DATA SHEET

SKY12213-478LF: 0.5 to 6.0 GHz, 150 W High Power Silicon PIN Diode SPST Switch

Applications

- Failsafe switching in TD-SCDMA, WiMAX, and LTE TDD base stations
- On/off switching in land mobile radios and military communications systems
- High power series diodes

Features

- High power handling: 150 W CW
- Low insertion loss: 0.5 to 1.0 dB typical
- High isolation: 23 dB typical
- Controlled with positive power supply
- Small, QFN (16-pin, 4 x 4 mm) Pb-free package (MSL1, 260 °C per JEDEC J-STD-020)

Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04-0074.

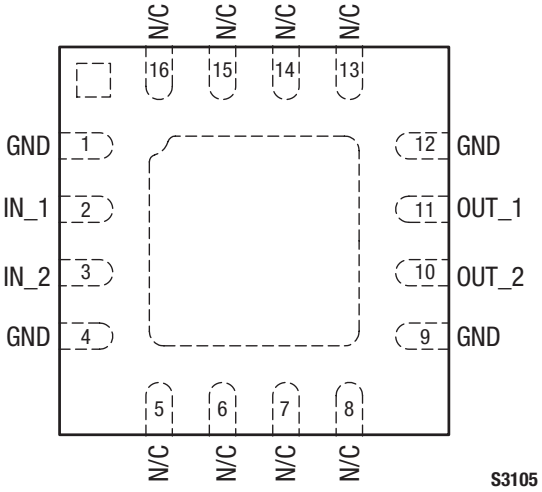


Figure 2. SKY12213-478LF Pinout – 16-Pin QFN (Top View)

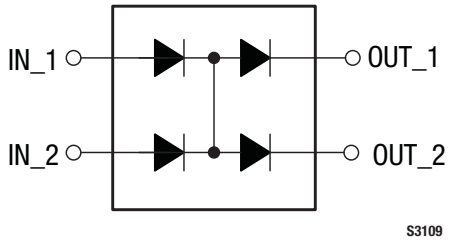


Figure 1. SKY12213-478LF Block Diagram

Description

The SKY12213-478LF is a high power handling, Single-Pole, Single-Throw (SPST) silicon PIN diode switch. The device operates over the 0.5 GHz to 6.0 GHz band. It features low insertion loss, excellent power handling, and superb linearity with low DC power consumption.

The SKY12213-478LF is well-suited for use as a high power SPST switch in a variety of telecommunication systems such as WiMAX, TD-SCDMA, or LTE base stations. It can also be used as a high power series diode in a multitude of PIN diode applications.

The device is provided in a 4 x 4 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.

Table 1. SKY12213-478LF Signal Descriptions

Pin	Name	Description	Pin	Name	Description
1	GND	Ground. Must be connected to ground using lowest possible impedance.	9	GND	Ground. Must be connected to ground using lowest possible impedance.
2	IN_1	Input RF port 1 and DC bias input port.	10	OUT_2	Output RF port 2 and DC bias input port.
3	IN_2	Input RF port 2 and DC bias input port.	11	OUT_1	Output RF port 1 and DC bias input port.
4	GND	Ground. Must be connected to ground using lowest possible impedance.	12	GND	Ground. Must be connected to ground using lowest possible impedance.
5	N/C	No connection	13	N/C	No connection
6	N/C	No connection	14	N/C	No connection
7	N/C	No connection	15	N/C	No connection
8	N/C	No connection	16	N/C	No connection

Table 2. SKY12213-478LF Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Units
RF CW input power @ input ports ($T_{SUBSTRATE}$ = 25 °C)	P_{IN}		190	W
RF peak input power @ input ports ($T_{SUBSTRATE}$ = 25 °C, RF burst width = 10 µs, RF burst repetition rate = 25 kHz)	P_{IN}		760	W
Control port reverse voltage	V_{CTL}		200	V
Control port forward current	I_{CTL}		200	mA
Operating temperature	T_{OP}	–55	+175	°C
Storage temperature	T_{STG}	–55	+200	°C
Electrostatic discharge:	ESD			
Charged Device Model (CDM), Class 4			1000	V
Human Body Model (HBM), Class 2			2000	V
Machine Model (MM), Class B			200	V

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. Recommended Operating Conditions

Parameter	Symbol	Min	Typical	Max	Units
Control port forward voltage	V_{CTL}	0	+28	+100	V
Control port reverse voltage	V_{CTL}	–100	–28	0	V
Control port forward current	I_{CTL}	50	100	100	mA

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY12213-478LF are provided in Table 2. Recommended operating conditions are specified in Table 3. Electrical specifications are provided in Table 4.

The state of the SKY12213-478LF is determined by the logic provided in Table 5. Table 6 provides the logic for use with the SKY12213-478LF Evaluation Board.

Typical performance characteristics of the SKY12213-478LF are illustrated in Figures 3 through 6.

Power derating data is plotted against temperature in Figures 7 and 8. "On/off" switch state circuit diagrams are shown in Figure 9.

Table 4. SKY12213-478LF Electrical Specifications, Bias Voltage = 28 V (1 of 2) (Note 1)
(T_{OP} = +25 °C, Characteristic Impedance [Z_0] = 50 Ω, EVB Optimized for 2.6 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Insertion loss, IN_1/2 to OUT_1/2 ports	IL	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, P_{IN} @ IN_1/2 ports = 0 dBm:				
		0.5 GHz		1.30		dB
		1.0 GHz		0.27		dB
		2.6 GHz		1.10	1.40	dB
		3.5 GHz		0.54		dB
		6.0 GHz		1.30		dB
Isolation, IN_1/2 to OUT_1/2 ports	Iso	Pins 2 & 3 = 0 V @ 0 mA, pins 10 & 11 = 0 V, P_{IN} @ IN_1/2 ports = 0 dBm:				
		0.5 GHz		34		dB
		1.0 GHz		26		dB
		2.6 GHz	20	24		dB
		3.5 GHz		24		dB
		6.0 GHz		20		dB
Input return loss	|S11|	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, IN_1/2 ports insertion loss state, 0.5 to 6.0 GHz		15		dB
Output return loss	|S22|	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, OUT_1/2 ports insertion loss state, 0.5 to 6.0 GHz		15		dB
2nd harmonic	2fo	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, IN_1/2 ports insertion loss state, P_{IN} = +30 dBm:				
		0.5 GHz		–101		dBc
		1.0 GHz		–98		dBc
		2.6 GHz		–108		dBc
		3.5 GHz		–112		dBc
		6.0 GHz		–95		dBc

Table 4. SKY12213-478LF Electrical Specifications, Bias Voltage = 28 V (2 of 2) (Note 1)
(T_{OP} = +25 °C, Characteristic Impedance [Z_0] = 50 Ω, EVB Optimized for 2.6 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
3rd harmonic	3fo	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, IN_1/2 ports insertion loss state, P_{IN} = +30 dBm:				
		0.5 GHz		–102		dBc
		1.0 GHz		–108		dBc
		2.6 GHz		–111		dBc
		3.5 GHz		–115		dBc
		6.0 GHz		–93		dBc
3rd Order Input Intercept Point	IIP3	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, P_{IN} @ IN_1/2 ports = +30 dBm/tone, tone spacing = 1 MHz, 2.6 GHz		+72		dBm
0.1 dB Input Compression Point	IP0.1dB	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, 2.6 GHz		+47		dBm
Maximum CW input power	P_{IN_CW}	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, 2.6 GHz		150		W
RF switching time	tsw	Pins 2 & 3 = +28 V @ 100 mA, pins 10 & 11 = 0 V, 10% to 90% RF rise time, repetition rate = 25 kHz		190		ns

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

Table 5. SKY12213-478LF Truth Table

Switch State (See Figure 9)	Path	Control Conditions	
	IN_1/2 to OUT_1/2 (pins 2,3 to pins 10, 11)	Input Port Bias (Pins 2, 3) (V)	Output Port Bias (Pins 10, 11) (mA)
On	Low insertion loss	+28	–100
Off	High isolation	–28	0

Table 6. SKY12213-478LF Evaluation Board Truth Table

Switch State (See Figure 9)	Path	Control Conditions	
	RFIN to RFOUT	Bias 1 Port (V)	Bias 2 Port
On	Low insertion loss	+28	ground
Off	High isolation	–28	ground

Typical Performance Characteristics

(T_{OP} = +25 °C, Characteristic Impedance [Z_0] = 50 Ω, EVB Optimized for 2.6 GHz Operation, Bias = 28 V/100 mA, Unless Otherwise Noted)

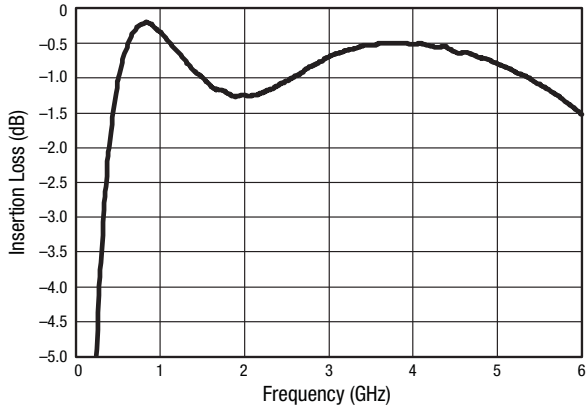


Figure 3. Insertion Loss vs Frequency

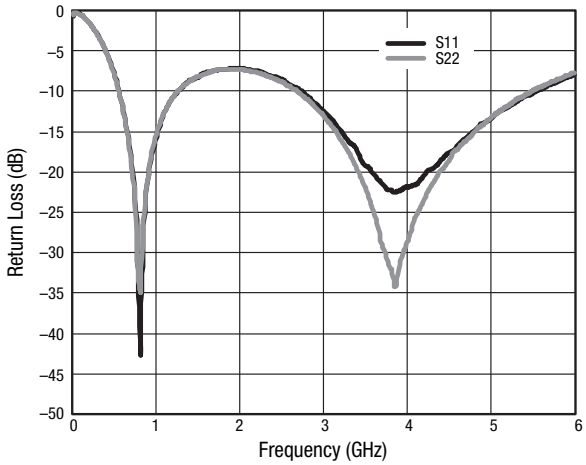


Figure 4. Return Loss vs Frequency

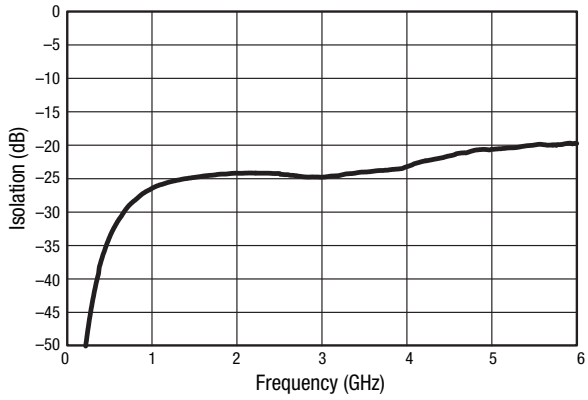


Figure 5. Isolation vs Frequency

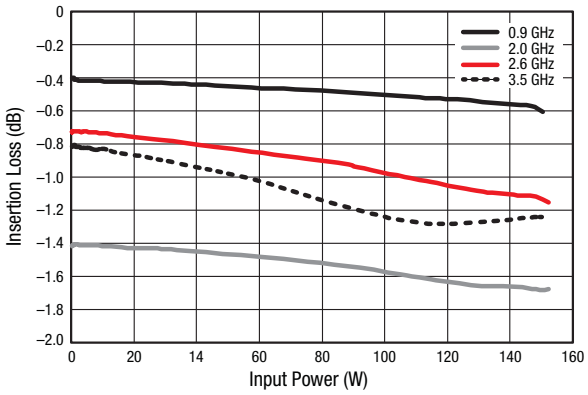


Figure 6. Insertion Loss vs CW Input Power

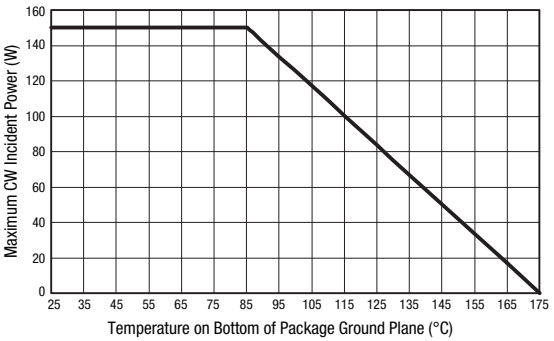


Figure 7. Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Ground Plane Temperature

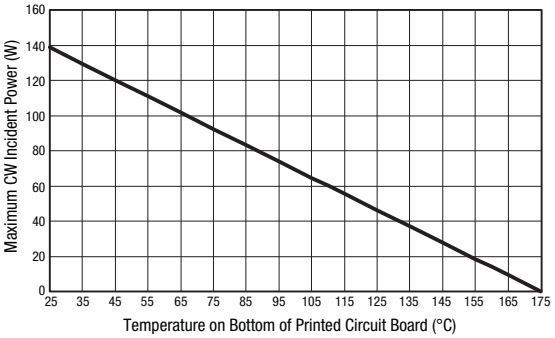


Figure 8. Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Circuit Board Temperature

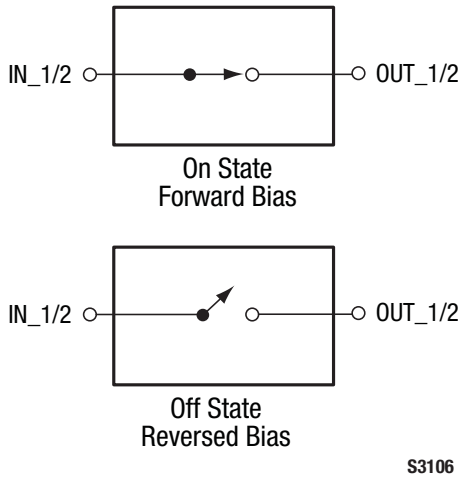


Figure 9. SKY12213-478LF Equivalent Circuit Diagrams

Evaluation Board Description

The SKY12213-478LF Evaluation Board is used to test the performance of the SKY12213-478LF PIN Diode SPST switch. An assembly drawing for the Evaluation Board is shown in Figure 10. The layer detail is provided in Figure 11.

The SKY12213-478LF is designed to handle very large signals. Sufficient power may be dissipated by this switch to cause heating of the PIN diode contained in the switch. It is very important to use a printed circuit board design that provides adequate cooling capability to keep the junction temperature of the PIN diode below its maximum rated operating temperature.

As indicated in Figure 7, the x-axis temperature is referenced to the bottom of the QFN package. A printed circuit board with a very low thermal resistance and external heat sink design must be used to achieve the results shown in this Figure. The power derating curve with the x-axis temperature referenced to the bottom of the printed circuit board is provided in Figure 8.

Due to the very high power level requirements on the SKY12213-478LF and the input DC blocking capacitors, antenna port connections are combined outside the package on the Evaluation Board. The schematic diagram shown in Figure 12 indicates how these connections are made.

The evaluation circuit is designed to facilitate control of the SKY12213-478LF. The state of the PIN diode within the SKY12213-478LF is controlled with +28 V applied to the Bias 1 (input) port; the Bias 2 (output) port is connected to DC ground. The switch state circuit diagrams are shown in Figure 9.

The values of resistors R3 and R4 (refer to the schematic diagram in Figure 12), which are both nominally 280 Ω, determine how much current flows through the forward biased diode.

For example, to place the SKY12213-478LF into the “on” state, +28 V is applied to the Bias 1 port, which forward biases the diode between pins 2 and 3, and pins 10 and 11.

The values of R3 and R4 may be adjusted to accommodate other bias voltages. A resistance value of 280 Ω is selected to produce approximately 100 mA of forward bias current in the diodes, which are forced into conduction when the bias source voltage is +28 V.

The component values shown in the Evaluation Board schematic (Figure 12) were selected to optimize performance over the 0.5 to 6.0 GHz band.

Refer to Table 7 for the Evaluation Board Bill of Materials. Table 8 provides voltage, current, and resistor values for bias adjustments.

Package Dimensions

The PCB layout footprint for the SKY12213-478LF is shown in Figure 13. Typical case markings are noted in Figure 14. Package dimensions for the 16-pin QFN are shown in Figure 15, and tape and reel dimensions are provided in Figure 16.

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 SKY12213-478LF 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.

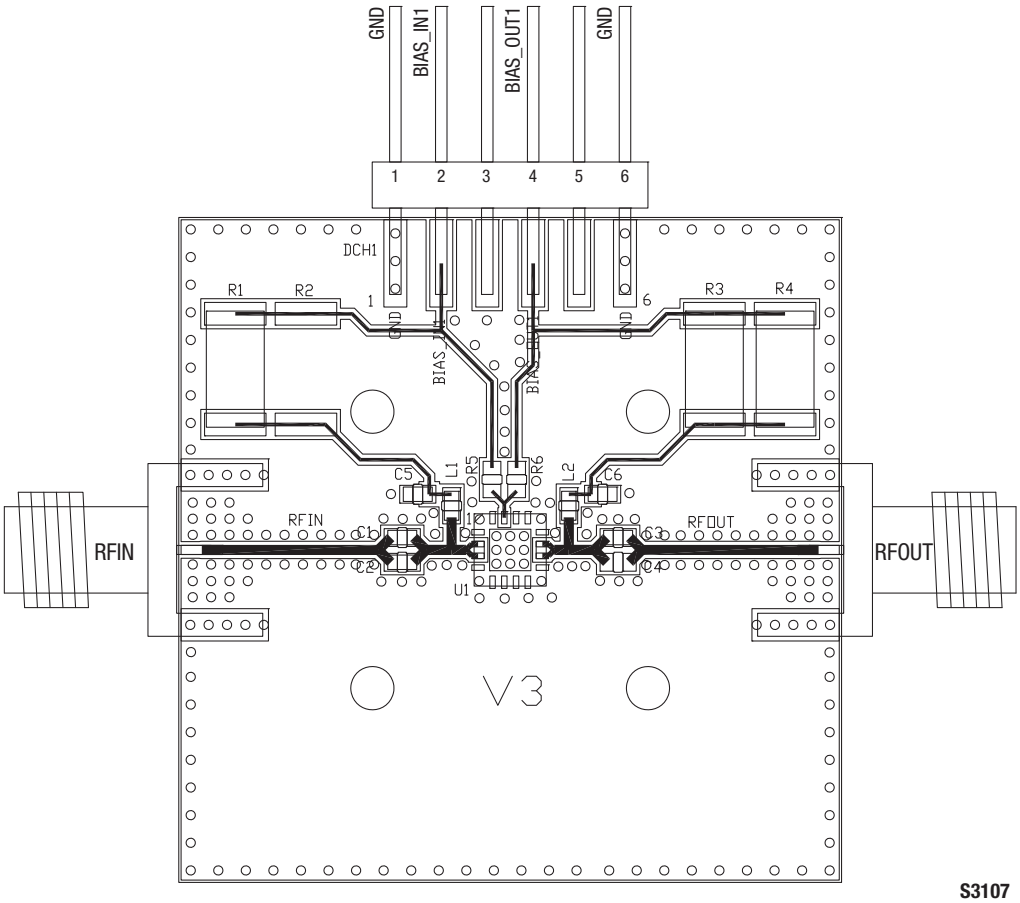
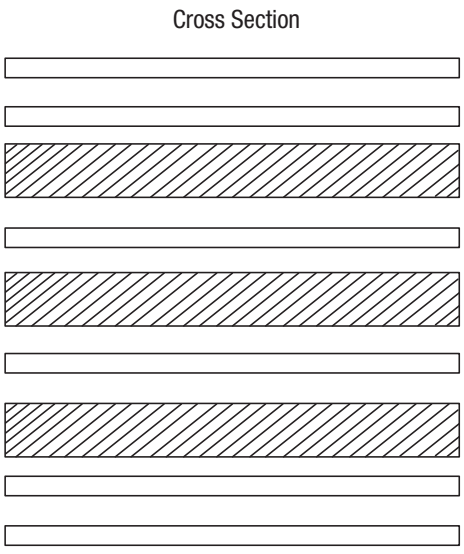


Figure 10. SKY12213-478LF Evaluation Board Assembly Diagram

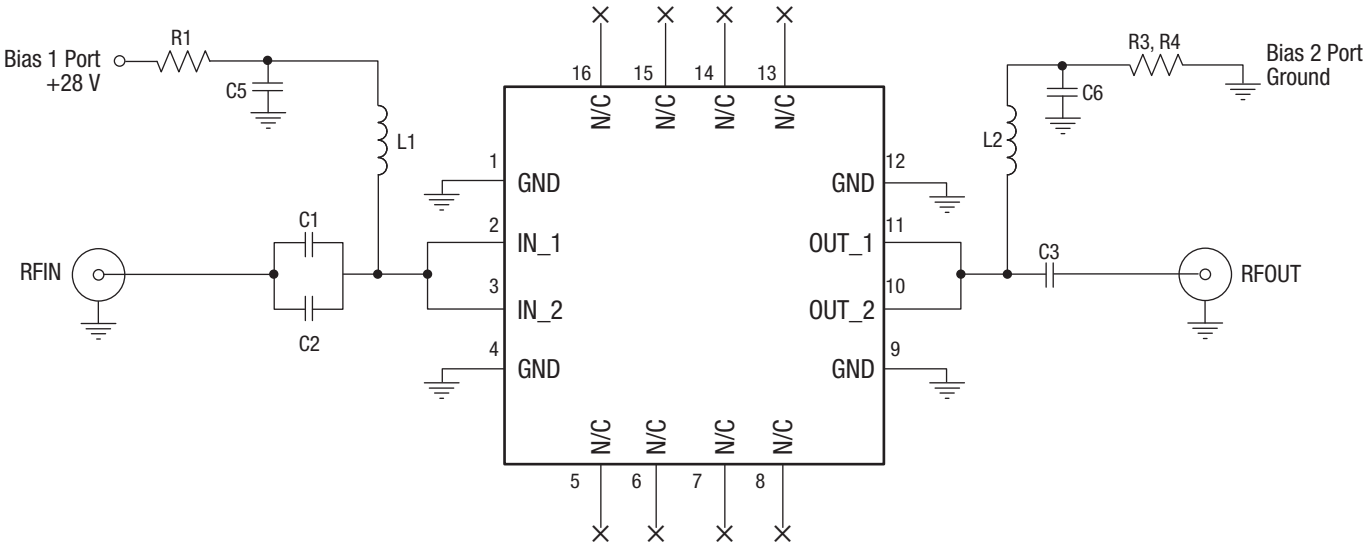


Cross Section	Name	Thickness (in)	Material
	Top Soldermask		
	L1	(0.0028)	Cu foil
	Laminate	0.012 ± 0.0006	Rogers RO4003C Core
	L2	(0.0014)	Cu foil
	Laminate	(Note 1)	FR4 Prepreg
	L3	(0.0014)	Cu foil
	Laminate	0.010 ± 0.0006	FR4 Core
	L4	(0.0028)	Cu foil
	Bottom Soldermask		

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

S2531

Figure 11. Layer Detail Physical Characteristics



NOTE: The N/C pins (5 to 8 and 13 to 16) are not internally connected, so they can be left open or grounded.

S3108

Figure 12. Evaluation Board Schematic

Table 8. Evaluation Board Bill of Materials (Note 1)

Component	Value	Size	Manufacturer	Mfr Part Number	Characteristics
C1, C2, C3, C5, C6	1000 pF	0603	TDK	C1608C0G1H102JT	COG, 50 V, ±5%
C4	DNI	–	–	–	–
L1, L2	22 nH	0603	Taiyo-Yuden	HK160822NJ-T	SRF 1600 MHz, ±5%
R1	0 Ω	2512	Vishay Dale	CRCW25120000Z0EG	500 V, 1 W
R2, R5, R6	DNI	–	–	–	–
R3, R4 (Note 2)	560 Ω	2512	Multicomp	MCPWR12FTEA5600	Total value = 280 Ω, 500 V, 1.5 W, ±1%

Note 1: Component values selected are based on the desired frequency and bias level. Values may be adjusted for a specific response.

Note 2: Evaluation Board includes a 280 Ω resistor for 28 V, 100 mA operation. Operating at 28 V and 100 mA requires a resistor with a power dissipation greater than 2.8 W.

Table 9. Component Calculation Values

V_S (V)	V_{DIODE} (V)	V_{RES} (V)	Current (A)	Target Resistance (Ω)	Power Dissipation (W)
28	2	26	0.05	520	1.3
28	2	26	0.10	260	2.6

Notes: V_S = supply voltage; V_{DIODE} = voltage drop across the diode; V_{RES} = voltage drop across the resistor.
Resistor values are calculated by (V_S – V_{DIODE})/I, where I is the desired bias current. The approximate voltage drop across the diode is 2 V.
The resistor power dissipation is calculated by I x (V_S – V_{DIODE}). The resistor selected must be rated to sufficiently handle power greater than the dissipated power.

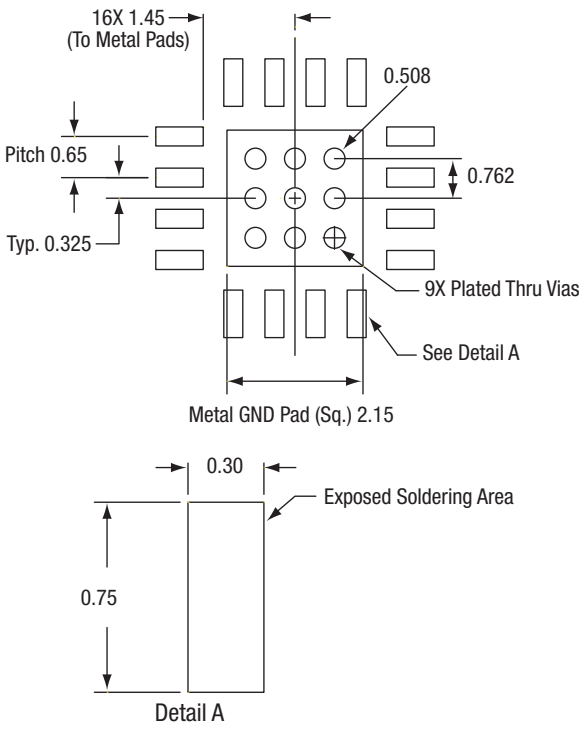


Figure 13. SKY12213-478LF PCB Layout Footprint

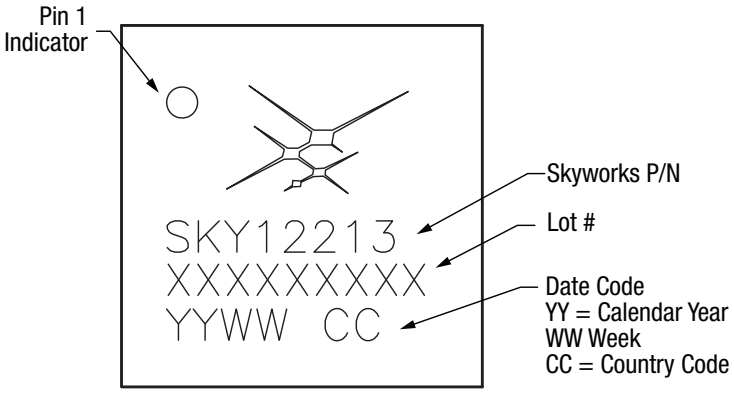
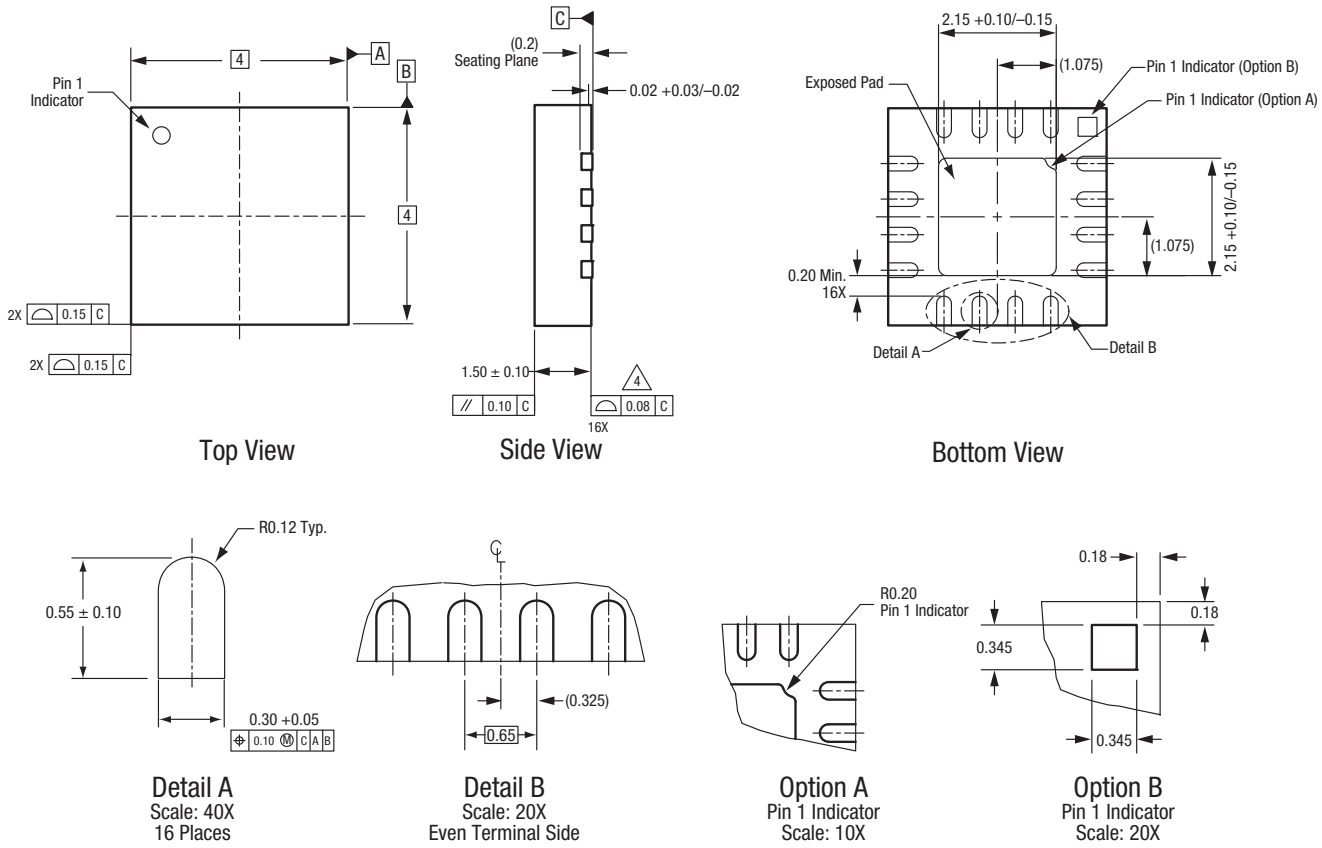


Figure 14. Typical Case Markings



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.
Package may have option A or option B pin 1 indicator.

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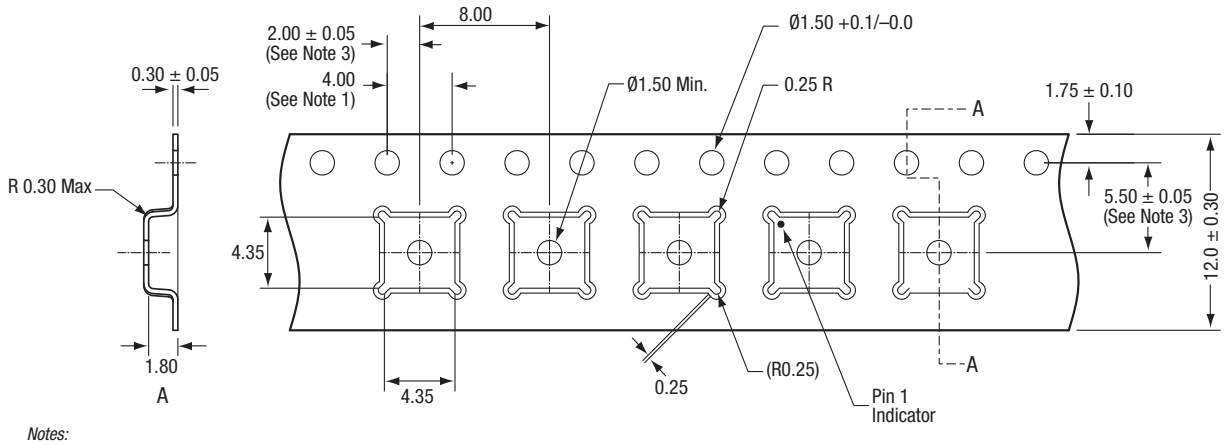
Figure 15. SKY12213-478LF 16-Pin QFN Package Dimensions



Notes:

1. *Sprocket hole pitch cumulative tolerance: ±0.2 mm*
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 adhesive.*
5. *ESD surface resistivity must meet all ESD requirements of Skyworks, specified in GP01-D232.*
6. *All dimensions are in millimeters.*

S2817

Figure 16. SKY12213-478LF Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY12213-478LF PIN Diode SPST Switch	SKY12213-478LF	SKY12213-478LF-EVB

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Наши контакты:

Телефон: +7 812 627 14 35

Электронная почта: sales@st-electron.ru

Адрес: 198099, Санкт-Петербург, Промышленная ул, дом № 19, литера Н, помещение 100-Н Офис 331