DATA SHEET

SKY12212-478LF: 0.05 to 2.70 GHz, 100 W High Power Silicon PIN Diode SPDT Switch

Applications

- Transmit/receive switching and failsafe switching in TD-SCDMA, WiMAX, and LTE base stations
- Transmit/receive switching in land mobile radios and military communication systems

Features

- High-power handling: 100 W CW, 480 W peak
- Low insertion loss: 0.4 dB typical
- High antenna to receive isolation: 44 dB @ 1.2 GHz typical
- Controlled with positive power supply
- Bias driver circuit available on request
- Circuit board for high-power, low-frequency applications available on request
- 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.

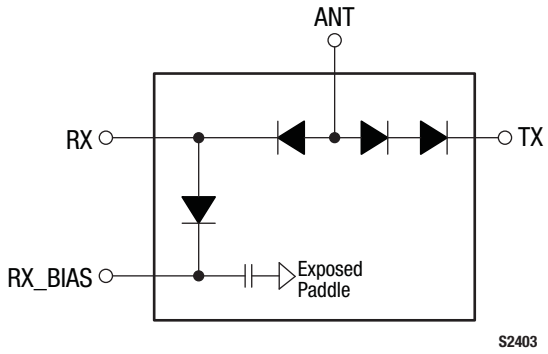

Figure 1. SKY12212-478LF Block Diagram

Description

The SKY12212-478LF is a high-power handling, single-pole, double-throw (SPDT) silicon PIN diode switch. The device operates over the 50 MHz to 2.7 GHz band. It features low insertion loss, excellent power handling, and superb linearity with low DC power consumption.

The SKY12212-478LF is well-suited for use as a high power transmit/receive switch in a variety of telecommunication systems such as WiMAX, TD-SCDMA, or LTE base stations.

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.

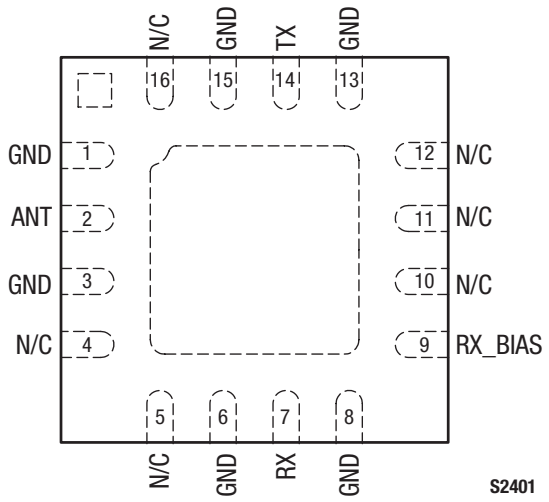

Figure 2. SKY12212-478LF Pinout (Top View)

Table 1. SKY12212-478LF Signal Descriptions

Pin	Name	Description	Pin	Name	Description
1	GND	Ground. Must be connected to ground using lowest possible impedance.	9	RX_BIAS	RF ground port and DC bias input port
2	ANT	Antenna RF port and DC bias input port	10	N/C	No connection
3	GND	Ground. Must be connected to ground using lowest possible impedance.	11	N/C	No connection
4	N/C	No connection	12	N/C	No connection
5	N/C	No connection	13	GND	Ground. Must be connected to ground using lowest possible impedance.
6	GND	Ground. Must be connected to ground using lowest possible impedance.	14	TX	Transmit RF input port and DC bias input port
7	RX	Receive output port and DC bias input port	15	GND	Ground. Must be connected to ground using lowest possible impedance.
8	GND	Ground. Must be connected to ground using lowest possible impedance.	16	N/C	No connection

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY12212-478LF are provided in Table 2. Recommended operating conditions are specified in Table 3 and electrical specifications are provided in Table 4.

Typical performance characteristics of the SKY12212-478LF are illustrated in Figures 3 through 9.

The state of the SKY12212-478LF is determined by the logic provided in Table 6. Table 7 provides the logic for use with the SKY12212-478LF Evaluation Board.

Power derating data is plotted against temperature in Figures 10, 11, and 12. Equivalent circuit diagrams for transmit and receive are shown in Figure 13.

Table 2. SKY12212-478LF Absolute Maximum Ratings[1]

Parameter	Symbol	Minimum	Maximum	Units
RF CW input power, TX and ANT ports ($T_{SUBSTRATE}$ = 25 °C)	P_{IN}		120	W
RF peak input power, TX and ANT ports ($T_{SUBSTRATE}$ = 25 °C, RF burst width = 10 µs, RF burst repition rate = 25 kHz)	P_{IN}		480	W
RF CW input power, RX port ($T_{SUBSTRATE}$ = 25 °C)	P_{IN}		60	W
RF peak input power, RX port ($T_{SUBSTRATE}$ = 25 °C, RF burst width = 10 µs, RF burst repition rate = 25 kHz)	P_{IN}		240	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 1A			250	V
Machine Model (MM), Class A			100	V

[1] 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. Recommended Operating Conditions (Per ANT, TX, RX, and RX_BIAS Inputs)

Parameter	Symbol	Min	Typ	Max	Units
Control port reverse voltage	V_{CTL}	5	28	100	V
Control port forward current	I_{CTL}	50	100	100	mA

Table 4. SKY12212-478LF Electrical Specifications[1] (1 of 2)
(T_{OP} = +25 °C, Characteristic Impedance [Z_0] = 50 Ω, EVB Optimized for 0.05 to 2.70 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Insertion loss, TX to ANT ports	IL_{TX-ANT}	V_{PIN_2} = 2 V, I_{PIN_14} = -100 mA, I_{PIN_9} = -100 mA, V_{PIN_7} = 28 V, TX port P_{IN} @ pin 14 = 0 dBm:				
		50 MHz		0.47		dB
		0.6 GHz		0.29		dB
		1.2 GHz		0.33	0.60	dB
		2.0 GHz		0.46		dB
		2.7 GHz		0.55		dB
Insertion loss, ANT to RX ports	IL_{ANT-RX}	V_{PIN_2} = 1 V, V_{PIN_14} = 28 V, I_{PIN_7} = -133 mA, V_{PIN_9} = 28 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		50 MHz		0.44		dB
		0.6 GHz		0.26		dB
		1.2 GHz		0.24	0.60	dB
		2.0 GHz		0.32		dB
		2.7 GHz		0.34		dB
Isolation, TX to RX ports	$Iso_{\_TX-RX}$	V_{PIN_2} = 1 V, I_{PIN_14} = -100 mA, I_{PIN_9} = -100 mA, V_{PIN_7} = 28 V, TX port P_{IN} @ pin 14 = 0 dBm:				
		50 MHz		47		dB
		0.6 GHz		41		dB
		1.2 GHz	45	50		dB
		2.0 GHz		38		dB
		2.7 GHz		29		dB
Isolation, ANT to TX ports	$Iso_{\_ANT-TX}$	V_{PIN_2} = 1 V, V_{PIN_14} = 28 V, I_{PIN_7} = -133 mA, V_{PIN_9} = 28 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		50 MHz		59		dB
		0.6 GHz		39		dB
		1.2 GHz	30	34		dB
		2.0 GHz		30		dB
		2.7 GHz		28		dB
Isolation, ANT to RX ports	$Iso_{\_ANT-RX}$	V_{PIN_2} = 2 V, I_{PIN_14} = -100 mA, I_{PIN_9} = -100 mA, V_{PIN_7} = 28 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		50 MHz		47		dB
		0.6 GHz		41		dB
		1.2 GHz	40	47		dB
		2.0 GHz		37		dB
		2.7 GHz		29		dB
Input return loss		0.5 to 2.7 GHz:				
		RX insertion loss state, ANT port (@ pin 2)		25		dB
		TX insertion loss state, TX port (@ pin 14)		20		dB

Table 4. SKY12212-478LF Electrical Specifications[1] (2 of 2)
(T_{OP} = +25 °C, Characteristic Impedance [Z_O] = 50 Ω, EVB Optimized for 0.05 to 2.70 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Transmit 2nd harmonic	2fo	TX insertion loss state, TX port P_{IN} @ pin 14 = +30 dBm:				
		50 MHz		-81		dBc
		0.6 GHz		-114		dBc
		1.2 GHz		-90		dBc
		2.0 GHz		-109		dBc
		2.7 GHz		-89		dBc
Transmit 3rd harmonic	3fo	TX insertion loss state, TX port P_{IN} @ pin 14 = +30 dBm:				
		50 MHz		-97		dBc
		0.6 GHz		-98		dBc
		1.2 GHz		-105		dBc
		2.0 GHz		-82		dBc
		2.7 GHz		-90		dBc
Transmit 3rd order input intercept point	IIP3	V_{PIN_2} = 2 V, I_{PIN_14} = -100 mA, I_{PIN_9} = -100 mA, V_{PIN_7} = 28 V, TX port P_{IN} @ pin 14 = +30 dBm/tone, tone spacing = 1 MHz:				
		@ 1.2 GHz		+67		dBm
Transmit 0.1 dB input compression point	IP0.1dB	V_{PIN_2} = 2 V, I_{PIN_14} = -100 mA, I_{PIN_9} = -100 mA, V_{PIN_7} = 28 V:				
		@ 0.05 to 2.70 GHz		+49		dBm
Receive 0.1 dB input compression point	IP0.1dB	V_{PIN_2} = 1 V, V_{PIN_14} = 28 V, I_{PIN_7} = -133 mA, V_{PIN_9} = 28 V:				
		@ 0.05 to 2.70 GHz		+46		dBm
Maximum transmit CW input power	P_{IN_CW}	V_{PIN_2} = 2 V, I_{PIN_14} = -100 mA, I_{PIN_9} = -100 mA, V_{PIN_7} = 28 V:				
		@ 0.05 to 2.70 GHz		100		W
Maximum receive CW input power	P_{IN_CW}	V_{PIN_2} = 1 V, V_{PIN_14} = 28 V, I_{PIN_7} = -133 mA, V_{PIN_9} = 28 V:				
		@ 0.05 to 2.70 GHz		40		W
Transmit RF switching time	t_{SW}	10% to 90% RF rise time, repetition rate = 0.1 MHz, @ 1.20 GHz		600		ns
Thermal resistance (junction to case)	Θ_{JC}			10.5		°C/W

1 Performance is guaranteed only under the conditions listed in this table.

Typical Performance Characteristics

(T_{OP} = +25 °C, Characteristic Impedance [Zo] = 50 Ω, EVB Optimized for 0.05 to 2.70 GHz Operation, Bias = 28 V/100 mA, Unless Otherwise Noted)

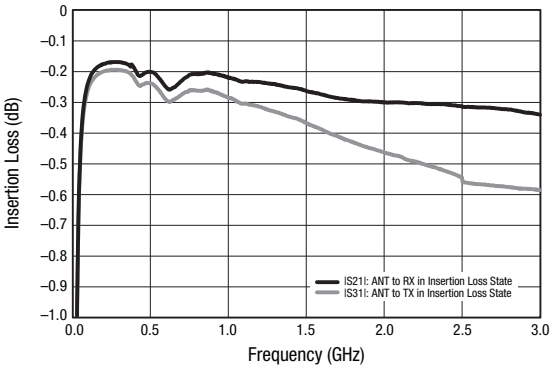

Figure 3. Insertion Loss vs Frequency

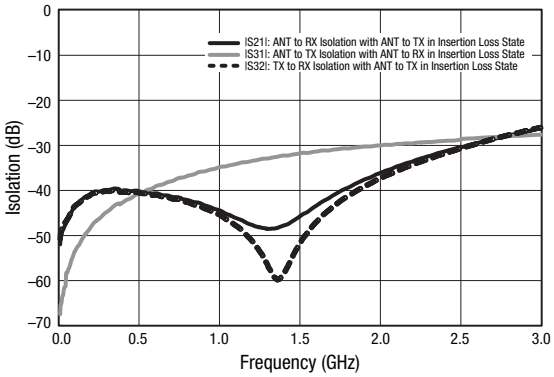

Figure 4. Isolation vs Frequency

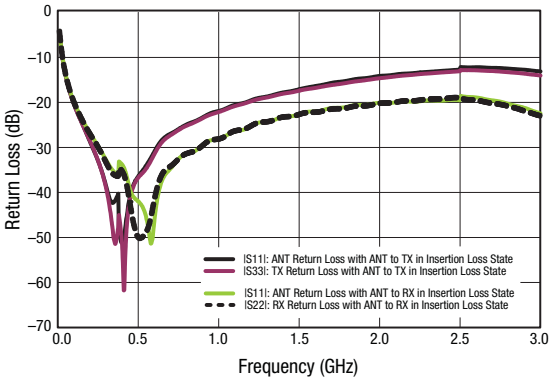

Figure 5. Return Loss vs Frequency

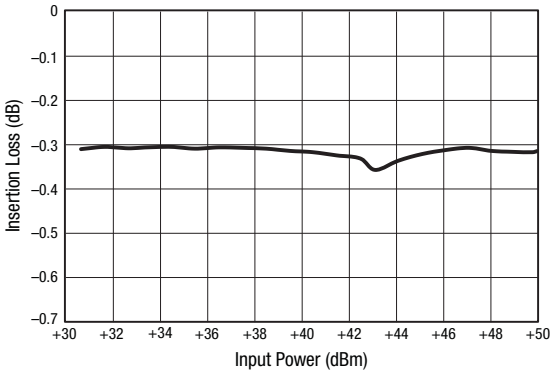

Figure 6. Insertion Loss vs CW Input Power (TX to ANT Port, f = 700 MHz, 28 V, 100 mA, EVB Loss Included)

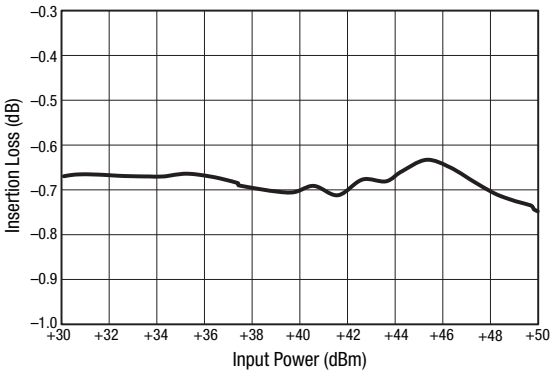

Figure 7. Insertion Loss vs CW Input Power (TX to ANT Port, f = 2000 MHz, 28 V, 100 mA, EVB Loss Included)

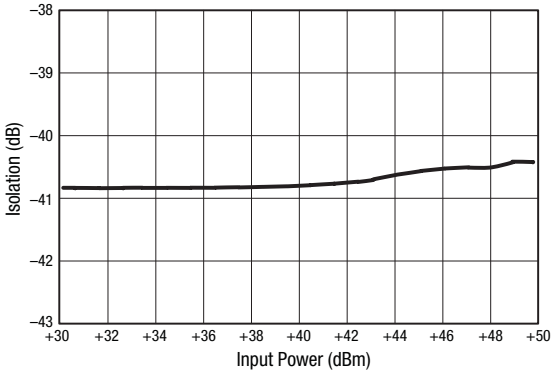

Figure 8. Isolation vs CW Input Power (ANT to RX Port, f = 700 MHz, 28 V, 100 mA, EVB Loss Included)

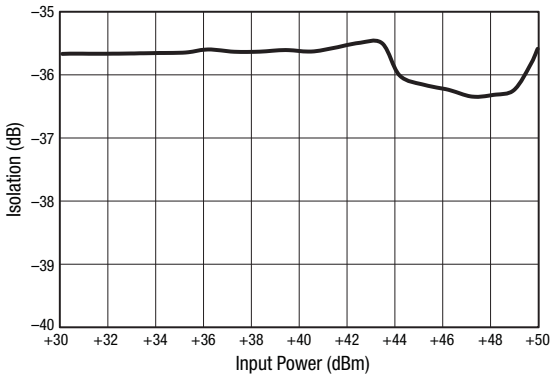

Figure 9. Isolation vs CW Input Power
(ANT to RX Port, f = 2000 MHz, 28 V, 100 mA, EVB Loss Included)

Table 5. SKY12212-478LF Truth Table

Switch State	Path		Control Conditions			
	Antenna-to-Receiver Port (Pin 2 to Pin 7)	Transmitter-to-Antenna Port (Pin 14 to Pin 2)	Antenna Port Bias Input (Pin 2)	Nominal Receiver Output Port (Pin 7)	Nominal Transmitter Port Bias Input (Pin 14)	RX_BIAS Input (Pin 9)
Receive (see Figure 12)	Low insertion loss	High isolation	1 V	-133 mA	28 V	28 V
Transmit (see Figure 12)	High isolation	Low insertion loss	2 V	28 V	-100 mA	-100 mA

Table 6. SKY12212-478LF Evaluation Board Truth Table

Switch State	Path		Control Conditions			
	Antenna-to-Receiver Port	Transmitter-to-Antenna Port	Antenna Port Bias Input	Receiver Output Port	Transmitter Port Bias Input	RX_BIAS Input
Receive (see Figure 12)	Low insertion loss	High isolation	5 V	0 V (ground)	28 V	28 V
Transmit (see Figure 12)	High isolation	Low insertion loss	5 V	28 V	0 V (ground)	0 V (ground)

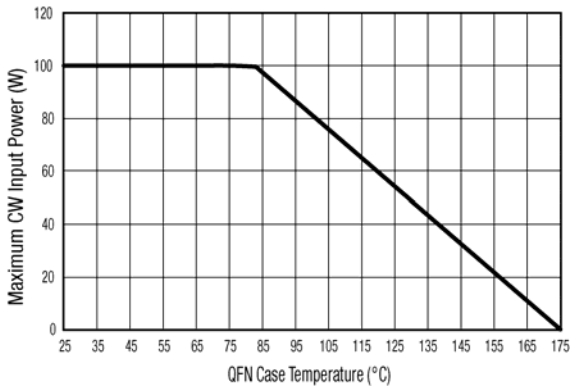

Figure 10. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs QFN Case Temperature

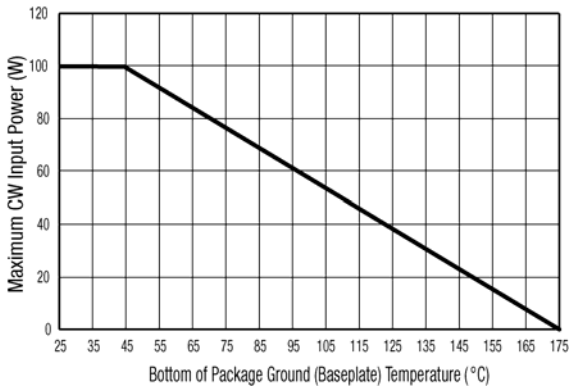

Figure 11. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Ground Plane (Base Plate) Temperature

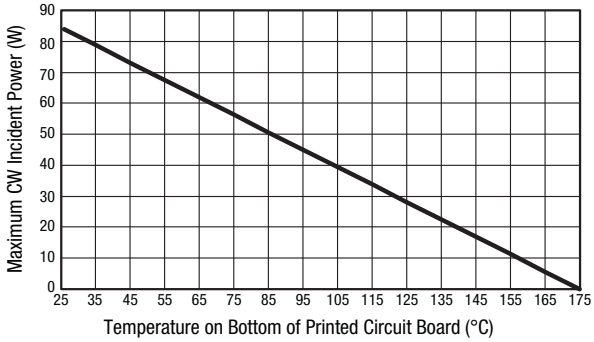

Figure 12. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Printed Circuit Board Temperature

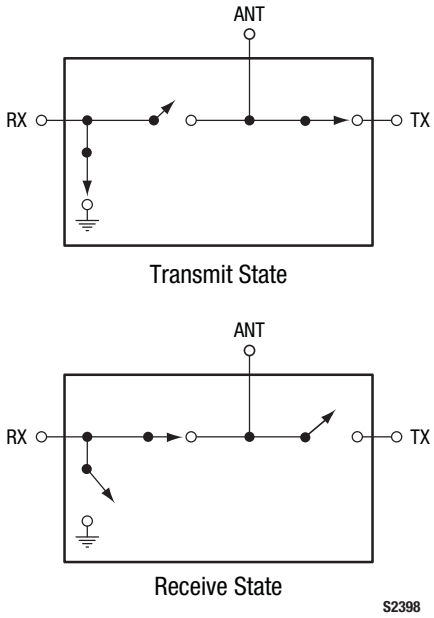

Figure 13. SKY12212-478LF Equivalent Circuit Diagrams

Evaluation Board Description

The SKY12212-478LF Evaluation Board is used to test the performance of the SKY12212-478LF PIN Diode SPDT switch. An assembly drawing for the Evaluation Board is shown in Figure 14. The layer detail physical characteristics are provided in Figure 15.

The SKY12212-478LF is designed to handle very large signals. Sufficient power may be dissipated by this switch to cause heating of the PIN diodes 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 diodes below their maximum rated operating temperature.

As indicated in Figure 10, the x-axis temperature is referenced to the QFN case temperature. At max RF power and Tb = 85 °C, the case temperature measures about 30 °C higher than the base plate temperature. The power derating curve with the x-axis temperature referenced to the base plate is shown in Figure 11. 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 12.

The evaluation circuit is designed to facilitate control of the SKY12212-478LF transmit/receive switch with bias signals derived from positive voltages. The state of the PIN diodes within the SKY12212-478LF is controlled with 5 V applied to the ANT port and bias voltages of either 28 V or 0 V applied to the remaining bias inputs (RX and TX ports). The switch state circuit diagrams are shown in Figure 13.

The value of resistor R1 (31 Ω) is selected to provide 100 mA of forward current through the "on" series diode with 5 V applied to the ANT port bias pin. The R2 resistance value of 262 Ω is selected to produce approximately 100 mA of forward bias current in the RX shunt diode with a source voltage is 28 V.

The magnitudes of the voltages applied to the TX and RX ports determine which of the RX or TX series diodes is biased into forward conduction. For example, to place the SKY12212-478LF into the transmit state, 0 V is applied to the TX port (which forward biases the diode between pins 2 and 14), 28 V is applied to the RX port (which reverse biases the diode between pins 2 and 7), and 0 V is applied to the RX_BIAS port (which applies a forward bias through R2 to the diode connected between pins 7 and 9).

The component values shown in the Evaluation Board schematic (Figure 16) were selected to optimize performance in the 0.05 to 2.7 GHz band.

Figure 14 shows the Evaluation Board assembly diagram, and Figure 15 shows the layer detail physical characteristics. Refer to Table 7 for the Evaluation Board Bill of Materials. Table 8 provides voltage, current, and resistor values for bias adjustments.

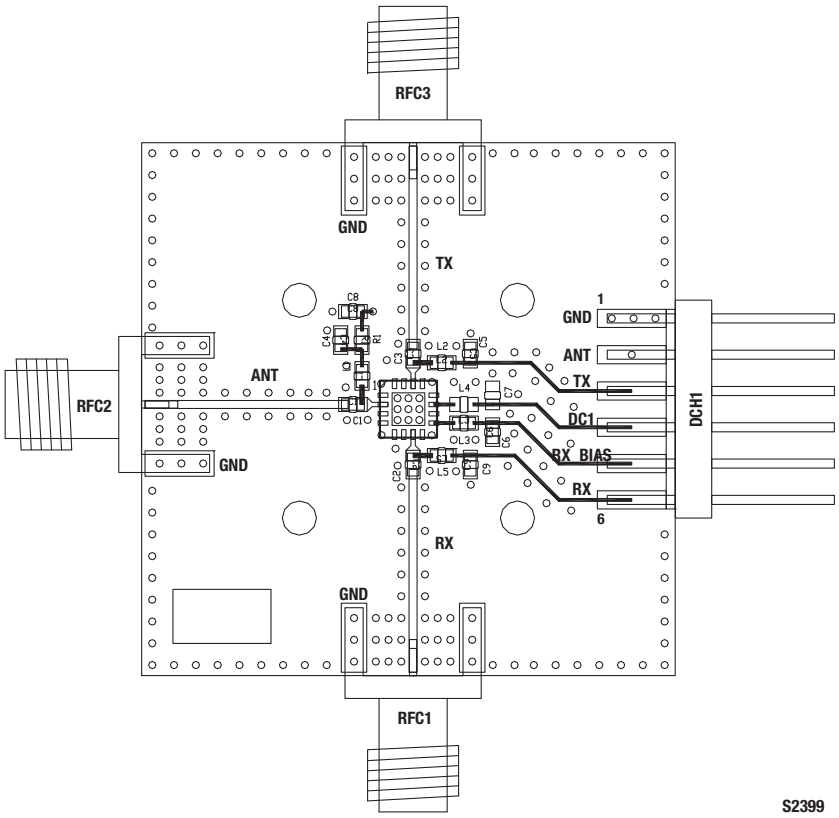

Figure 14. SKY12212-478LF Evaluation Board Assembly Diagram

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.

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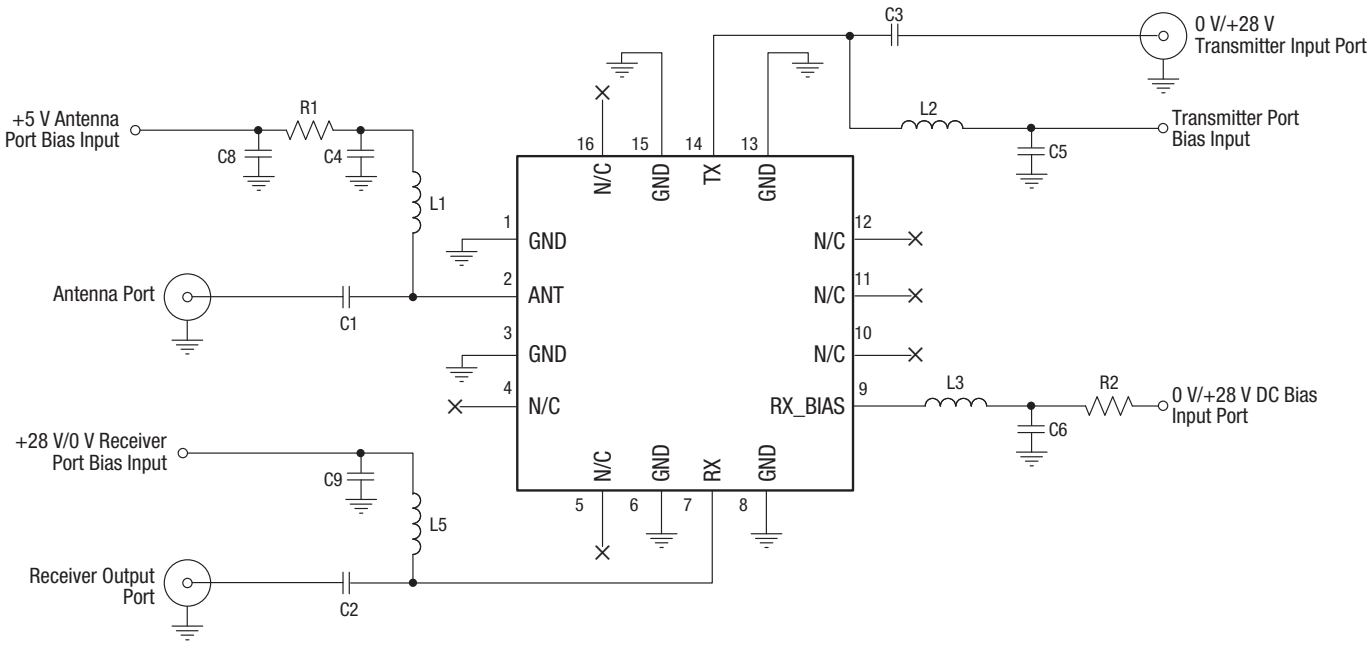
Figure 15. Layer Detail Physical Characteristics



NOTE: The N/C pins (4, 5, 10, 11, 12, and 16) are not internally connected, so they can be left open or grounded.

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Figure 16. Evaluation Board Schematic

Table 7. Evaluation Board Bill of Materials[1]

Component	Value	Size	Manufacturer	Mfr Part Number	Characteristics
C1, C2, C3	1000 pF	0603	TDK	C1608C0G1H102JT	COG, 50 V, ±5%
C8	1 µF	0603	TDK	C2012X7R1H104K	X7R, 50 V, ±10%
L1, L2, L3, L5	820 nH	0603	Coil Craft	0603LS-821XJL	SRF, 410 MHz, ±5%
C4, C5, C6, C9	10000 pF	0603	Murata	GRM188R7H103K	X7R, 50 V, ±5%
R1[2]	62 Ω	0603	Panasonic	ERJ-3GEYJ620V	0.2 W, ±5%
R2[3]	262 Ω	-	-	-	Axial leaded (off board)

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

2 Two 62 Ω resistors are combined in parallel to achieve a minimum power handling requirement and 31 Ω resistance.

3: Evaluation Board does not include resistor R2. Operating at 28 V and 100 mA requires resistor R2 with a power dissipation greater than 2.7 W.

Table 8. Component Calculation Values[1]

V_S (V)	V_{DIODE} (V)	V_{RES} (V)	Current (A)	Resistance (Ω)	Power Dissipation (W)
28	1	27	0.10	262	2.7
5	2	3	0.10	30	0.3

1 V_S = supply voltage; V_{DIODE} = voltage drop across the diode; V_{RES} = voltage drop across the resistor.
R1 and R2 values are calculated by (V_S - V_{DIODE})/I, where I is the desired bias current. The power dissipation in R1 or R2 is calculated by I x (V_S - V_{DIODE}). The resistor selected must be safely rated with a power greater than the dissipated power.

Package Dimensions

The PCB layout footprint for the SKY12212-478LF is shown in Figure 17. Typical part markings are noted in Figure 18. Package dimensions are shown in Figure 19, and tape and reel dimensions are provided in Figure 20.

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 SKY12212-478LF 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.

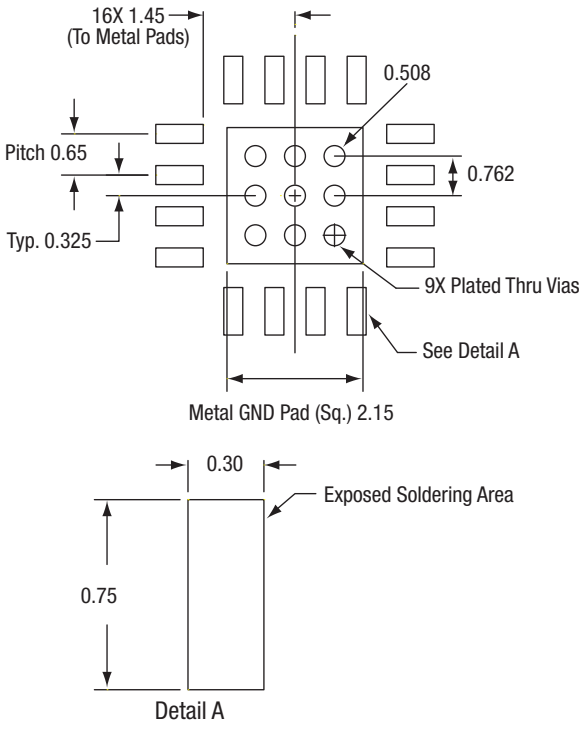


Figure 17. SKY12212-478LF PCB Layout Footprint

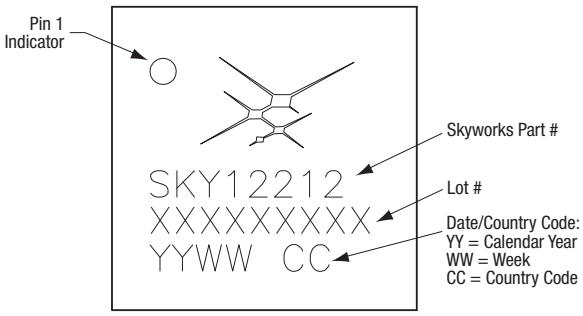
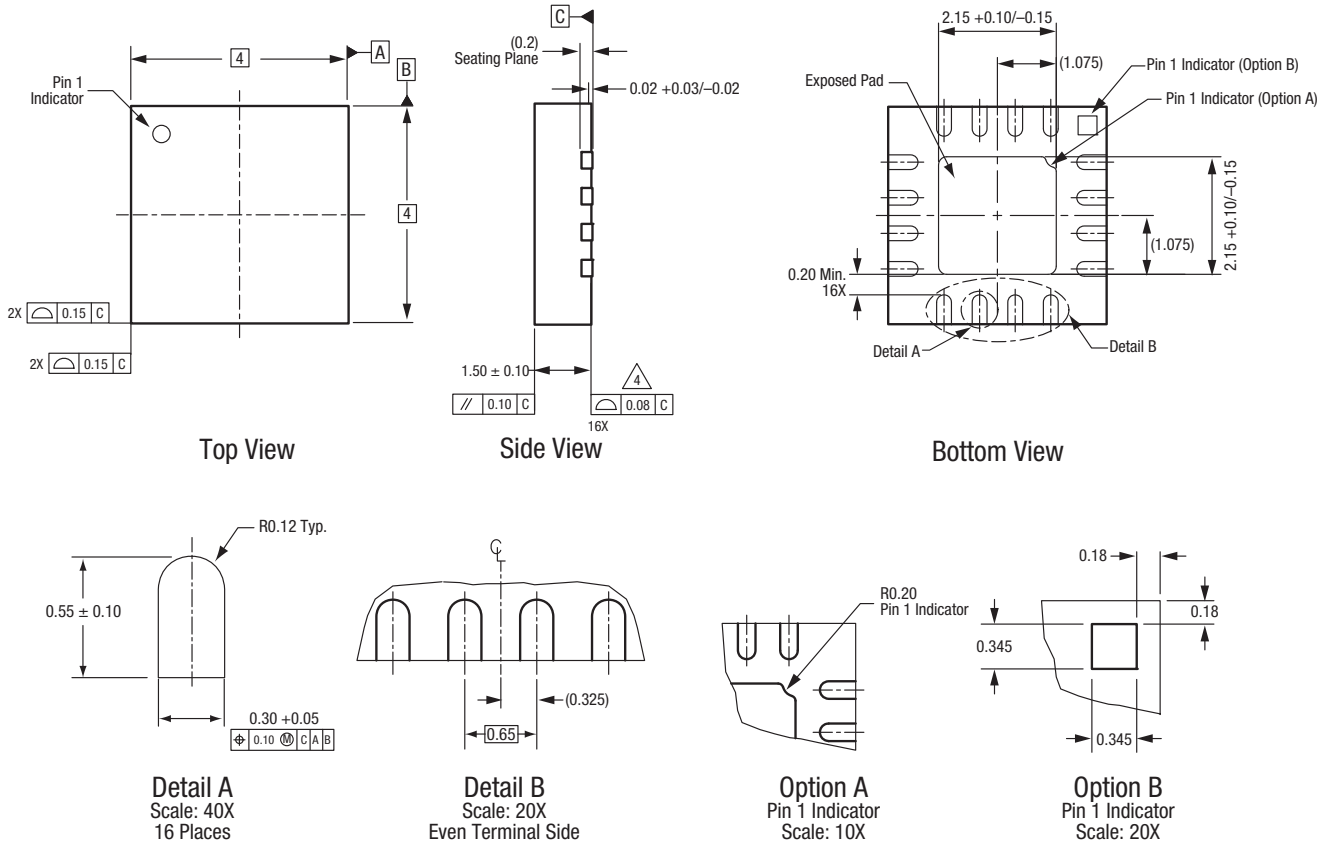


Figure 18. Typical Part Markings (Top View)



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

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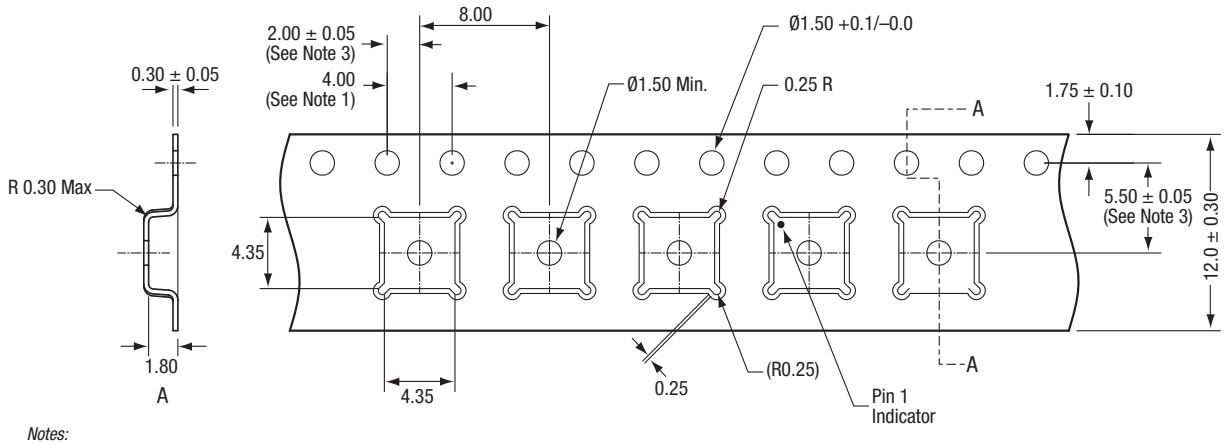
Figure 19. SKY12212-478LF Package Dimensions



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.*

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Figure 20. SKY12212-478LF Tape and Reel Dimensions

Ordering Information

Part Number	Product Description	Evaluation Board Part Number
SKY12212-478LF	PIN Diode SPDT Switch	SKY12212-478LF-EVB

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