DATA SHEET

SKY12207-478LF: 0.9 to 4.0 GHz 50 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: 50 W CW, 300 W peak
- Low insertion loss: 0.4 dB typical
- High antenna-to-receive isolation: 42 dB @ 2.6 GHz typical
- Controlled with positive power supply
- Bias driver circuit 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.

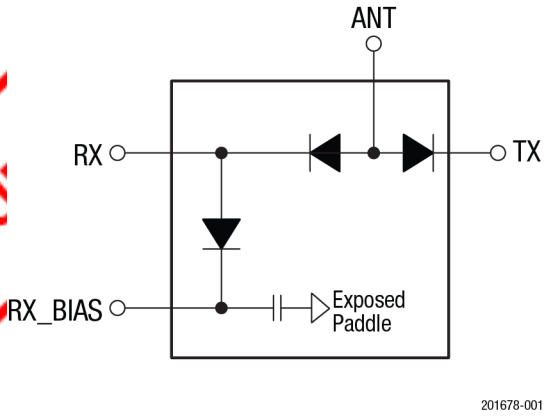

Figure 1. SKY12207-478LF Block Diagram

Description

The SKY12207-478LF 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 SKY12207-478LF 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.

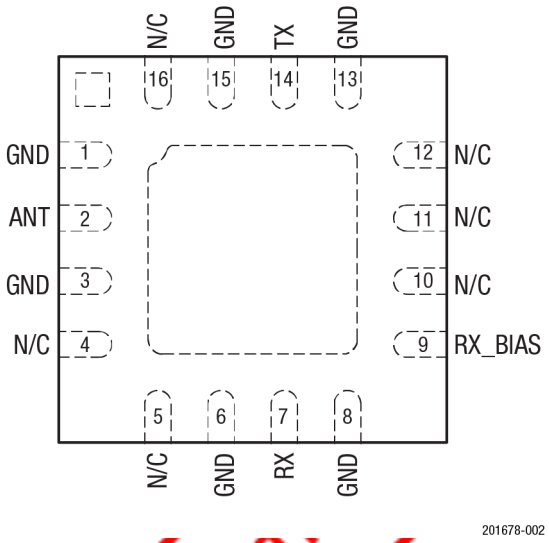

Figure 2. SKY12207-478LF Pinout – 16-Pin QFN
(Top View)

Table 1. SKY12207-478LF 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 SKY12207-478LF are provided in Table 2. Recommended operating conditions are specified in Table 3 and electrical specifications are provided in Tables 5 and 6.

Typical performance characteristics of the SKY12207-478LF are illustrated in Figures 3 through 9.

The switch state of the SKY12207-478LF is determined by the truth table provided in Table 4.

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. SKY12207-478LF Absolute Maximum Ratings[1]

Parameter	Symbol	Minimum	Maximum	Units
RF CW input power, TX and ANT ports (TSUBSTRATE = 25 °C)	PIN		75	W
RF peak input power, TX and ANT ports (TSUBSTRATE = 25 °C, RF burst width = 10 µs, RF burst repetition rate = 25 kHz)	PIN		300	W
RF CW input power, RX port (TSUBSTRATE = 25 °C)	PIN		60	W
RF peak input power, RX port (TSUBSTRATE = 25 °C, RF burst width = 10 µs, RF burst repetition rate = 25 kHz)	PIN		240	W
Control port reverse voltage	VCTL		200	V
Control port forward current	ICTL		200	mA
Operating temperature	TOP	–55	+175	°C
Storage temperature	TSTG	–55	+200	°C
Electrostatic discharge:				

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**:Industry-standard ESD handling precautions must be adhered to at all times to avoid damage to this device.*

Table 3. Recommended Operating Conditions (Per ANT, CTL = TX, RX, and RX_BIAS Inputs)

Parameter	Symbol	Min	Typ	Max	Units
ANT bias voltage	VANT	3	5	10	V
ANT bias current	IANT	20	50	50	mA
Control port reverse voltage	VCTL	5	28	50	V
Control port current	ICTL	10	10	50	mA

Table 4. SKY12207-478LF Truth Table

Switch State	Path		Control Conditions			
	Antenna-to-Receiver Port	Transmitter-to-Antenna Port	ANT	RX	TX	RX_BIAS
Receive (see Figure 12)	Low insertion loss	High isolation	5 V	0 V (ground)	VCTL	VCTL
Transmit (see Figure 12)	High isolation	Low insertion loss	5 V	VCTL	0 V (ground)	0 V (ground)

Table 5. SKY12207-478LF Electrical Specifications (1 of 2) (VANT = 5 V, IANT = 50 mA, VCTL = 28/0 V, ICTL = 0/50 mA, TOP = +25 °C, Characteristic Impedance [ZO] = 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}	RX = 28 V, TX, RX_BIAS = 0 V TX port P_{IN} @ pin 14 = 0 dBm: 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz		 0.25 0.29 0.31 0.32 0.41	 0.55 	 dB dB dB dB dB
Insertion loss, ANT to RX ports	IL_{ANT-RX}	RX = 0 V, TX, RX_BIAS = 28 V RX_BIAS port P_{IN} @ pin 2 = 0 dBm: 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz		 0.28 0.32 0.33 0.39 0.70	 0.60 	 dB dB dB dB dB
Isolation, TX to RX ports	$Iso_{\_TX-RX}$	RX = 28 V, TX, RX_BIAS = 0 V TX port P_{IN} @ pin 14 = 0 dBm: 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz	 37.0 	 34.0 37.0 38.5 42.0 32.0	 	 dB dB dB dB dB
Isolation, ANT to TX ports	$Iso_{\_ANT-TX}$	RX = 0 V, TX, RX_BIAS = 28 V RX_BIAS port P_{IN} @ pin 2 = 0 dBm: 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz	 17.0 	 26.0 22.0 21.0 20.0 16.0	 	 dB dB dB dB dB
Isolation, ANT to RX ports	$Iso_{\_ANT-RX}$	RX = 28 V, TX, RX_BIAS = 0 V ANT port P_{IN} @ pin 2 = 0 dBm: 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz	 39 	 33 37 38 42 30	 	 dB dB dB dB dB

Table 5. SKY12207-478LF Electrical Specifications (2 of 2)[1] (VANT = 5 V, IANT = 50 mA, VCTL = 28/0 V, ICTL = 0/50 mA, TOP = +25 °C, Characteristic Impedance [ZO] = 50 **Ω**, EVB Optimized for 2.6 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Input return loss	RL	1.8 to 2.5 GHz: RX insertion loss state, ANT port (@ pin 2) TX insertion loss state, TX Port (@ pin 14)		 28 26		 dB dB
Transmit 2nd harmonic	2fo	TX insertion loss state, RX = 28 V, TX, RX_BIAS = 0 V TX port P_{IN} @ pin 14 = +30 dBm: TX, RX_BIAS = 0V 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz		 –72 –66 –84 –68 –71		 dBc dBc dBc dBc dBc
Transmit 3rd harmonic	3fo	TX insertion loss state, RX = 28 V, TX, RX_BIAS = 0 V TX port P_{IN} @ pin 14 = +30 dBm: TX, RX_BIAS = 0V 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz		 –88 –80 –84 –81 –74		 dBc dBc dBc dBc dBc
Transmit 3rd Order Input Intercept Point	IIP3	RX = 28 V, TX, RX_BIAS = 0 V, TX port P_{IN} @ pin 14 = +30 dBm/tone, tone spacing = 1 MHz, @ 2.60 GHz		+78		dBm
Transmit 0.1 dB Compression Point	IP0.1dB	RX = 28 V, TX, RX_BIAS = 0 V, @ 2.60 GHz		+47		dBm
Receive 0.1 dB Compression Point	IP0.1dB	RX = 0 V, TX, RX_BIAS = 28 V, @ 2.60 GHz		+46		dBm
Maximum transmit CW input power	P_{IN_CW}	RX = 28 V, TX, RX_BIAS = 0 V, 0.9 to 3.5 GHz		50		W
Maximum receive CW input power	P_{IN_CW}	RX = 0 V, TX, RX_BIAS = 28 V, 0.9 to 3.5 GHz		40		W
Transmit RF switching time	t_{SW}	RX = 28 V, TX, RX_BIAS = 0 V, 10% to 90% RF on, repetition rate = 0.1 MHz, @ 2.6 GHz		170		ns
Thermal resistance (junction to case)	Θ_{JC}			32		°C/W

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

Table 6. SKY12207-478LF Electrical Specifications (1 of 2) (VANT = 5 V, IANT = 50 mA, VCTL = 5/0 V, ICTL = 0/50 mA, TOP = +25 °C, Characteristic Impedance [ZO] = 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}	RX = 5 V, TX, RX_BIAS = 0 V, TX port P_{IN} @ pin 14 = 0 dBm:				
		900 MHz		0.25		dB
		1.80 GHz		0.30		dB
		2.01 GHz		0.32		dB
		2.60 GHz		0.34	0.55	dB
		3.50 GHz		0.43		dB
Insertion loss, ANT to RX ports	IL_{ANT-RX}	RX = 0 V, TX, RX_BIAS = 5 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		900 MHz		0.28		dB
		1.80 GHz		0.31		dB
		2.01 GHz		0.33		dB
		2.60 GHz		0.41	0.60	dB
		3.50 GHz		0.72		dB
Isolation, TX to RX ports	$Iso_{\_TX-RX}$	RX = 5 V, TX, RX_BIAS = 0 V, TX port P_{IN} @ pin 14 = 0 dBm:				
		900 MHz		33.0		dB
		1.80 GHz		36.4		dB
		2.01 GHz		38.0		dB
		2.60 GHz	40.0	43.0		dB
		3.50 GHz		31.0		dB
Isolation, ANT to TX ports	$Iso_{\_ANT-TX}$	RX = 0 V, TX, RX_BIAS = 5 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		900 MHz		25.0		dB
		1.80 GHz		22.0		dB
		2.01 GHz		21.0		dB
		2.60 GHz	17.0	19.0		dB
		3.50 GHz		15.0		dB
Isolation, ANT to RX ports	$Iso_{\_ANT-RX}$	RX = 5 V, TX, RX_BIAS = 0 V, ANT port P_{IN} @ pin 2 = 0 dBm:				
		900 MHz		33		dB
		1.80 GHz		36		dB
		2.01 GHz		37		dB
		2.60 GHz	39	42		dB
		3.50 GHz		31		dB

Table 6. SKY12207-478LF Electrical Specifications (2 of 2)[1] (VANT = 5 V, IANT = 50 mA, VCTL = 5/0 V, ICTL = 0/50 mA, TOP = +25 °C, Characteristic Impedance [ZO] = 50 **Ω**, EVB Optimized for 2.6 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Input return loss	RL	1.8 to 2.5 GHz: RX insertion loss state, ANT port (@ pin 2) TX insertion loss state, TX port (@ pin 14)		 28 26		 dB dB
Transmit 2nd harmonic	2fo	TX insertion loss state, RX = 5 V, TX, RX_BIAS = 0 V TX port P_{IN} @ pin 14 = +30 dBm: 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz		 –36 –43 –61 –51 –58		 dBc dBc dBc dBc dBc
Transmit 3rd harmonic	3fo	TX insertion loss state, RX = 5 V, TX, RX_BIAS = 0 V TX port P_{IN} @ pin 14 = +30 dBm: 900 MHz 1.80 GHz 2.01 GHz 2.60 GHz 3.50 GHz		 –57 –55 –59 –59 –52		 dBc dBc dBc dBc dBc
Transmit 3rd Order Input Intercept Point	IIP3	RX = 5 V, TX, RX_BIAS = 0 V, TX port P_{IN} @ pin 14 = +30 dBm/tone, tone spacing = 1 MHz, @ 2.60 GHz		+74		dBm
Transmit 0.1 dB Compression Point	IP0.1dB	RX = 5 V, TX, RX_BIAS = 0 V, @ 2.60 GHz		+33		dBm
Receive 0.1 dB Compression Point	IP0.1dB	RX = 0 V, TX, RX_BIAS = 5 V, @ 2.60 GHz		+34		dBm
Maximum transmit CW input power	P_{IN_CW}	RX = 5 V, TX, RX_BIAS = 0 V, 0.9 to 3.5 GHz		15		W
Maximum receive CW input power	P_{IN_CW}	RX = 0 V, TX, RX_BIAS = 5 V, 0.9 to 3.5 GHz		10		W
Transmit RF switching time	t_{SW}	RX = 5 V, TX, RX_BIAS = 0 V, 10% to 90% RF on, repetition rate = 0.1 MHz, @ 2.60 GHz		170		ns
Thermal resistance (junction to case)	Θ_{JC}			32		°C/W

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

Typical Performance Characteristics

(VANT = 5 V, IANT = 50 mA, ICTL = 50mA TOP = +25 °C, Characteristic Impedance [ZO] = 50 Ω, EVB Optimized for 2.6 GHz Operation, Unless Otherwise Noted)

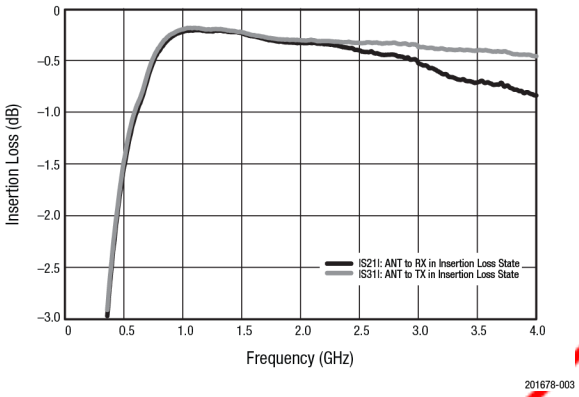

Figure 3. Insertion Loss vs Frequency
(ANT to RX and ANT to TX Ports; VCTL = 28 V)

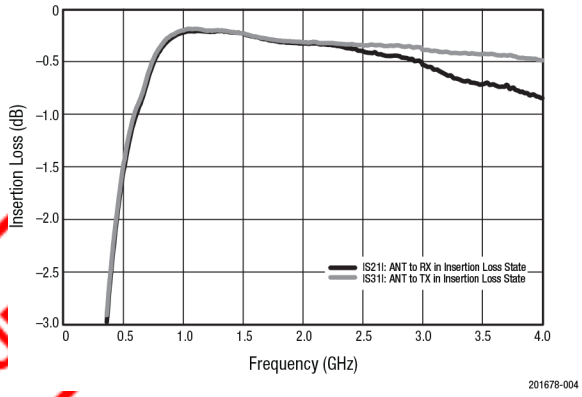

Figure 4. Insertion Loss vs Frequency
(ANT to RX and ANT to TX Ports; VCTL = 5 V)

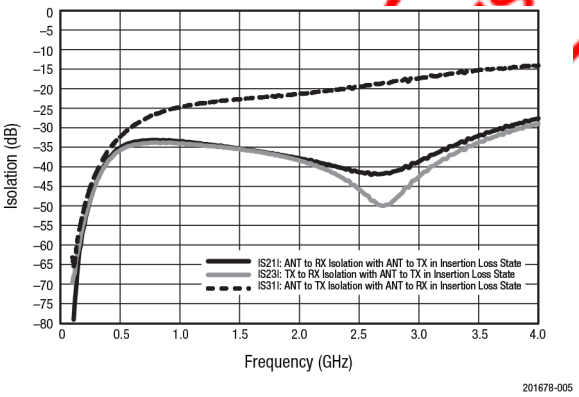

Figure 5. Isolation vs Frequency
(ANT to RX, TX to RX, and ANT to TX Ports; VCTL = 28 V)

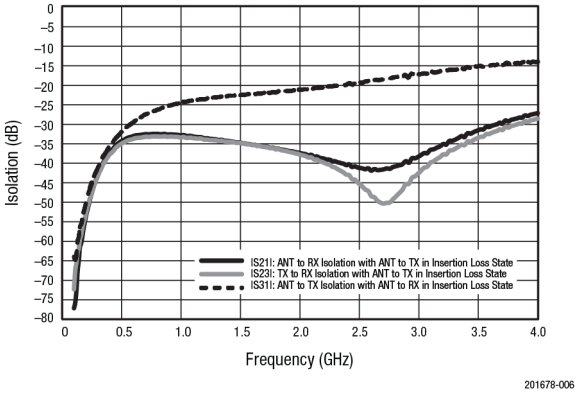

Figure 6. Isolation vs Frequency
(ANT to RX, TX to RX, and ANT to TX Ports; VCTL = 5 V)

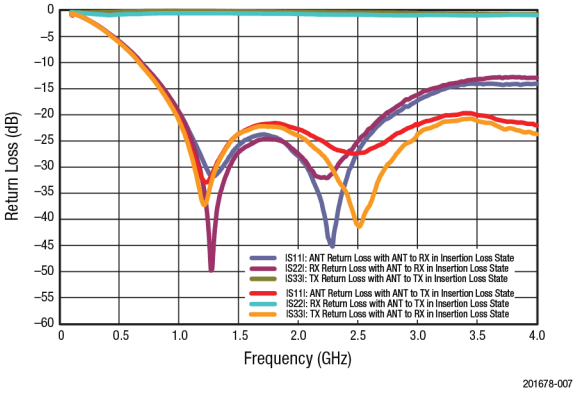

Figure 7. Return Loss vs Frequency
(ANT, TX, and RX Ports; VCTL = 28 V)

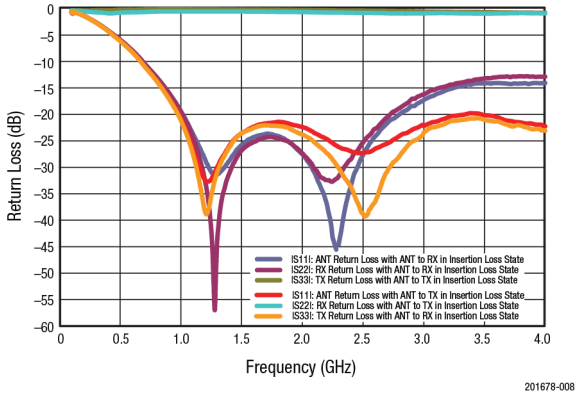

Figure 8. Return Loss vs Frequency
(ANT, TX, and RX Ports; VCTL = 5 V)

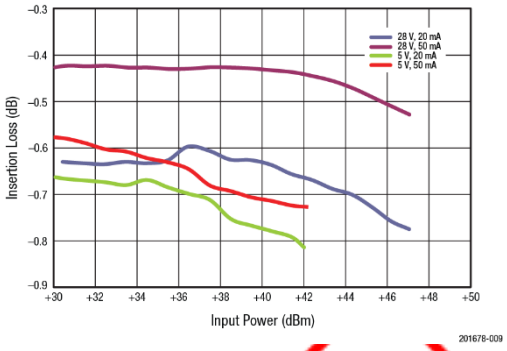

Figure 9. Insertion Loss vs CW Input Power (TX to ANT Port, f = 2.6 GHz)

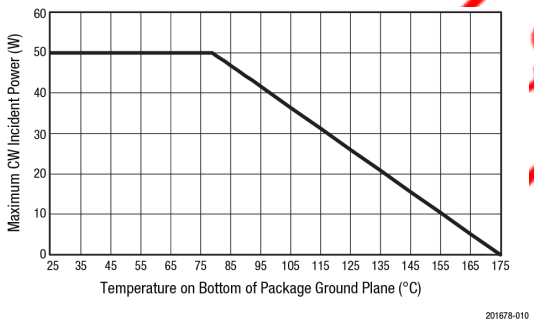

Figure 10. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.3 dB) vs Temperature on Bottom of Package Ground Plane

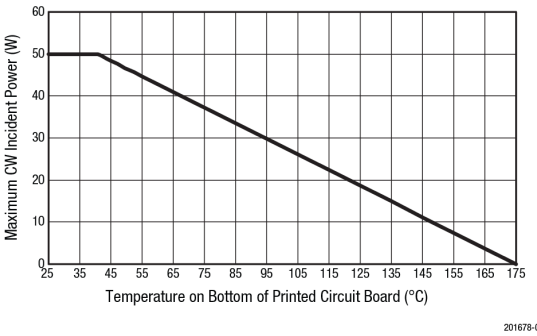

Figure 11. Transmit Power Derating, Maximum CW Incident Power (Insertion Loss = 0.3 dB) vs Temperature on Bottom of Printed Circuit Board

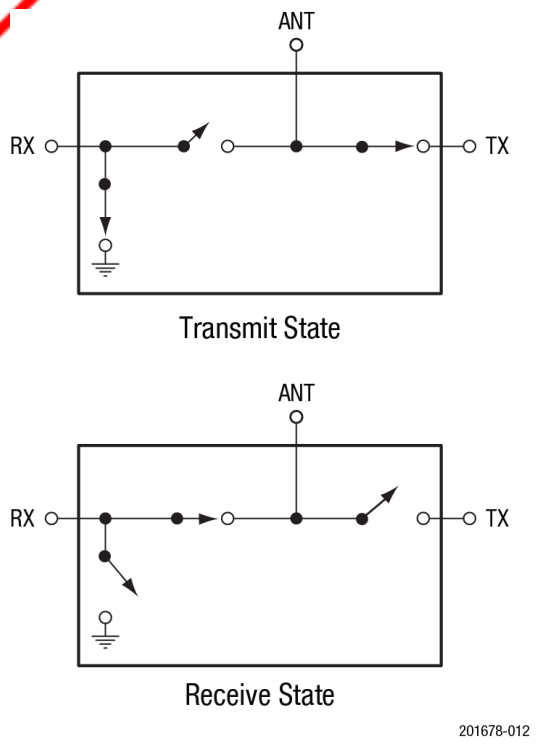

Figure 12. SKY12207-478LF Equivalent Circuit Diagrams

Evaluation Board Description

The SKY12207-478LF Evaluation Board is used to test the performance of the SKY12207-478LF PIN Diode SPDT switch. An assembly drawing for the Evaluation Board is shown in Figure 13. The layer detail is provided in Figure 14.

The SKY12207-478LF 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 SKY12207-478LF transmit/receive switch with bias signals derived from positive voltages. The state of the PIN diodes within the SKY12207-478LF is controlled with 5 V applied to the ANT pin and bias voltages of either 28 V / 5 V or 0 V applied to the remaining bias inputs (RX, TX and RX_BIAS pins). The switch state circuit diagrams are shown in Figure 12.

The value of resistor R1, 80 Ω, is selected to provide 50 mA of forward current through the "on" series diode with 5 V applied to the ANT pin. An R2 resistance value of 540 Ω is selected to produce approximately 50 mA of forward bias current in the RX shunt diode with a source voltage of 28 V. For a lower control current (ICTL), an R2 resistance value of 2.7K Ω should be selected to produce approximately 10 mA of forward bias current in the RX shunt diode with a source voltage of 28 V.

The magnitudes of the voltages applied to the TX and RX pins determine which of the RX or TX series diodes is biased into forward conduction. For example, to place the SKY12207-478LF into the transmit state, 0 V is applied to the TX pin (which forward biases the diode between pins 2 and 14), 28 V or 5 V is applied to the RX pin (which reverse biases the diode between pins 2 and 7), and 0 V is applied to the RX_BIAS pin (which applies a forward bias through R2 to the diode connected between pins 7 and 9).

The component values shown in the Evaluation Board circuit diagram (Figure 15) were selected to optimize performance in the 2.0 to 3.5 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 SKY12207-478LF 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 SKY12207-478LF 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.

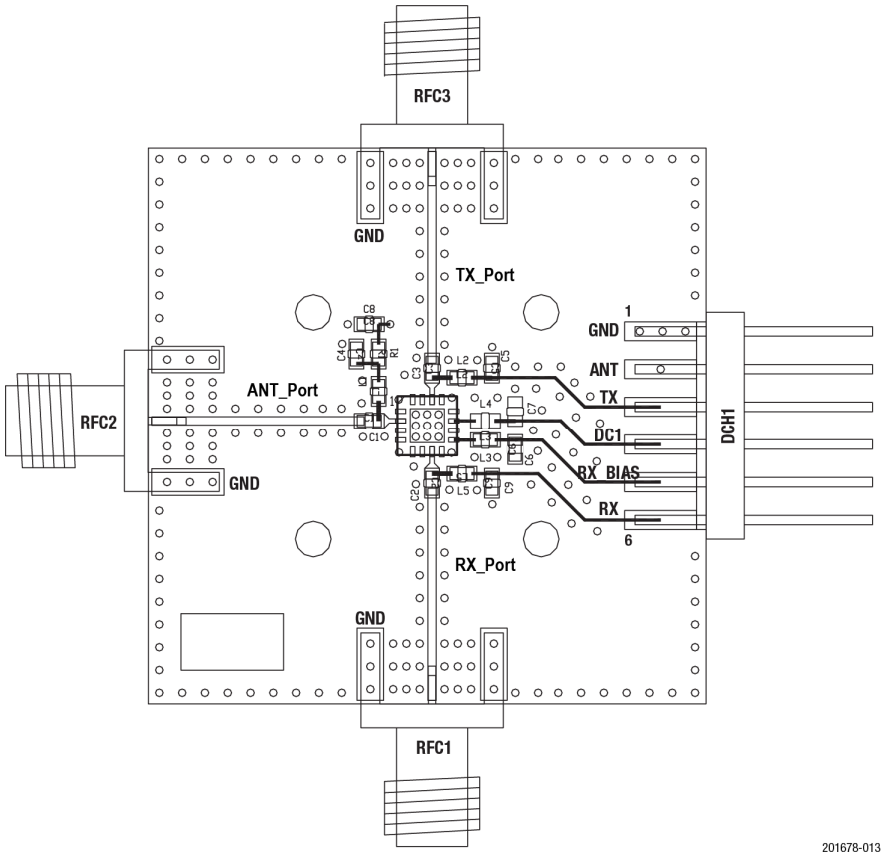

Figure 13. SKY12207-478LF Evaluation Board Assembly Diagram

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 14. Layer Detail Physical Characteristics

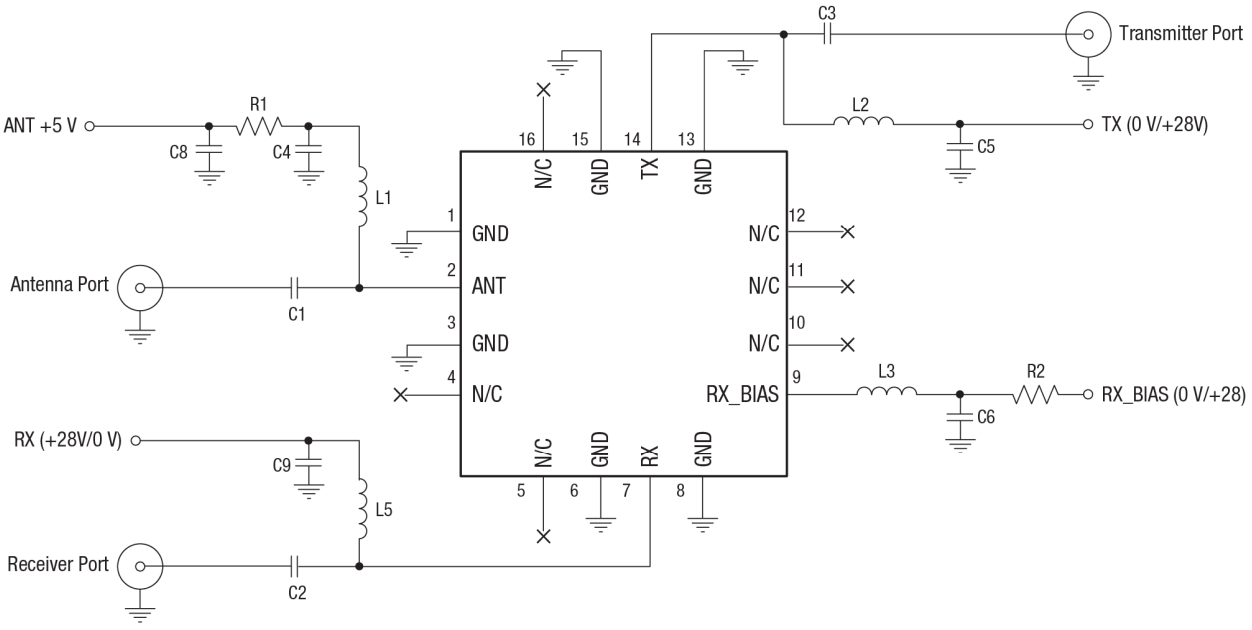


Figure 15. SKY12207-478LF Evaluation Board Schematic

Table 7. SKY12207-478LF Evaluation Board Bill of Materials (BOM)[1]

Component	Value	Size	Product Number	Manufacturer	Mfr Part Number	Characteristics
C1, C2, C3, C4, C5, C6, C9	1000 pF	0603	5404R23-057	TDK	C1608C0G1H102JT	COG, 50 V, ±5%
C8	1 µF	0603	5404R29-070	TDK	C2012X7R1H104K	X7R, 50 V, ±10%
L1, L2, L5	22 nH	0603	55332R34-028	Taiyo-Yuden	HK160822NJ-T	SRF, 1600 MHz, ±5%
L3	560 nH	0603		Coil Craft	0603LS-561XJLB	SRF, 525 MHz, ±5%
R1[2]	80 Ω	0603		Panasonic	ERJ-3GEYJ161V	0.1 W, 5%
R2[3]	540			Rohm Semi	ESR10EZPF2701	Resistor, 540ohm

1 Component values selected are based on the desired frequency and bias level. Values may be adjusted for a specific response.
2 Two 160 Ω resistors are combined in parallel to achieve a minimum power handling requirement and an 80 Ω resistance.
3 Stock evaluation board does not include resistor R2. Operating at 28 V and 50 mA requires an R2 external resistor with a power dissipation greater than 1.35 W.

Table 8. SKY12207-478LF Component Values for Specified and Optional Bias Currents[1]

VS (V)	VDIODE (V)	VRES (V)	Current (A)	Resistance (Ω)	Power Dissipation (W)
28[2]	1	27	0.05	540	1.35
28	1	27	0.02	1350	0.54
28	1	27	0.01	2.7K	0.27
5[2]	1	4	0.05	80	0.20
5	1	4	0.02	200	0.08

1 Vs = supply voltage; VDIODE = voltage drop across the diode; VRES = voltage drop across the resistor.
R1 and R2 values are calculated by (Vs – VDIODE)/I, where I is the desired bias current.
The power dissipation in R1 or R2 is calculated by I x (VS – VDIODE). The resistor selected must be safely rated with a power greater than the dissipated power.
2 Stock evaluation board resistor and current values.

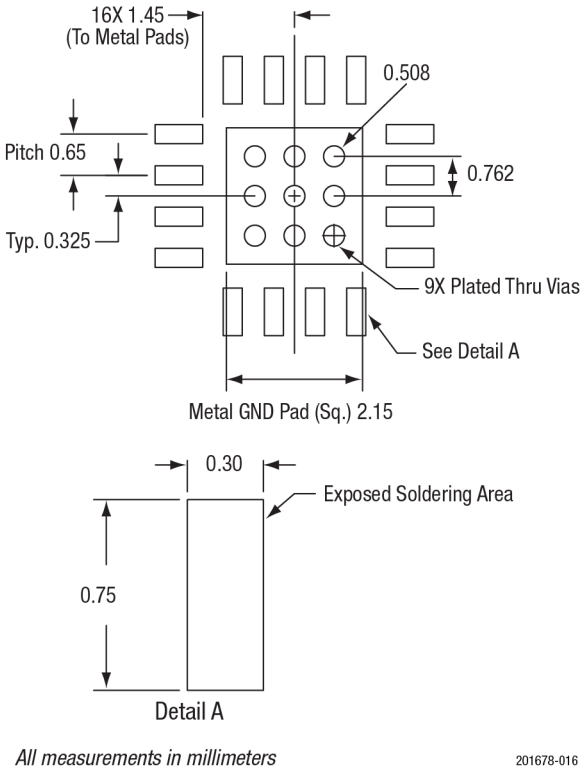


Figure 16. SKY12207-478LF PCB Layout Footprint

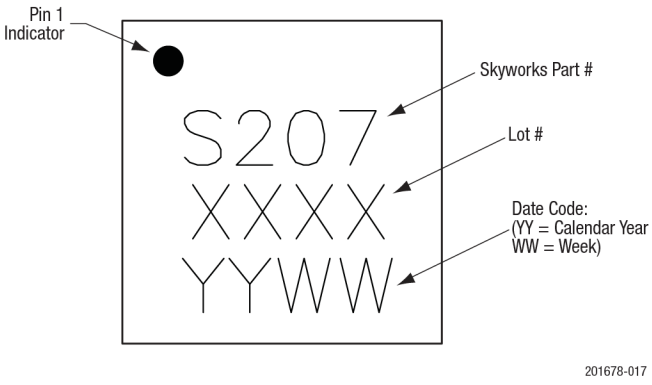
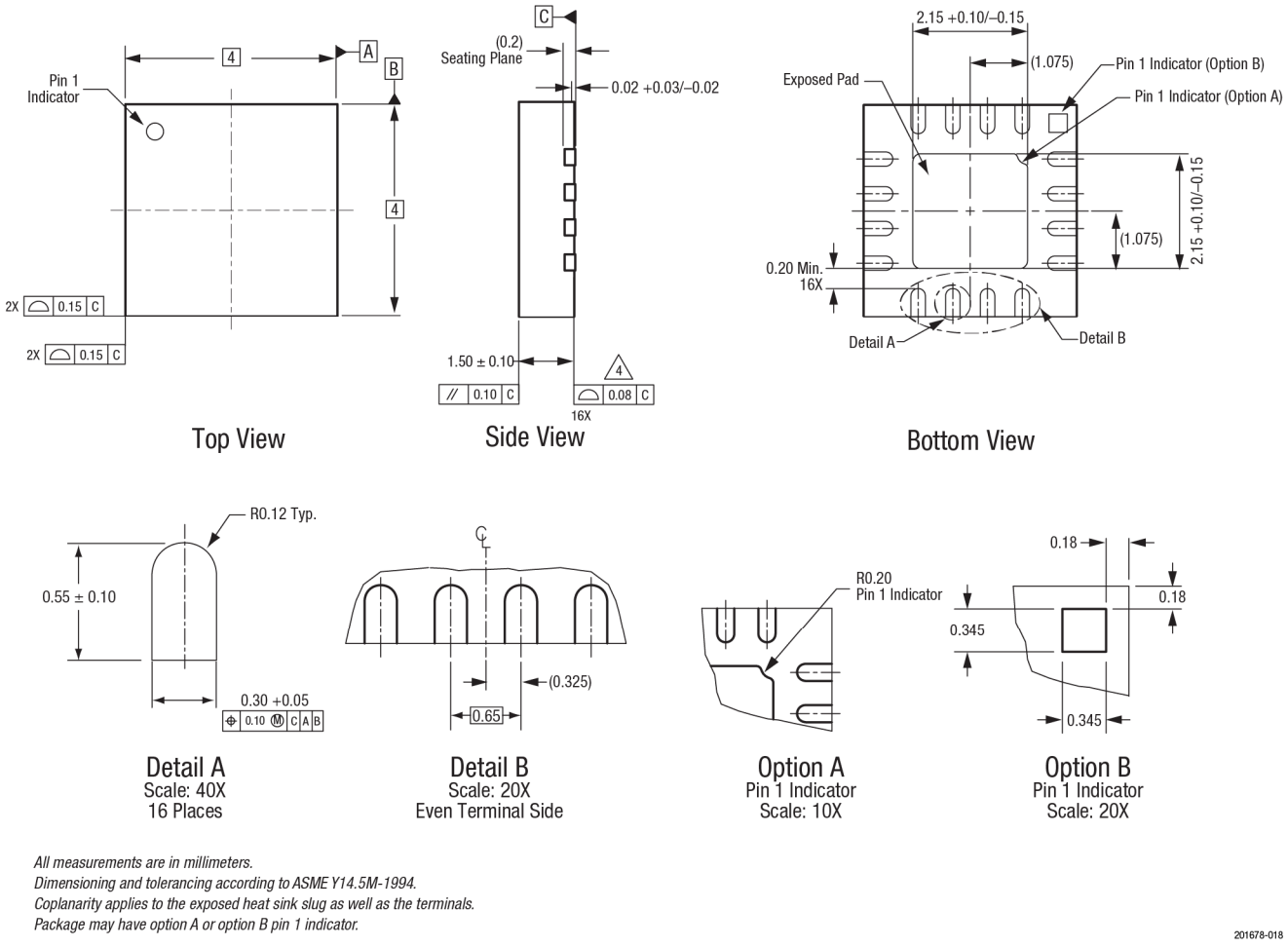


Figure 17. Typical Case Markings



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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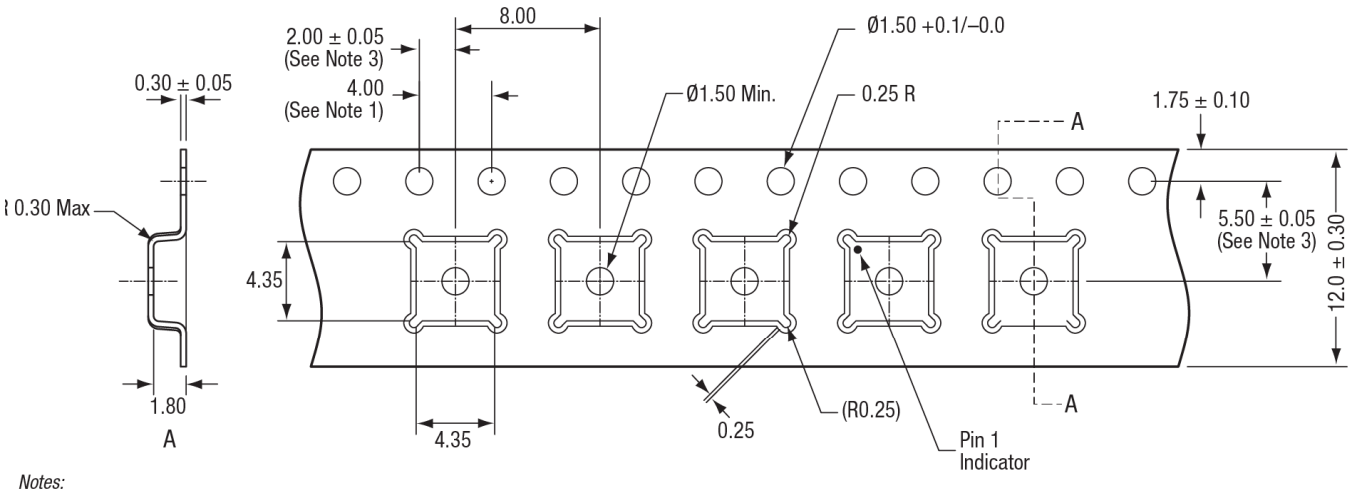
Figure 18. SKY12207-478LF 16-Pin QFN Package Dimensions



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. SKY12207-478LF Tape and Reel Dimensions

Ordering Information

Part Number	Product Description	Evaluation Board Part Number
SKY12207-478LF PIN Diode SPDT Switch	SKY12207-478LF	SKY12207-478LF-EVB