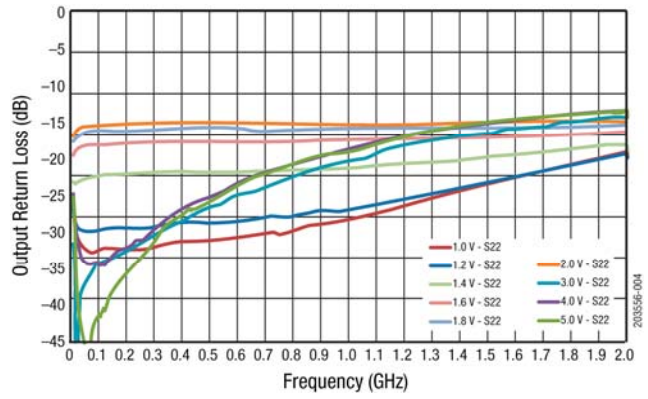
<sup>3</sup> L1 is 0201 size, 150 nH inductor from TDK. Part number is MLG0603SR15J.

**Typical Performance Characteristics**

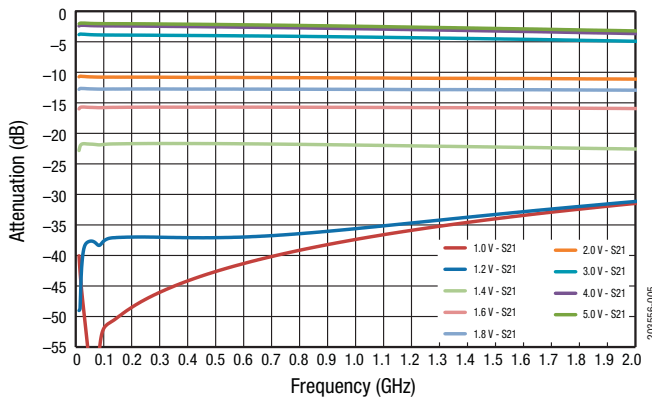
(TOP = +25 °C, VCTRL = 0 to 5 V, PIN = 0 dBm, Characteristic Impedance [Z0] = 50 Ω, J1 = Input Port, J2 = Output Port, Unless Otherwise Noted)



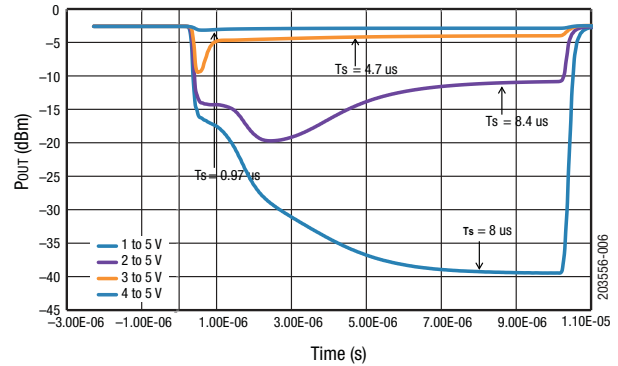
**Figure 3. Attenuation vs Frequency over Control Voltage**



**Figure 4. Input Return Loss vs Frequency over Control Voltage**

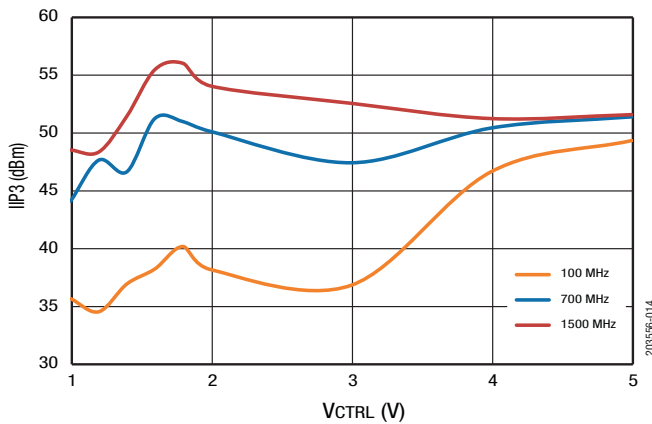


**Figure 5. Output Return Loss vs Frequency over Control Voltage**

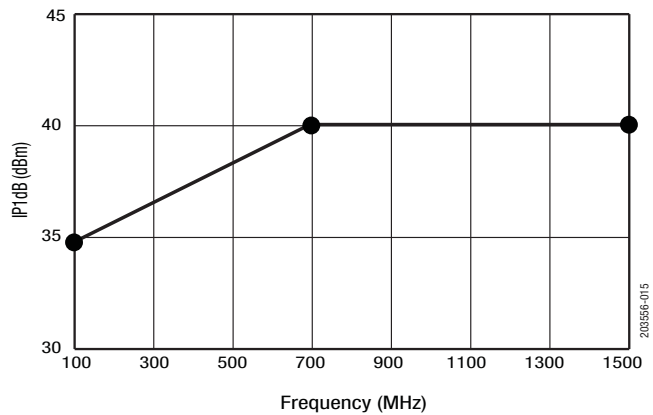


Note: Settling Time -0.2 dB from final settled value.

**Figure 6. Settling Time -Falling Edge (f = 700 MHz, Rep Rate = 50 kHz, Duty Cycle = 50%, 25 °C)**



**Figure 7. IIP3 vs VCTRL over Frequency (1 MHz tone spacing, +22 dBm/tone)**



**Figure 8. IP1dB vs Frequency**

### Evaluation Board Description

The SKY12239-11 Evaluation Board is used to test the performance of the SKY12239-11 variable attenuator. A schematic of the Evaluation Board is shown in Figure 9. Table 4 lists the Bill of Materials. An assembly drawing for the Evaluation Board is shown in Figure 10. The Evaluation Board layer detail is shown in Figure 11.

The attenuation level of the SKY12239-11 is controlled by applying 1 to 5 V to the V\_CONTROL pins.

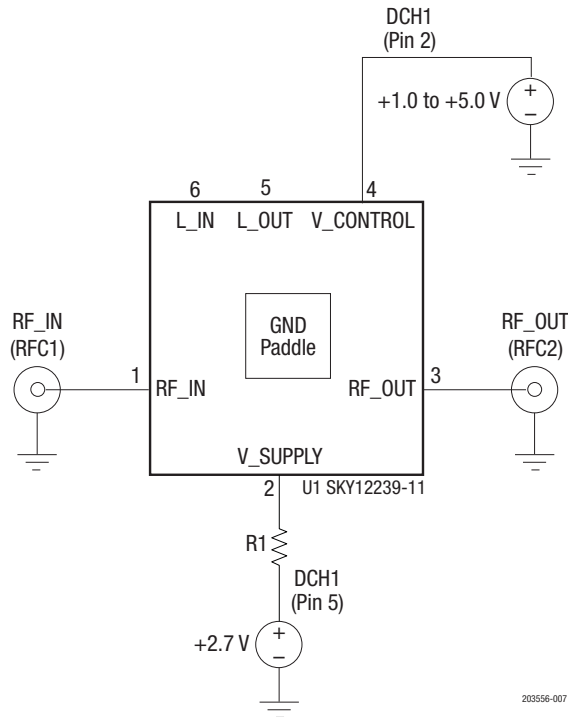


Figure 9. SKY12239-11 Evaluation Board Schematic

Table 4. SKY12239-11 Evaluation Board Bill of Materials (BOM)

Component	Description	Value	Size
R1	Resistor	0 Ω	0402
L1	Inductor	DNI	0402

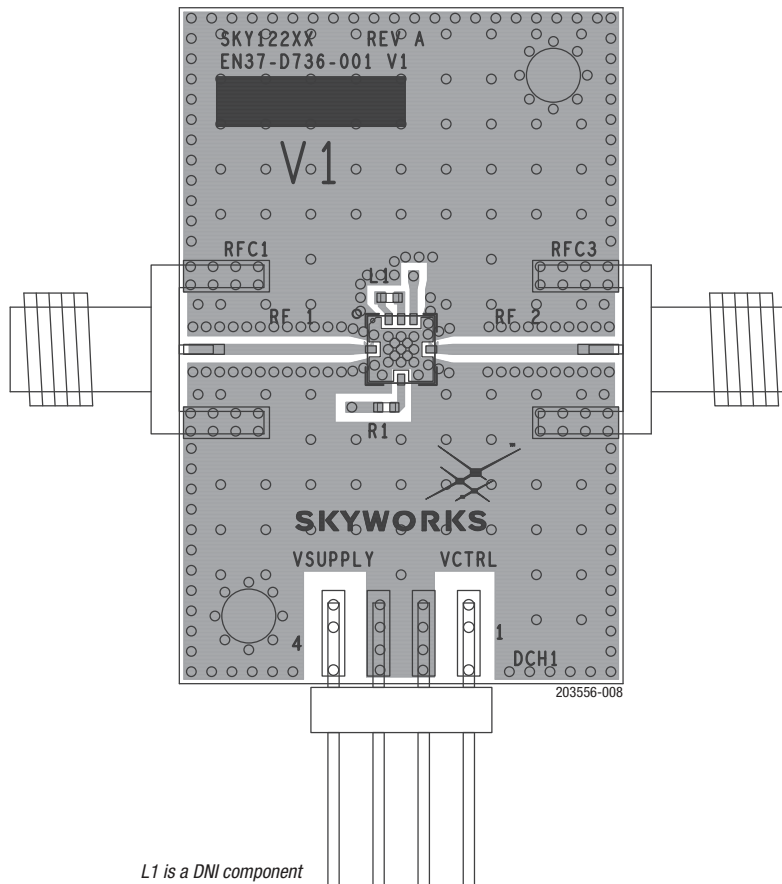


Figure 10. SKY12239-11 Evaluation Board Assembly Diagram

Cross Section	Name	Thickness (in)	Material
	Top Solder Mask		
	L1	(0.0007)	Finished Copper Thickness
	Dielectric	0.010	Rogers R04350 Core
	L2	(0.0007)	Finished Copper Thickness
	Dielectric	(Note 1)	FR4 Prepreg
	L3	(0.0007)	Finished Copper Thickness
	Bottom Solder Mask		

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

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Figure 11. Layer Detail Physical Characteristics

## Package Dimensions

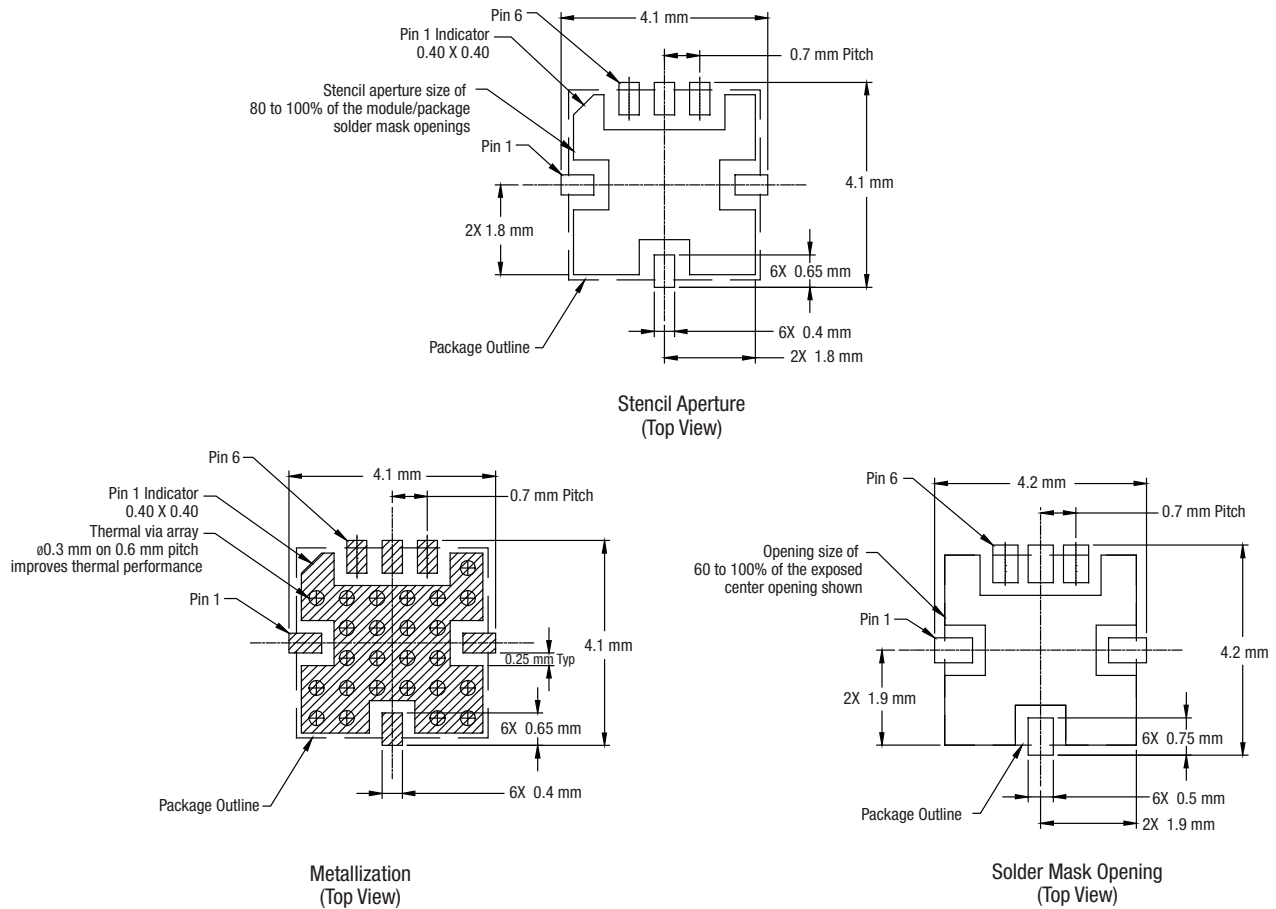
The PCB layout footprint for the SKY12239-11 is shown in Figure 12. Typical part markings are shown in Figure 13. Package dimensions are shown in Figure 14, and tape and reel dimensions are provided in Figure 15.

## Package and Handling Information

Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. 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 SKY12239-11 is rated to Moisture Sensitivity Level 3 (MSL3) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *PCB Design & SMT Assembly/Rework Guidelines for MCM-L Packages*, document number 101752.

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.

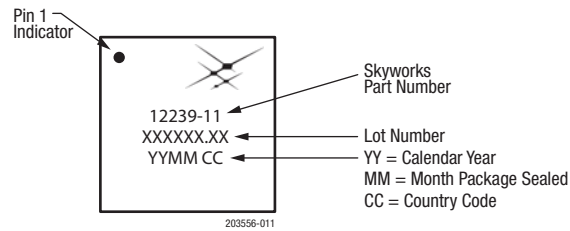


**Notes:**

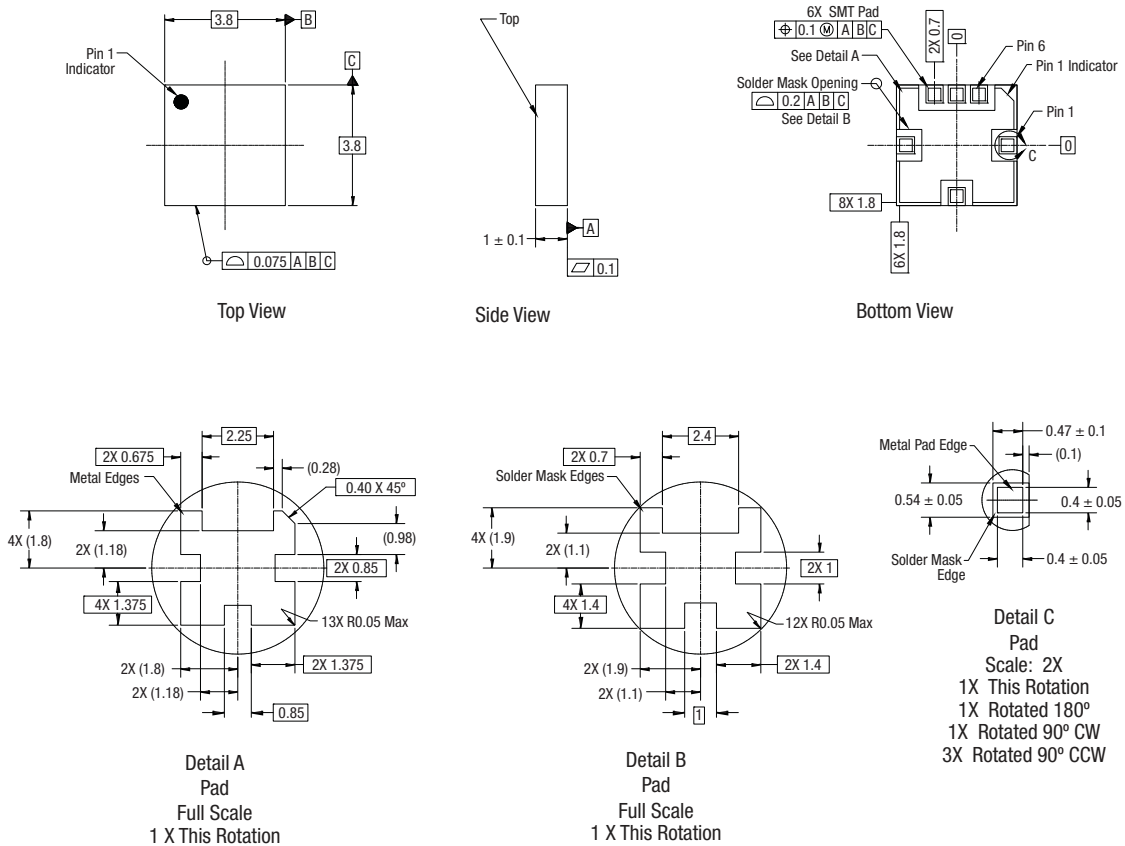
1. Thermal vias should be resin filled and capped in accordance with IPC-4761 type VII vias.
2. Recommended Cu thickness is 30 to 35  $\mu\text{m}$ .

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**Figure 12. SKY12239-11 PCB Layout Footprint**

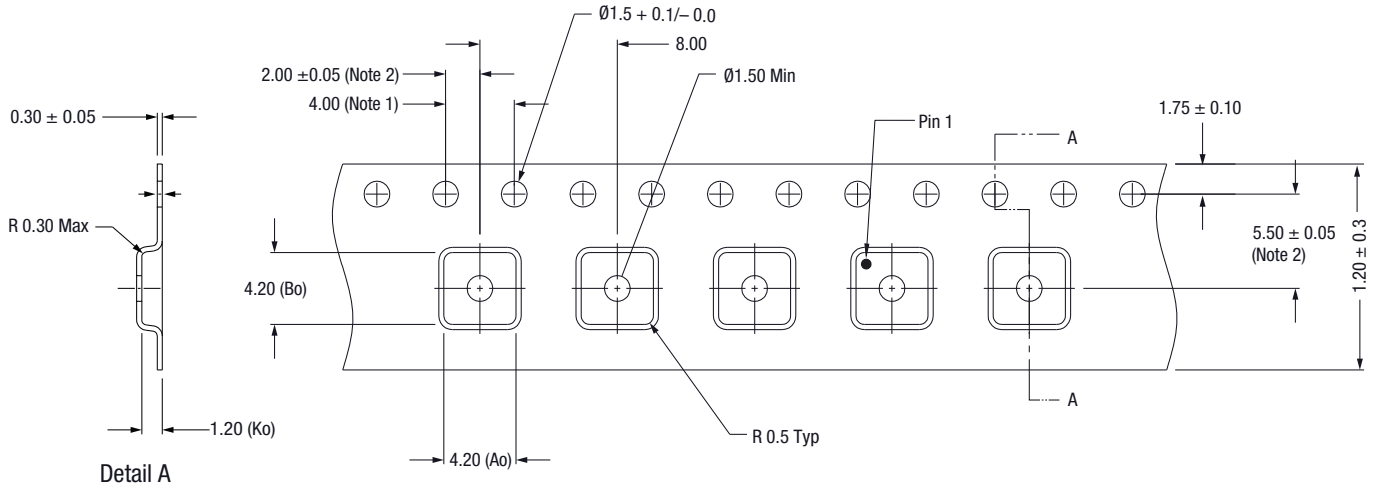


**Figure 13. Typical Part Markings (Top View)**



**Figure 14. SKY12239-11 Package Dimensions**





Notes:

1. 10-sprocket hole pitch cumulative tolerance:  $\pm 0.2$  mm.
2. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.
3. Ao and Bo are calculated on a plane at a distance "R" above the bottom of the pocket.
4. All dimensions are in millimeters.

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Figure 15. SKY12239-11 Tape and Reel Dimensions

## Ordering Information

Part Number	Product Description	Evaluation Board Part Number
SKY12239-11	High IIP3 10 MHz to 1.5 GHz Voltage-Controlled Variable Attenuator	SKY12239-11-EVB

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