

DATA SHEET

# SKY12212-478LF: 0.05-2.70 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
- Small, QFN (16-pin, 4 x 4 mm) Pb-free package (MSL1, 260 °C per JEDEC J-STD-020)



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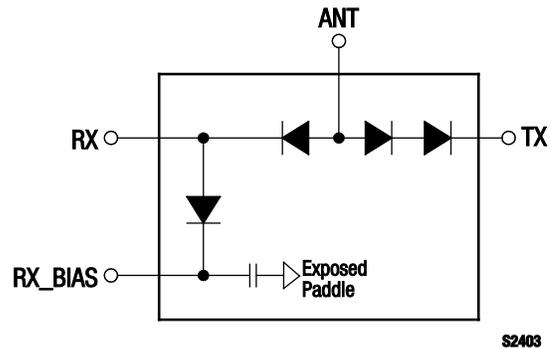


Figure 1. SKY12212-478LF Block Diagram

## 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.

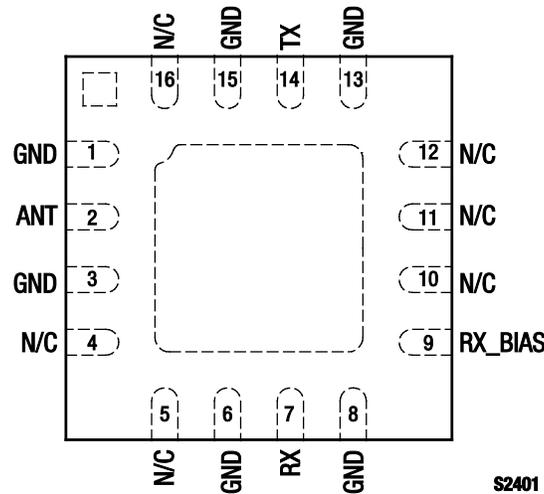


Figure 2. SKY12212-478LF Pinout – 16-Pin QFN (Top View)

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 and 11. Equivalent circuit diagrams for transmit and receive are shown in Figure 12.

**Table 2. SKY12212-478LF Absolute Maximum Ratings**

Parameter	Symbol	Minimum	Maximum	Units
RF CW input power, TX and ANT ports (T <sub>SUBSTRATE</sub> = 25 °C)	P <sub>IN</sub>		120	W
RF peak input power, TX and ANT ports (T <sub>SUBSTRATE</sub> = 25 °C, RF burst width = 10 μs, RF burst repetition rate = 25 kHz)	P <sub>IN</sub>		480	W
RF CW input power, RX port (T <sub>SUBSTRATE</sub> = 25 °C)	P <sub>IN</sub>		60	W
RF peak input power, RX port (T <sub>SUBSTRATE</sub> = 25 °C, RF burst width = 10 μs, RF burst repetition rate = 25 kHz)	P <sub>IN</sub>		240	W
Control port reverse voltage	V <sub>CTL</sub>		200	V
Control port forward current	I <sub>CTL</sub>		200	mA
Operating temperature	T <sub>OP</sub>	-55	+175	°C
Storage temperature	T <sub>STG</sub>	-55	+200	°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. Recommended Operating Conditions (Per ANT, TX, RX, and RX\_BIAS Inputs)**

Parameter	Symbol	Min	Typical	Max	Units
Control port reverse voltage	V <sub>CTL</sub>	5	28	100	V
Control port forward current	I <sub>CTL</sub>	50	100	100	mA

**Table 4. SKY12212-478LF Electrical Specifications (1 of 2) (Note 1)**  
**(T<sub>OP</sub> = +25 °C, Characteristic Impedance [Z<sub>0</sub>] = 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 <sub>TX-ANT</sub>	V <sub>PIN_2</sub> = 2 V, I <sub>PIN_14</sub> = -100 mA, I <sub>PIN_9</sub> = -100 mA, V <sub>PIN_7</sub> = 28 V, TX port P <sub>IN</sub> @ pin 14 = 0 dBm:  50 MHz 0.6 GHz 1.2 GHz 2.0 GHz 2.7 GHz		0.47 0.29 0.33 0.46 0.55	0.60	dB dB dB dB dB
Insertion loss, ANT to RX ports	IL <sub>ANT-RX</sub>	V <sub>PIN_2</sub> = 1 V, V <sub>PIN_14</sub> = 28 V, I <sub>PIN_7</sub> = -100 mA, V <sub>PIN_9</sub> = 28 V, ANT port P <sub>IN</sub> @ pin 2 = 0 dBm:  50 MHz 0.6 GHz 1.2 GHz 2.0 GHz 2.7 GHz		0.44 0.26 0.24 0.32 0.34	0.60	dB dB dB dB dB
Isolation, TX to RX ports	ISO <sub>TX-RX</sub>	V <sub>PIN_2</sub> = 1 V, I <sub>PIN_14</sub> = -100 mA, I <sub>PIN_9</sub> = -100 mA, V <sub>PIN_7</sub> = 28 V, TX port P <sub>IN</sub> @ pin 14 = 0 dBm:  50 MHz 0.6 GHz 1.2 GHz 2.0 GHz 2.7 GHz	45	47 41 50 38 29		dB dB dB dB dB
Isolation, ANT to TX ports	ISO <sub>ANT-TX</sub>	V <sub>PIN_2</sub> = 1 V, V <sub>PIN_14</sub> = 28 V, I <sub>PIN_7</sub> = -100 mA, V <sub>PIN_9</sub> = 28 V, ANT port P <sub>IN</sub> @ pin 2 = 0 dBm:  50 MHz 0.6 GHz 1.2 GHz 2.0 GHz 2.7 GHz	30	59 39 34 30 28		dB dB dB dB dB
Isolation, ANT to RX ports	ISO <sub>ANT-RX</sub>	V <sub>PIN_2</sub> = 2 V, I <sub>PIN_14</sub> = -100 mA, I <sub>PIN_9</sub> = -100 mA, V <sub>PIN_7</sub> = 28 V, ANT port P <sub>IN</sub> @ pin 2 = 0 dBm:  50 MHz 0.6 GHz 1.2 GHz 2.0 GHz 2.7 GHz	40	47 41 47 37 29		dB dB dB dB dB
Input return loss		0.5 to 2.7 GHz:  RX insertion loss state, ANT port (@ pin 2)  TX insertion loss state, TX port (@ pin 14)		25  20		dB  dB

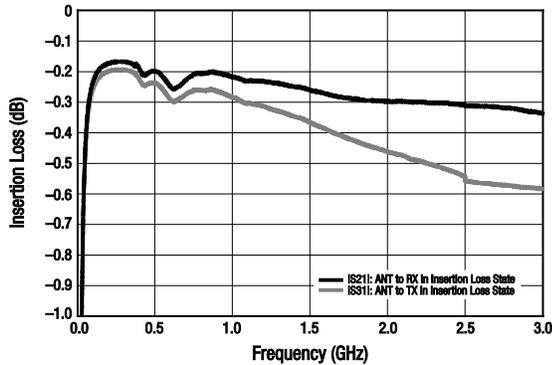
**Table 4. SKY12212-478LF Electrical Specifications (2 of 2) (Note 1)**  
**(TOP = +25 °C, Characteristic Impedance [Z<sub>0</sub>] = 50 Ω, EVB Optimized for 0.05 to 2.70 GHz Operation, Unless Otherwise Noted)**

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Transmit 2 <sup>nd</sup> harmonic	2fo	TX insertion loss state, TX port P <sub>IN</sub> @ pin 14 = +30 dBm:  50 MHz 0.6 GHz 1.2 GHz 2.0 GHz 2.7 GHz		-81 -114 -90 -109 -89		dBc dBc dBc dBc dBc
Transmit 3 <sup>rd</sup> harmonic	3fo	TX insertion loss state, TX port P <sub>IN</sub> @ pin 14 = +30 dBm:  50 MHz 0.6 GHz 1.2 GHz 2.0 GHz 2.7 GHz		-97 -98 -105 -82 -90		dBc dBc dBc dBc dBc
Transmit 3 <sup>rd</sup> Order Input Intercept Point	IIP3	V <sub>PIN_2</sub> = 2 V, I <sub>PIN_14</sub> = -100 mA, I <sub>PIN_9</sub> = -100 mA, V <sub>PIN_7</sub> = 28 V, TX port P <sub>IN</sub> @ pin 14 = +30 dBm/tone, tone spacing = 1 MHz: @ 1.2 GHz		+67		dBm
Transmit 0.1 dB Input Compression Point	IPO.1dB	V <sub>PIN_2</sub> = 2 V, I <sub>PIN_14</sub> = -100 mA, I <sub>PIN_9</sub> = -100 mA, V <sub>PIN_7</sub> = 28 V: @ 0.05 to 2.70 GHz		+49		dBm
Receive 0.1 dB Input Compression Point	IPO.1dB	V <sub>PIN_2</sub> = 1 V, V <sub>PIN_14</sub> = 28 V, I <sub>PIN_7</sub> = -100 mA, V <sub>PIN_9</sub> = 28 V: @ 0.05 to 2.70 GHz		+46		dBm
Maximum transmit CW input power	P <sub>IN_CW</sub>	V <sub>PIN_2</sub> = 2 V, I <sub>PIN_14</sub> = -100 mA, I <sub>PIN_9</sub> = -100 mA, V <sub>PIN_7</sub> = 28 V: @ 0.05 to 2.70 GHz		100		W
Maximum receive CW input power	P <sub>IN_CW</sub>	V <sub>PIN_2</sub> = 1 V, V <sub>PIN_14</sub> = 28 V, I <sub>PIN_7</sub> = -100 mA, V <sub>PIN_9</sub> = 28 V: @ 0.05 to 2.70 GHz		40		W
Transmit RF switching time	t <sub>sw</sub>	10% to 90% RF rise time, repetition rate = 0.1 MHz, @ 1.20 GHz		600		ns
Thermal resistance (junction to case)	Θ <sub>JC</sub>			14		°C/W

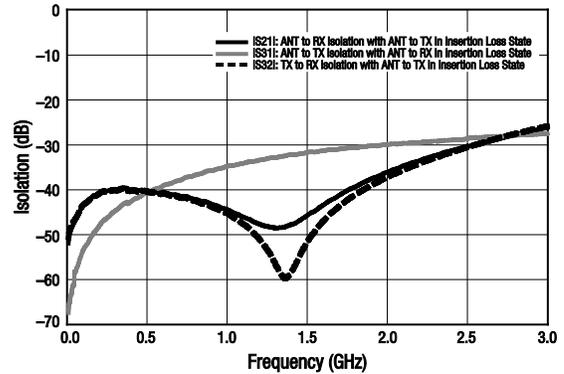
**Note 1:** Performance is guaranteed only under the conditions listed in this Table.

**Typical Performance Characteristics**

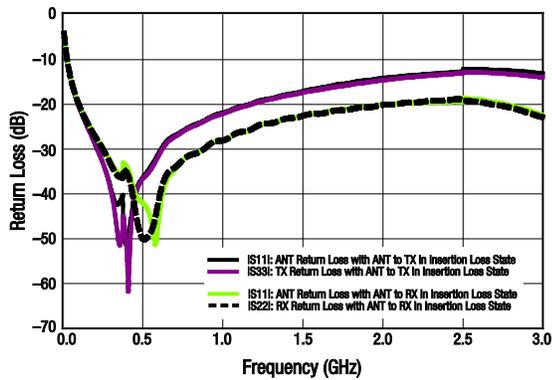
( $T_{OP} = +25\text{ }^{\circ}\text{C}$ , Characteristic Impedance [ $Z_0$ ] = 50  $\Omega$ , EVB Optimized for 0.05 to 2.70 GHz Operation, Bias = 28 V/100 mA, Unless Otherwise Noted)



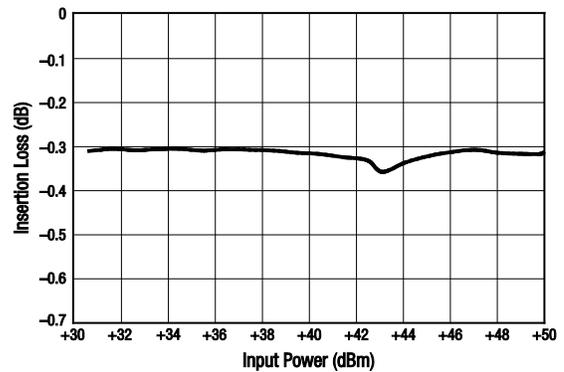
**Figure 3. Insertion Loss vs Frequency**



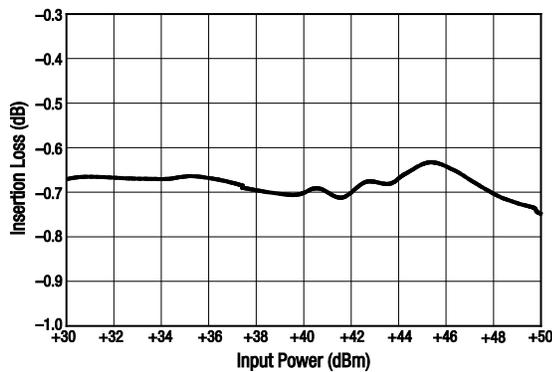
**Figure 4. Isolation vs Frequency**



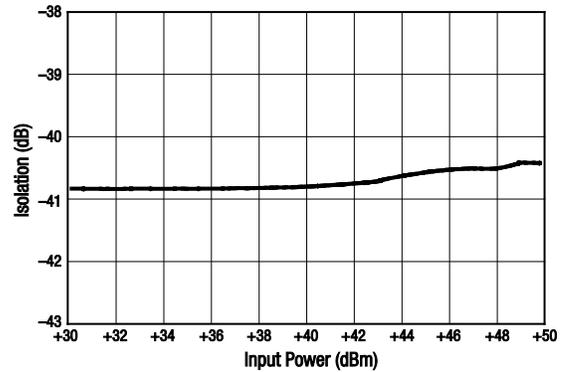
**Figure 5. Return Loss vs Frequency**



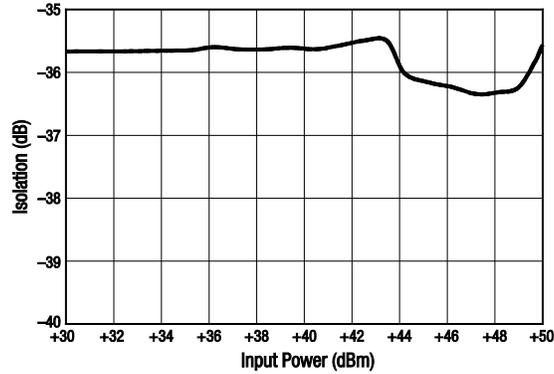
**Figure 6. Insertion Loss vs CW Input Power  
(TX to ANT Port,  $f = 700\text{ MHz}$ , 28 V, 100 mA, EVB Loss Included)**



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



**Figure 8. Isolation vs CW Input Power  
(ANT to RX Port,  $f = 700\text{ MHz}$ , 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 9)	Low insertion loss	High isolation	1 V	-100 mA	28 V	28 V
Transmit (see Figure 9)	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 9)	Low insertion loss	High isolation	5 V	0 V (ground)	28 V	28 V
Transmit (see Figure 9)	High isolation	Low insertion loss	5 V	28 V	0 V (ground)	0 V (ground)

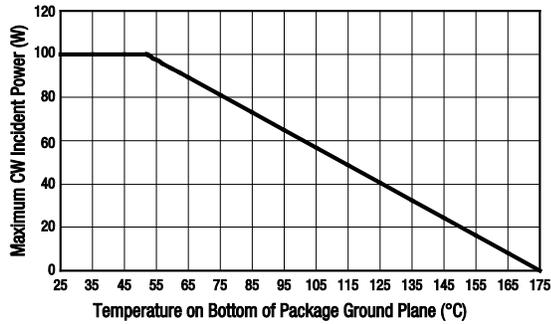


Figure 10. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Ground Plane Temperature

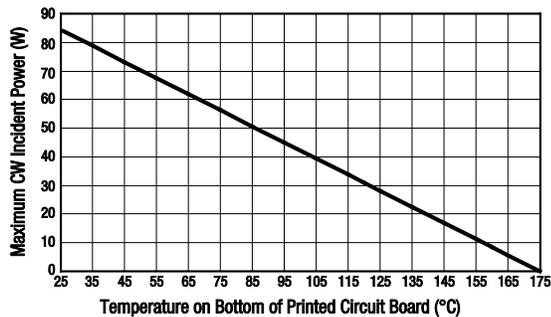


Figure 11. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Printed Circuit Board Temperature

### 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 13. The layer detail physical characteristics are provided in Figure 14.

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 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 11.

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

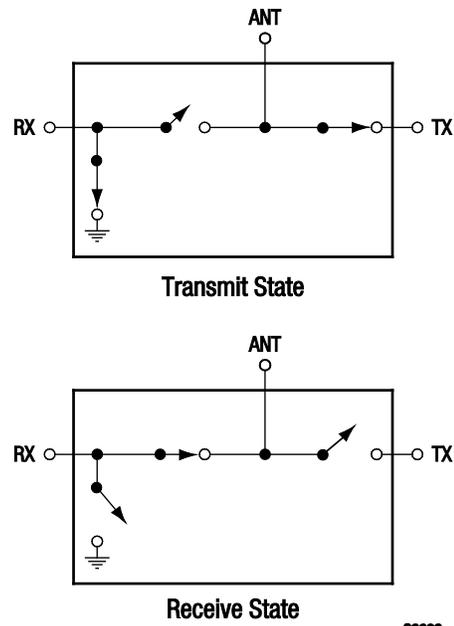


Figure 12. SKY12212-478LF Equivalent Circuit Diagrams

remaining bias inputs (RX and TX ports). The switch state circuit diagrams are shown in Figure 12.

The value of resistor R3 (refer to the schematic diagram in Figure 15), nominally 262 Ω, together with the magnitudes of the voltages applied to the TX and RX ports, determine which of the two series of diodes is biased into conduction and how much current flows through the forward biased diode.

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 R3 to the diode connected between pins 7 and 9).

The value of R3 may be adjusted to accommodate other bias voltages. A resistance value of 262 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 circuit diagram (Figure 15) were selected to optimize performance in the 0.05 to 2.7 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 SKY12212-478LF is shown in Figure 16. Typical case markings are noted in Figure 17. Package dimensions for the 16-pin QFN are shown in Figure 18, and tape and reel dimensions are provided in Figure 19.

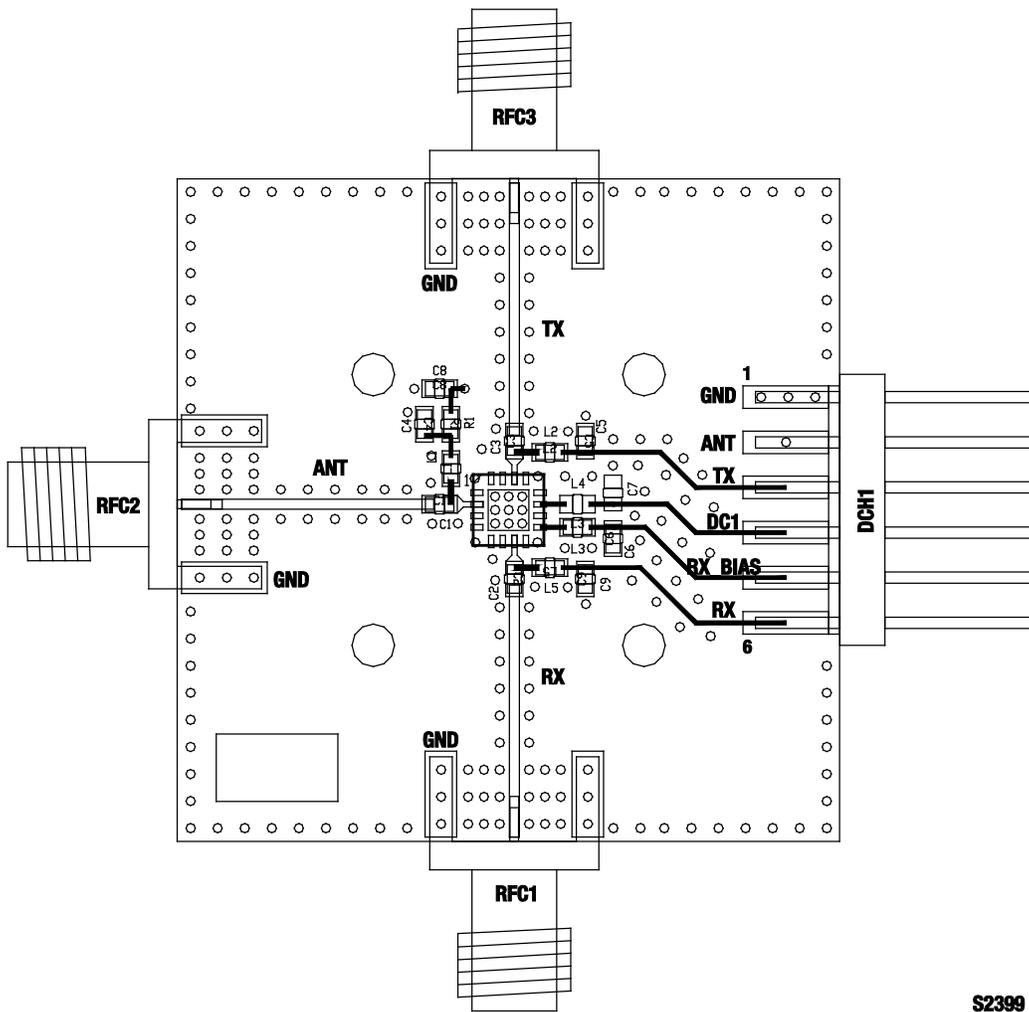
**Package and Handling Information**

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.

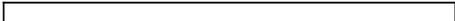
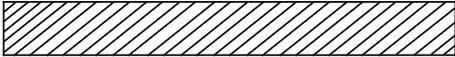
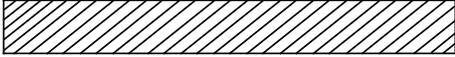
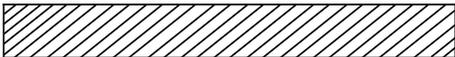
The SKY12212-478LF is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *Solder Reflow Information*, document number 200164.

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 13. SKY12212-478LF Evaluation Board Assembly Diagram**

S2399

Cross Section	Name	Thickness (in)	Material
	Top Soldermask		
	L1	(0.0028)	Cu foil
	Laminate	0.012 ± 0.0006	Rogers R04003C 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 14. Layer Detail Physical Characteristics

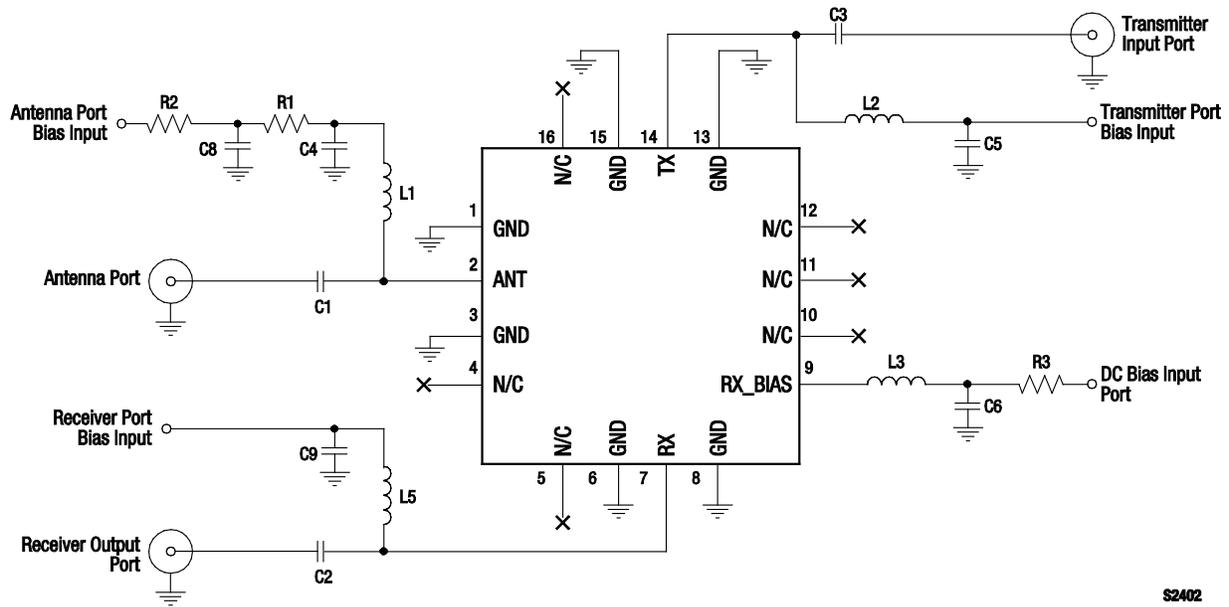


Figure 15. Evaluation Board Schematic

Table 7. Evaluation Board Bill of Materials (Note 1)

Component	Value	Size	Manufacturer	Manufacturer 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	0 Ω	0603	Rohm	MCR03EZPJ000	50 V, 0.1 W, ±5%
R2, R3 (Note 2)	262 Ω	–	–	–	Axial leaded (off board)

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 does not include 262 Ω values for resistors R2 and R3 for 28 V, 100 mA operation. Operating at 28 V and 100 mA requires R2 and R3 resistors with a power dissipation greater than 2.7 W.

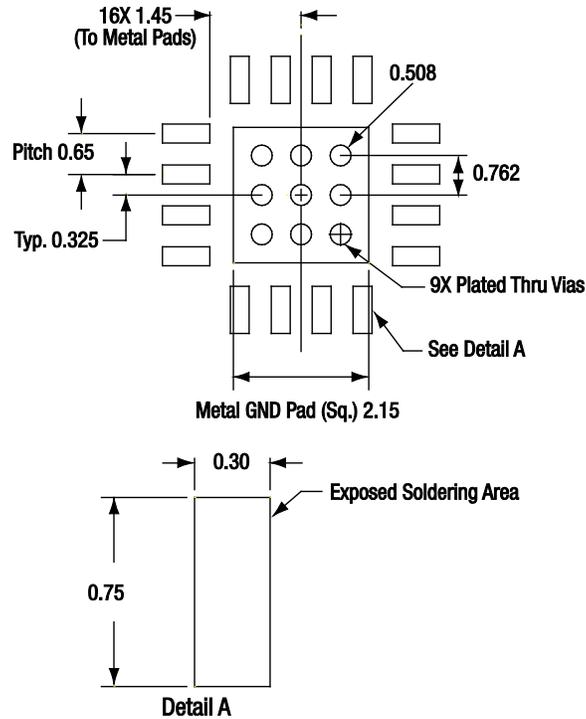
Table 8. Component Calculation Values

Vs (V)	V <sub>DIODE</sub> (V)	V <sub>RES</sub> (V)	Current (A)	Resistance (Ω)	Power Dissipation (W)
28	1	27	0.10	262	2.7
28	1	27	0.05	540	1.35

Notes: Vs = supply voltage; V<sub>DIODE</sub> = voltage drop across the diode; V<sub>RES</sub> = voltage drop across the resistor.

R2 and R3 values are calculated by  $(V_s - 1 \text{ V})/I$ , where I is the desired bias current. The approximate voltage drop across the diode is 1 V.

The power dissipation in R2 or R3 is calculated by  $I \times (V_s - V_{\text{DIODE}})$ . The resistor selected must be rated to safely power greater than the dissipated power.



All measurements in millimeters

S2274

Figure 16. SKY12212-478LF PCB Layout Footprint

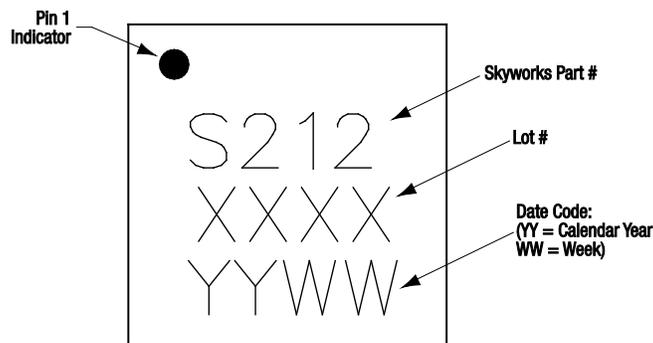
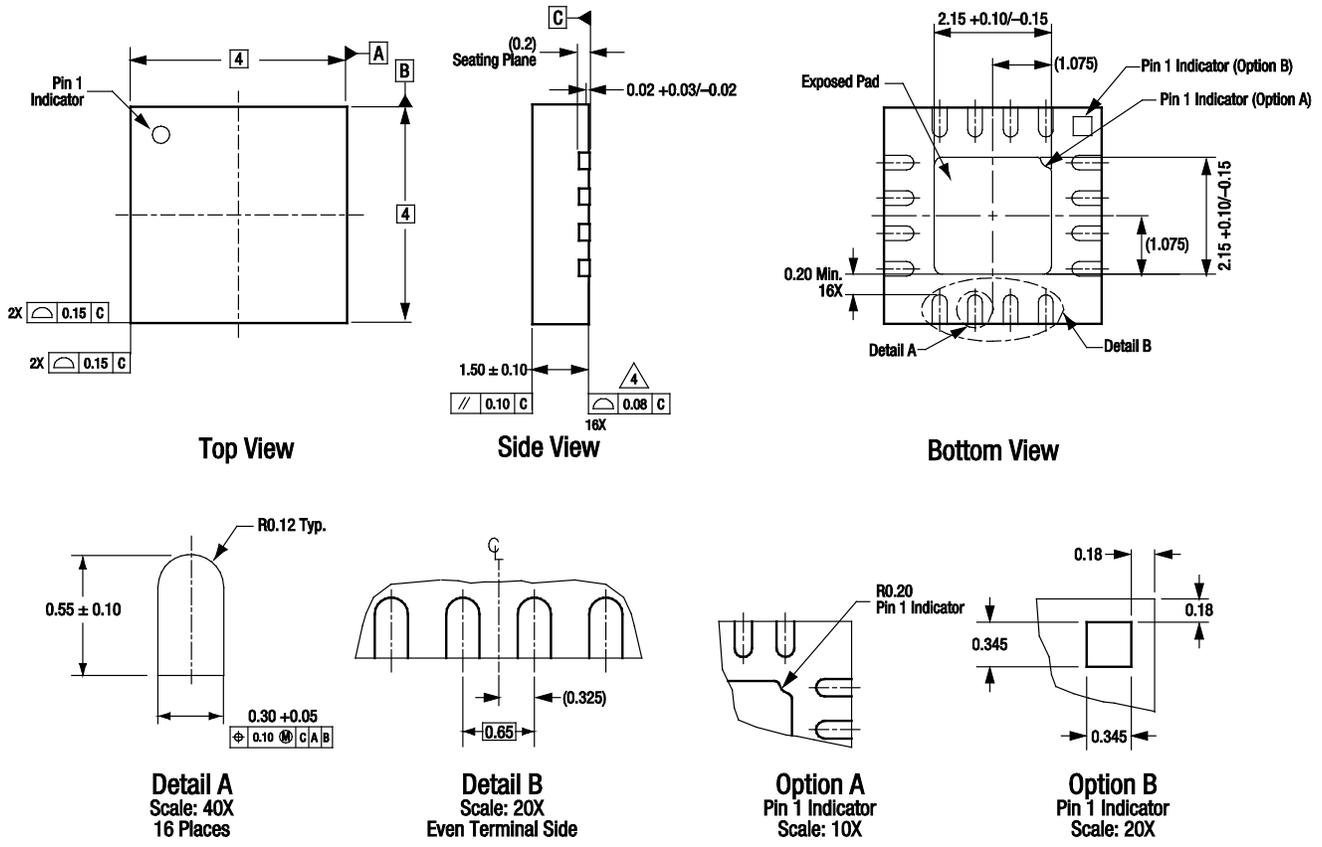


Figure 17. Typical Case Markings (Top View)



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

S2400a

Figure 18. SKY12212-478LF 16-Pin QFN Package Dimensions



**Ordering Information**

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY12212-478LF PIN Diode SPDT Switch	SKY12212-478LF	SKY12212-478LF-EVB

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