DATA SHEET

SKY12210-478LF: 0.9-4.0 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 @ 2.6 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)

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.

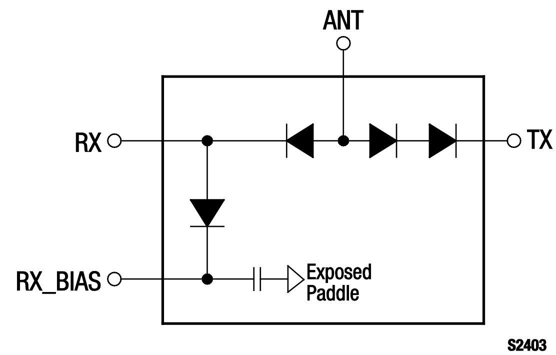


Figure 1. SKY12210-478LF Block Diagram

Description

The SKY12210-478LF is a high power handling, Single-Pole, Double-Throw (SPDT) silicon PIN diode switch. The device operates over the 900 MHz to 4 GHz band. It features low insertion loss, excellent power handling, and superb linearity with low DC power consumption.

The SKY12210-478LF 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.

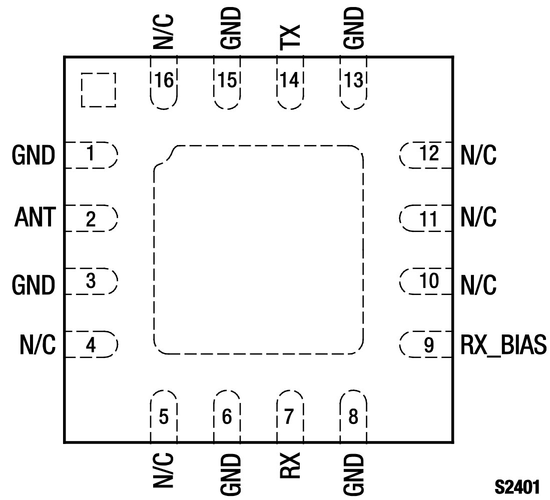


Figure 2. SKY12210-478LF Pinout – 16-Pin QFN (Top View)

Table 1. SKY12210-478LF 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 SKY12210-478LF 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 SKY12210-478LF are illustrated in Figures 3 through 9.

The state of the SKY12210-478LF is determined by the logic provided in Table 6. Table 7 provides the logic for use with the SKY12210-478LF 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. SKY12210-478LF Absolute Maximum Ratings

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

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_{CTL}	5	28	100	V
Control port forward current	I_{CTL}	50	100	100	mA

Table 4. SKY12210-478LF Electrical Specifications (1 of 2) (Note 1)
(T_{OP} = +25 °C, Characteristic Impedance [Z_O] = 50 Ω, EVB Optimized for 2.6 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:				
		900 MHz		0.52		dB
		1.80 GHz		0.33		dB
		2.01 GHz		0.38		dB
		2.60 GHz		0.48	0.70	dB
		3.50 GHz		0.47	0.70	dB
Insertion loss, ANT to RX ports	IL_{ANT-RX}	V_{PIN}_2 = 1 V, V_{PIN}_14 = 28 V, I_{PIN}_7 = –100 mA, V_{PIN}_9 = 28 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		900 MHz		0.56		dB
		1.80 GHz		0.26		dB
		2.01 GHz		0.29		dB
		2.60 GHz		0.34	0.50	dB
		3.50 GHz		0.36	0.50	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:				
		900 MHz		34		dB
		1.80 GHz		37		dB
		2.01 GHz		39		dB
		2.60 GHz	40	50		dB
		3.50 GHz	31	34		dB
Isolation, ANT to TX ports	$Iso_{\_ANT-TX}$	V_{PIN}_2 = 1 V, V_{PIN}_14 = 28 V, I_{PIN}_7 = –100 mA, V_{PIN}_9 = 28 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		900 MHz		35		dB
		1.80 GHz		30		dB
		2.01 GHz		29		dB
		2.60 GHz	25	28		dB
		3.50 GHz	22	25		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:				
		900 MHz		33		dB
		1.8 to 2.1 GHz	36	37		dB
		2.3 to 2.7 GHz	37	43		dB
		2.6 GHz	40	44		dB
		3.5 GHz	30	33		dB
Input return loss		1.8 to 3.5 GHz:				
		RX insertion loss state, ANT port (@ pin 2)		25		dB
		TX insertion loss state, TX port (@ pin 14)		20		dB

Table 4. SKY12210-478LF Electrical Specifications (2 of 2) (Note 1)
(T_{OP} = +25 °C, Characteristic Impedance [Z_O] = 50 Ω, EVB Optimized for 2.6 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:				
		900 MHz		–88		dBc
		1.80 GHz		–85		dBc
		2.01 GHz		–95		dBc
		2.60 GHz		–95		dBc
		3.50 GHz		–89		dBc
Transmit 3rd harmonic	3fo	TX insertion loss state, TX port P_{IN} @ pin 14 = +30 dBm:				
		900 MHz		–99		dBc
		1.80 GHz		–97		dBc
		2.01 GHz		–105		dBc
		2.60 GHz		–97		dBc
		3.50 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:				
		@ 2.6 GHz		+78		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:				
		@ 1.8 to 2.6 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} = –100 mA, V_{PIN_9} = 28 V:				
		@ 1.8 to 2.6 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:				
		@ 0.9 to 3.5 GHz		100		W
Maximum receive CW input power	P_{IN_CW}	V_{PIN_2} = 1 V, V_{PIN_14} = 28 V, I_{PIN_7} = –100 mA, V_{PIN_9} = 28 V:				
		@ 0.9 to 3.5 GHz		40		W
Transmit RF switching time	t_{SW}	10% to 90% RF on, repetition rate = 0.1 MHz, @ 2.60 GHz		157		ns
Thermal resistance (junction to case)	Θ_{JC}			14		°C/W

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

Typical Performance Characteristics

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

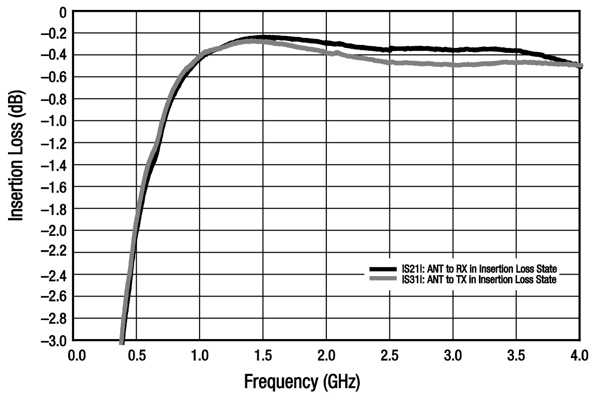


Figure 3. Insertion Loss vs Frequency

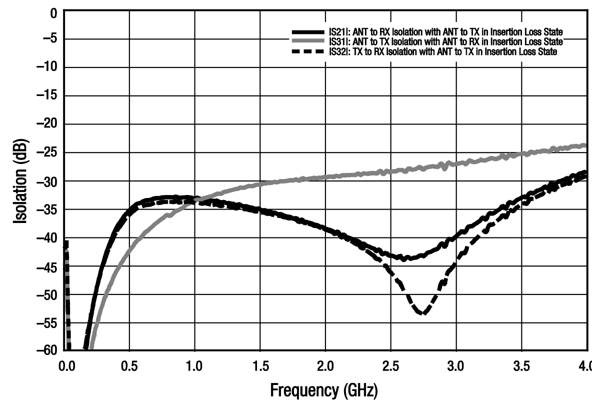


Figure 4. Isolation vs Frequency

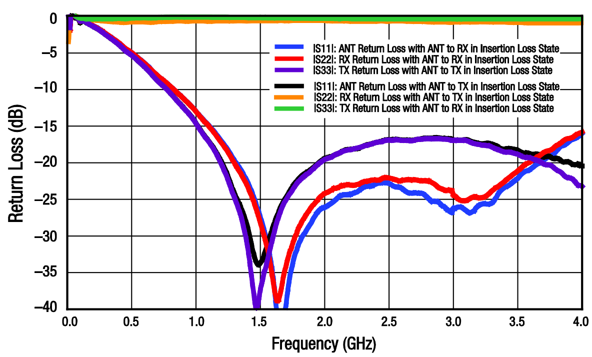


Figure 5. Return Loss vs Frequency

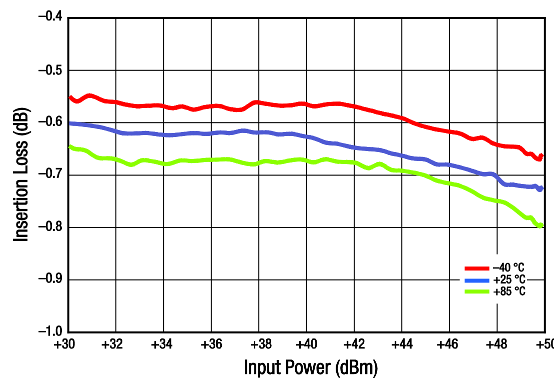


Figure 6. Insertion Loss vs CW Input Power (TX to ANT Port, f = 2600 MHz, 28 V, 100 mA, EVB Loss Included)

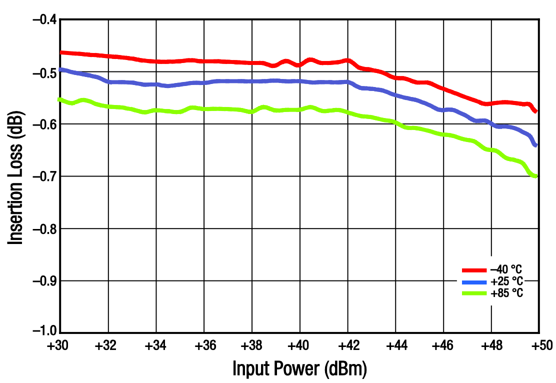


Figure 7. Insertion Loss vs CW Input Power (TX to ANT Port, f = 2300 MHz, 28 V, 100 mA, EVB Loss Included)

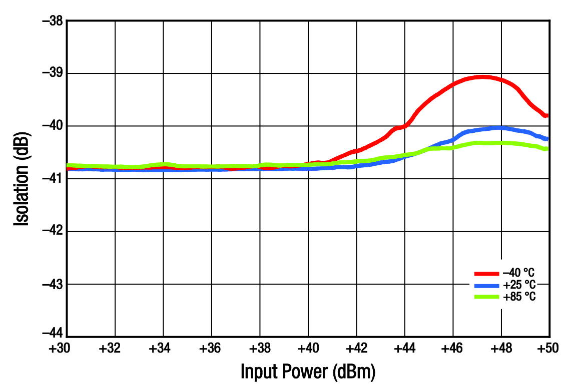


Figure 8. Isolation vs CW Input Power (ANT to RX Port, f = 2300 MHz, 28 V, 100 mA, EVB Loss Included)

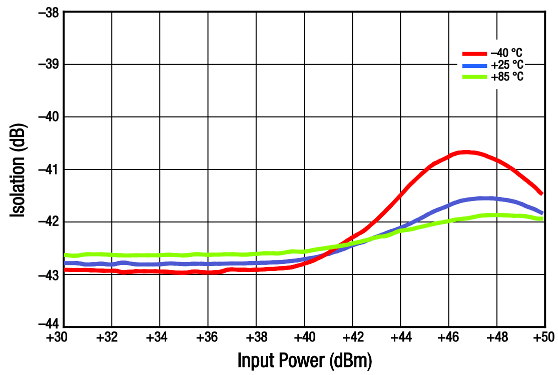


Figure 9. Isolation vs CW Input Power (ANT to RX Port, f = 2600 MHz, 28 V, 100 mA, EVB Loss Included)

Table 5. SKY12210-478LF 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. SKY12210-478LF 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)

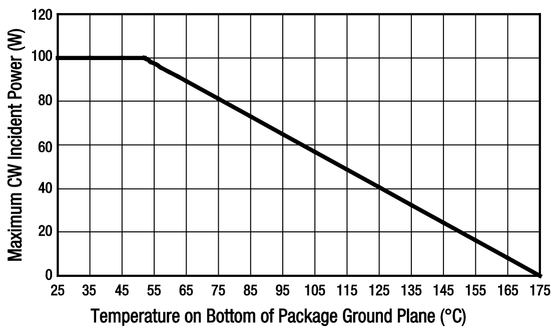


Figure 10. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Ground Plane Temperature

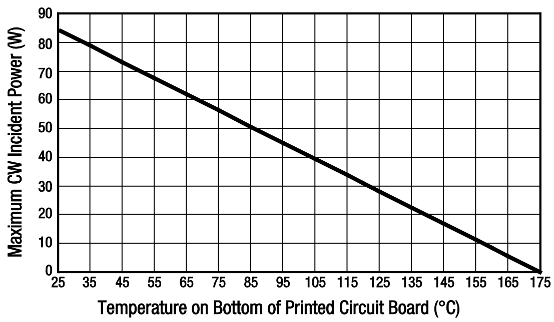


Figure 11. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.4 dB) vs Printed Circuit Board Temperature

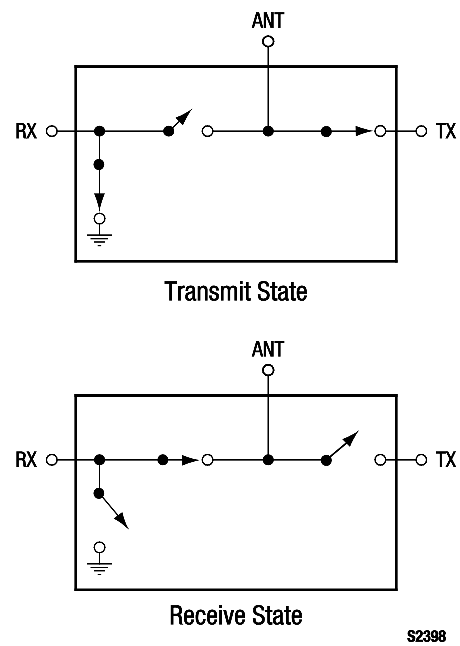


Figure 12. SKY12210-478LF Equivalent Circuit Diagrams

Evaluation Board Description

The SKY12210-478LF Evaluation Board is used to test the performance of the SKY12210-478LF 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 SKY12210-478LF 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 SKY12210-478LF transmit/receive switch with bias signals derived from positive voltages. The state of the PIN diodes within the SKY12210-478LF 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 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 SKY12210-478LF 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 2.3 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 SKY12210-478LF 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 SKY12210-478LF 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.

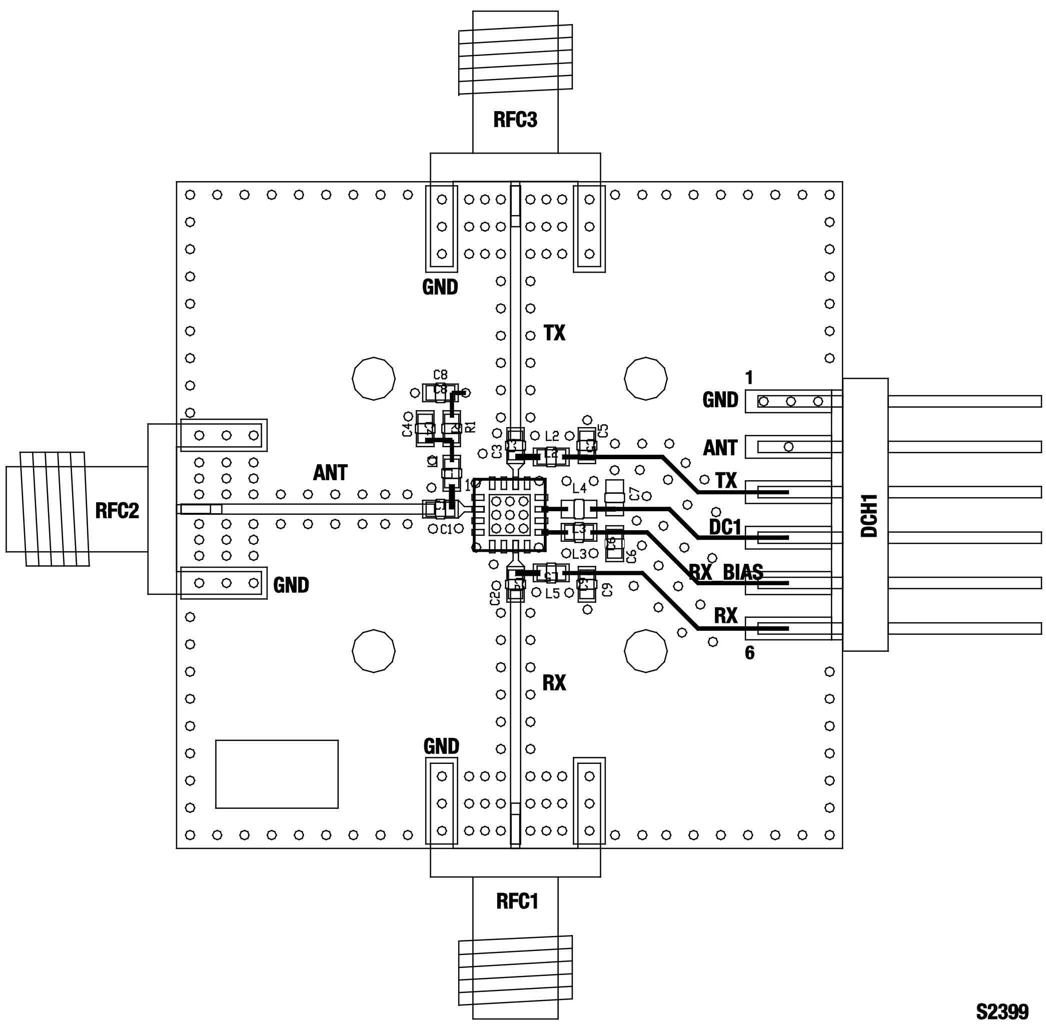
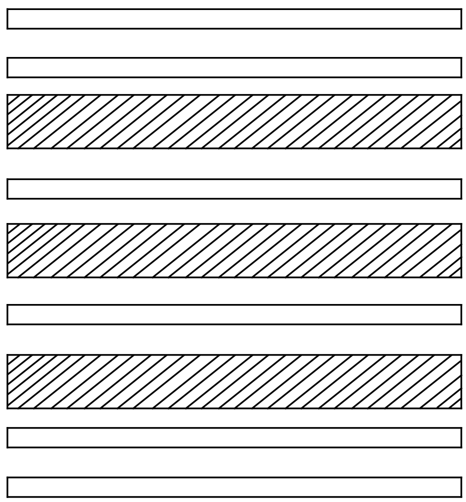


Figure 13. SKY12210-478LF Evaluation Board Assembly Diagram



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 14. Layer Detail Physical Characteristics

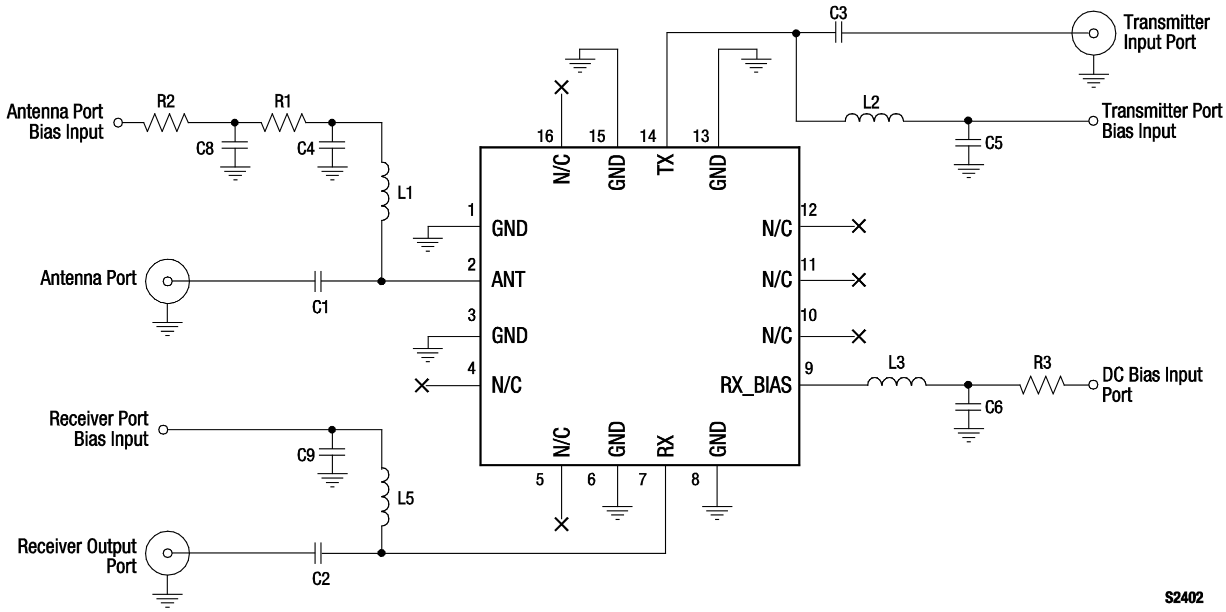


Figure 15. Evaluation Board Schematic

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

Component	Value	Size	Manufacturer	Manufacturer Part Number	Characteristics
C1, C2, C3, C4, C5, C6, C9	1000 pF	0603	TDK	C1608C0G1H102JT	COG, 50 V, ±5%
C8	1 μF	0603	TDK	C2012X7R1H104K	X7R, 50 V, ±10%
L1, L2, L5	22 nH	0603	Taiyo-Yuden	HK160822NJ-T	SRF, 1600 MHz, ±5%
L3	560 nH	0603	Coil Craft	0603LS-561XJLB	SRF, 525 MHz, ±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 basd 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

V_S (V)	V_{DIODE} (V)	V_{RES} (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: V_S = supply voltage; V_{DIODE} = voltage drop across the diode; V_{RES} = voltage drop across the resistor.
R2 and R3 values are calculated by (V_S – 1 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 x (V_S – V_{DIODE}). The resistor selected must be rated to safely power greater than the dissipated power.

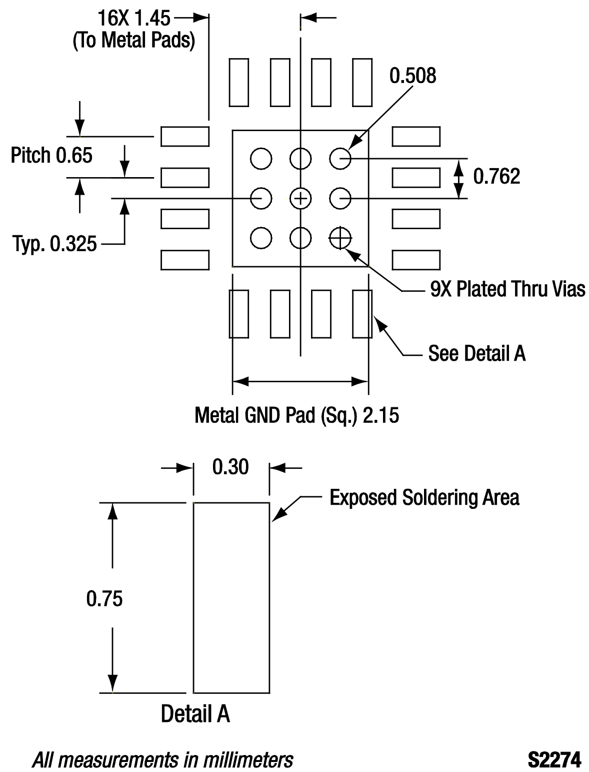


Figure 16. SKY12210-478LF PCB Layout Footprint

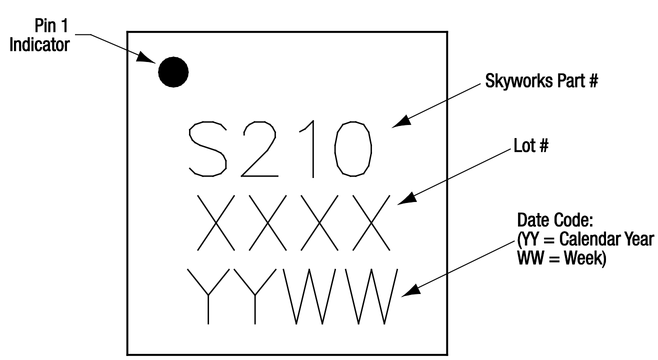
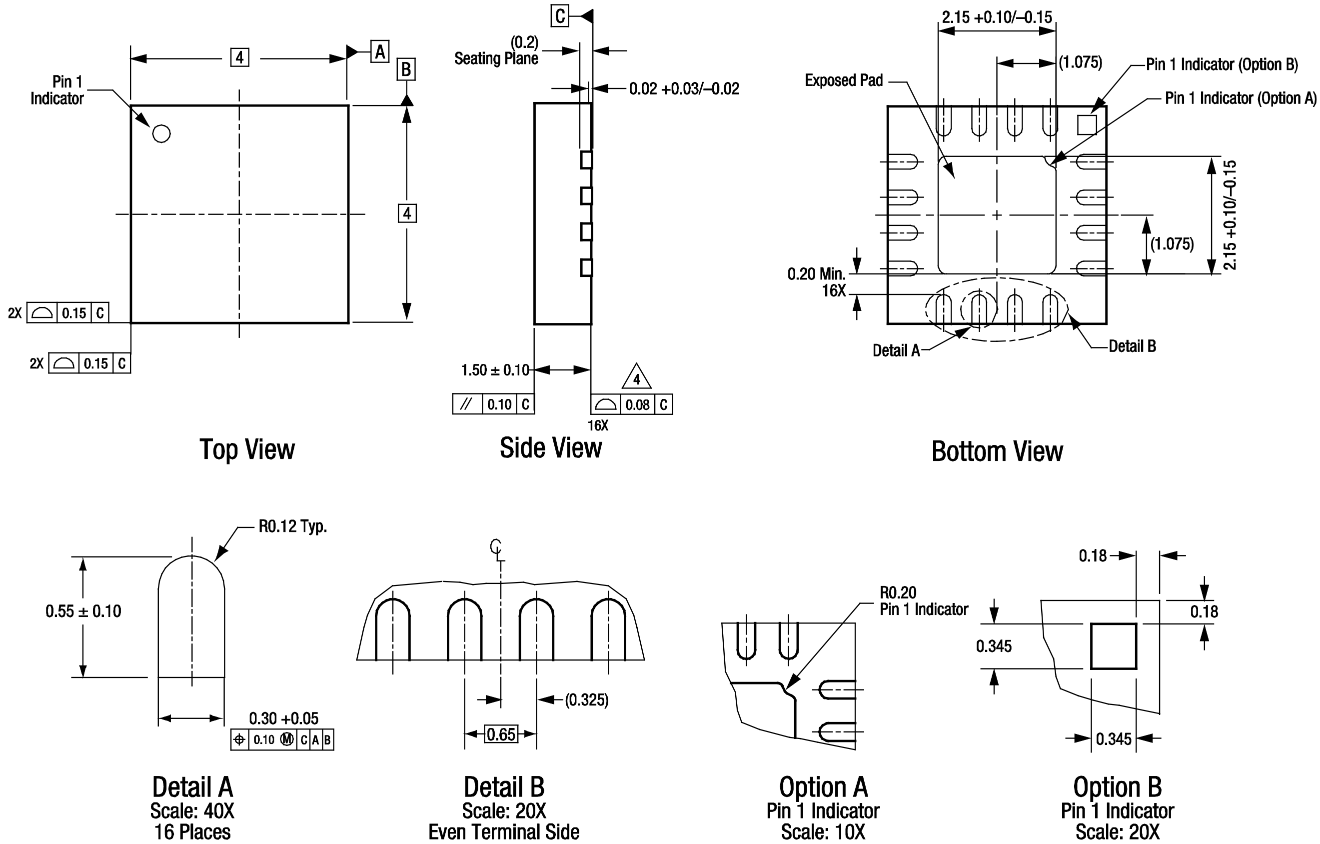


Figure 17. Typical Case Markings



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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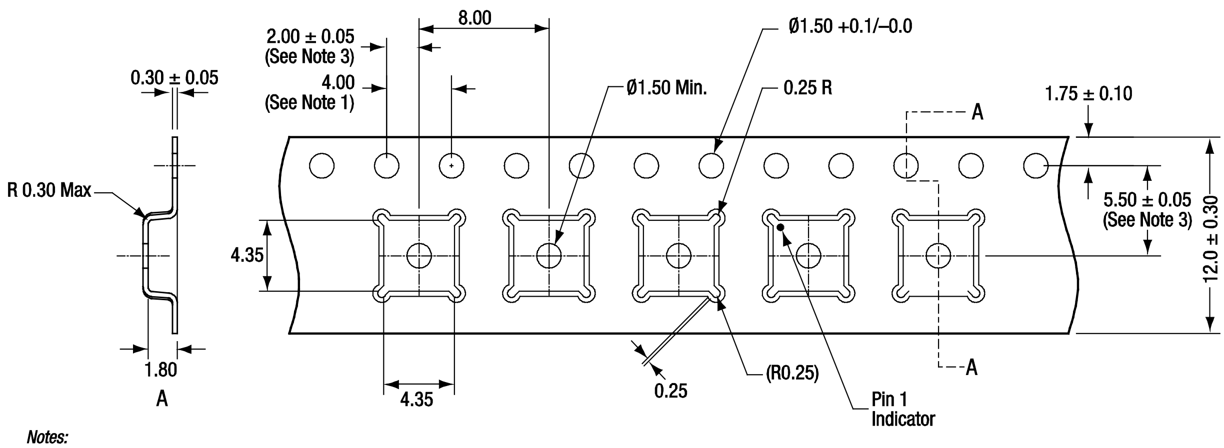
Figure 18. SKY12210-478LF 16-Pin QFN Package Dimensions



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.*

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Figure 19. SKY12210-478LF Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY12210-478LF PIN Diode SPDT Switch	SKY12210-478LF	SKY12210-478LF-EVB