DATA SHEET

SKY12209-478LF: 0.9 to 4.0 GHz 40 W High Power Silicon PIN Diode SPDT Switch

Applications

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

Features

- High power handling: 40 W CW
- Low insertion loss: 0.3 dB typical
- High isolation: 42 dB @ 2.6 GHz
- Controlled with positive power supply
- Fast RF rise time: 40 ns typical
- 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.

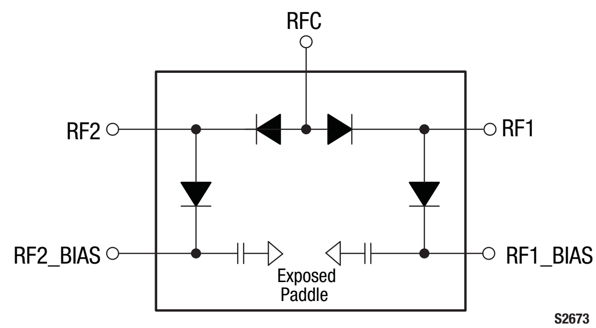


Figure 1. SKY12209-478LF Block Diagram

Description

The SKY12209-478LF is a high power handling, Single-Pole, Double-Throw (SPDT) silicon PIN diode switch with symmetrical switching paths from a single common port. The device operates over the 0.9 GHz to 4.0 GHz band. It features low insertion loss, excellent power handling, and superb linearity with low DC power consumption.

The SKY12209-478LF is well-suited for use as a high power transmit/receive and RF path 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.

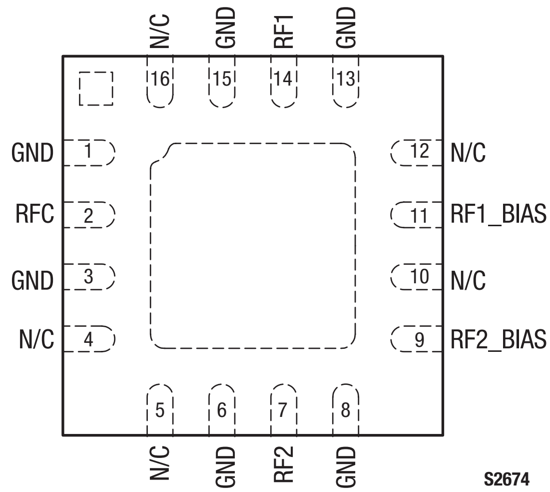


Figure 2. SKY12209-478LF Pinout – 16-Pin QFN (Top View)

Table 1. SKY12209-478LF Signal Descriptions

Pin	Name	Description	Pin	Name	Description
1	GND	Ground. Must be connected to ground using lowest possible impedance.	9	RF2_BIAS	RF ground port 2 and DC bias port
2	RFC	RF port and DC bias port	10	N/C	No connection
3	GND	Ground. Must be connected to ground using lowest possible impedance.	11	RF1_BIAS	RF ground port 1 and DC bias port
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	RF1	RF port 1 and DC bias port
7	RF2	RF port 2 and DC bias 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 SKY12209-478LF are provided in Table 2. Recommended operating conditions are specified in Table 3. Electrical specifications are provided in Table 4 (28 V bias voltage) and Table 5 (5 V bias voltage).

Typical performance characteristics of the SKY12209-478LF are illustrated in Figures 3 through 10.

The state of the SKY12209-478LF is determined by the logic provided in Table 6. Table 7 provides the logic for use with the SKY12209-478LF Evaluation Board.

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

Table 2. SKY12209-478LF Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Units
RF CW input power ($T_{SUBSTRATE}$ = 25 °C)	P_{IN}		60	W
RF peak input power ($T_{SUBSTRATE}$ = 25 °C, RF burst width = 10 μs, RF burst repetition 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 1C			1000	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 reverse voltage	V_{CTL}	5	28	100	V
Control port forward current (Note 1)	I_{CTL}	20	50	100	mA

Note 1: Per each diode in forward conduction mode.

Table 4. SKY12209-478LF Electrical Specifications, Bias Voltage = 28 V (Note 1)
(T_{OP} = +25 °C, Characteristic Impedance [Z_0] = 50 Ω, EVB Optimized for 0.9 to 4.0 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Insertion loss, RFC to RF1 and RF2 ports	$IL_{RFC-RF1}$ $IL_{RFC-RF2}$	RFC port P_{IN} @ pin 2 = 0 dBm:				
		0.90 GHz		0.62		dB
		1.80 GHz		0.40		dB
		2.01 GHz		0.42		dB
		2.60 GHz		0.50	0.70	dB
		3.50 GHz		0.65		dB
Isolation, RF1 to RF2 ports	$Iso\_{RF1-RF2}$	RF1 port P_{IN} @ pin 14 = 0 dBm:				
		0.90 GHz		35		dB
		1.80 GHz		37		dB
		2.01 GHz		39		dB
		2.60 GHz	40	46		dB
		3.50 GHz		36		dB
Isolation, RFC to RF1 and RF2 ports	$Iso\_{RFC-RF1}$ $Iso\_{RFC-RF2}$	RFC port P_{IN} @ pin 2 = 0 dBm:				
		0.90 GHz		35		dB
		1.80 GHz		37		dB
		2.01 GHz		39		dB
		2.60 GHz	38	42		dB
		3.50 GHz		36		dB
Input return loss, RFC port	RL_{RFC}	RFC port P_{IN} @ pin 2 = 0 dBm:				
		0.90 GHz		13		
		1.80 GHz		28		dB
		2.01 GHz		25		dB
		2.60 GHz		22		dB
		3.50 GHz		34		dB
2nd harmonic	2fo	RFC port P_{IN} @ pin 2 = +30 dBm:				
		0.90 GHz		–80		dBc
		1.80 GHz		–81		dBc
		2.01 GHz		–82		dBc
		2.60 GHz		–80		dBc
		3.50 GHz		–81		dBc
3rd harmonic	3fo	RFC port P_{IN} @ pin 2 = +30 dBm:				
		0.90 GHz		–92		dBc
		1.80 GHz		–92		dBc
		2.01 GHz		–95		dBc
		2.60 GHz		–96		dBc
		3.50 GHz		–93		dBc
3rd Order Input Intercept Point	IIP3	RFC port P_{IN} @ pin 2 = +30 dBm/tone, Δf = 1 MHz, @ 2.6 GHz		+76		dBm
Maximum CW input power	P_{IN_CW}	0.9 to 3.5 GHz		40		W
Transmit RF switching time	t_{SW}	10% to 90% RF rise time, repetition rate = 100 kHz, @ 2.6 GHz		40		ns
Thermal resistance (junction-to-case)	$Θ_{JC}$			64.2		°C/W

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

Table 5. SKY12209-478LF Electrical Specifications, Bias Voltage = 5 V (Note 1)
(T_{OP} = +25 °C, Characteristic Impedance [Z_0] = 50 Ω, EVB Optimized for 0.9 to 4.0 GHz Operation, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Insertion loss, RFC to RF1 and RF2 ports	$IL_{RFC-RF1}$ $IL_{RFC-RF2}$	RFC port P_{IN} @ pin 2 = 0 dBm:				
		0.90 GHz		0.63		dB
		1.80 GHz		0.43		dB
		2.01 GHz		0.46		dB
		2.60 GHz		0.54	0.70	dB
		3.50 GHz		0.63		dB
Isolation, RF1 to RF2 ports	$Iso_{RF1-RF2}$	RF1 port P_{IN} @ pin 14 = 0 dBm:				
		0.90 GHz		34		dB
		1.80 GHz		37		dB
		2.01 GHz		38		dB
		2.60 GHz	40	46		dB
		3.50 GHz		36		dB
Isolation, RFC to RF2 and RF1 ports	$Iso_{RFC-RF2}$ $Iso_{RFC-RF1}$	RFC port P_{IN} @ pin 2 = 0 dBm:				
		0.90 GHz		33		dB
		1.80 GHz		36		dB
		2.01 GHz		38		dB
		2.60 GHz	38	42		dB
		3.50 GHz		34		dB
Input return loss, RFC port	RL_{RFC}	RFC port P_{IN} @ pin 2 = 0 dBm:				
		0.90 GHz		12		
		1.80 GHz		28		dB
		2.01 GHz		26		dB
		2.60 GHz		25		dB
		3.50 GHz		32		dB
2nd harmonic	2fo	RFC port P_{IN} @ pin 2 = +30 dBm:				
		0.90 GHz		–40		dBc
		1.80 GHz		–51		dBc
		2.01 GHz		–51		dBc
		2.60 GHz		–51		dBc
		3.50 GHz		–55		dBc
3rd harmonic	3fo	RFC port P_{IN} @ pin 2 = +30 dBm:				
		0.90 GHz		–51		dBc
		1.80 GHz		–63		dBc
		2.01 GHz		–68		dBc
		2.60 GHz		–63		dBc
		3.50 GHz		–63		dBc
3rd Order Input Intercept Point	IIP3	RFC port P_{IN} @ pin 2 = +30 dBm/tone, Δf = 1 MHz, @ 2.6 GHz		+76		dBm
Maximum CW input power	P_{IN_CW}	0.9 to 3.5 GHz		15		W
Transmit RF switching time	t_{SW}	10% to 90% RF rise time, repetition rate = 100 kHz, @ 2.6 GHz		40		ns
Thermal resistance (junction-to-case)	Θ_{JC}			64.2		°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 0.9 to 4.0 GHz Operation, Unless Otherwise Noted)

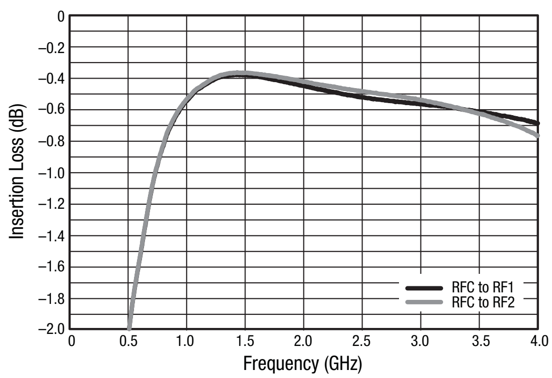


Figure 3. Insertion Loss vs Frequency
(VCTL = 28 V, ICTL = –50 mA)

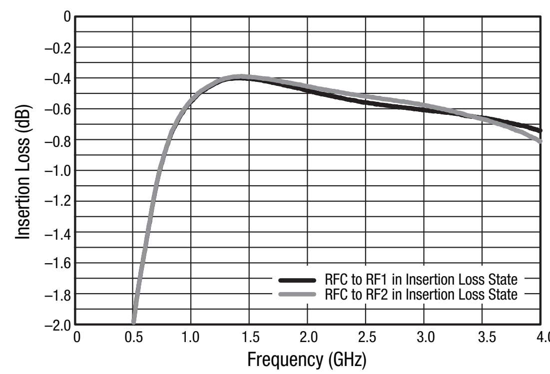


Figure 4. Insertion Loss vs Frequency
(VCTL = 5 V, ICTL = –50 mA)

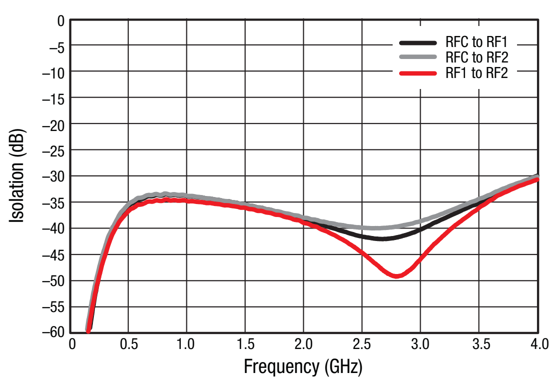


Figure 5. Isolation vs Frequency
(VCTL = 28 V, ICTL = –50 mA)

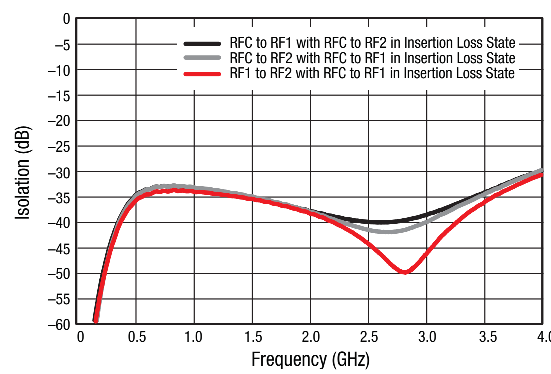


Figure 6. Isolation vs Frequency
(VCTL = 5 V, ICTL = –50 mA)

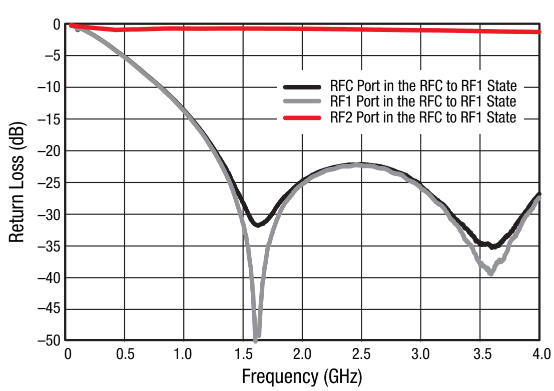


Figure 7. Return Loss vs Frequency
(VCTL = 28 V, ICTL = –50 mA)

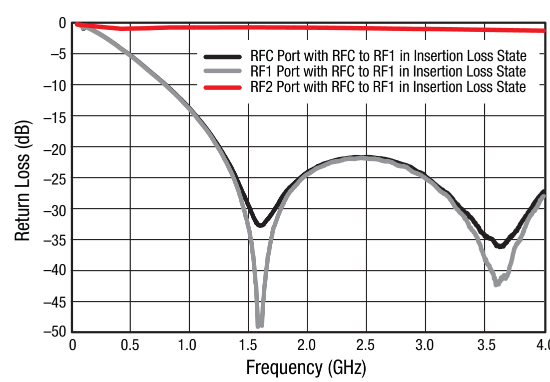


Figure 8. Return Loss vs Frequency
(VCTL = 5 V, ICTL = –50 mA)

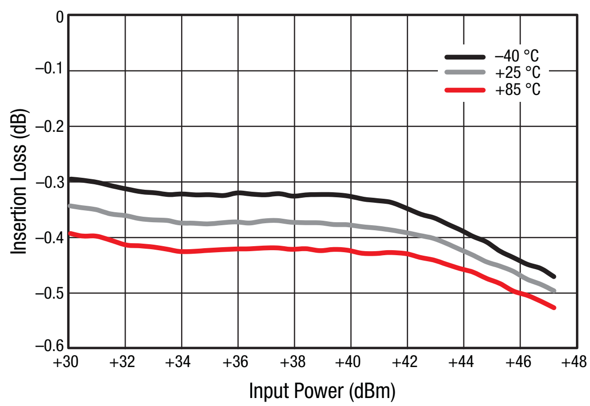


Figure 9. Insertion Loss vs CW Input Power (f = 2.6 GHz, Evaluation Board Loss Included)

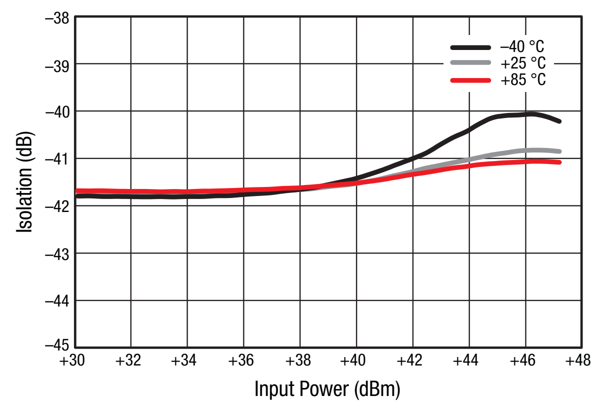


Figure 10. Isolation vs CW Input Power (f = 2.6 GHz, Evaluation Board Loss Included)

Table 6. SKY12209-478LF Truth Table

Path		Control Conditions				
RFC-to-RF2 Port (Pin 2 to Pin 7)	RFC-to-RF1 Port (Pin 2 to Pin 14)	RFC Port Bias (Pin 2)	RF2 Port Bias (Pin 7)	RF1 Port Bias (Pin 14)	RF2_BIAS (Pin 9)	RF1_BIAS (Pin 11)
Low insertion loss	High isolation	1 V	–50 mA	28 V	28 V	–50 mA
High isolation	Low insertion loss	1 V	28 V	–50 mA	–50 mA	28 V

Table 7. SKY12209-478LF Evaluation Board Truth Table

Path		Control Conditions				
RFC-to-RF2 Port	RFC-to-RF1 Port	RFC Port Bias (V)	RF2 Port Bias (V)	RF1 Port Bias (V)	RF2_BIAS (V)	RF1_BIAS (V)
Low insertion loss	High isolation	5	0 (ground)	28	28	0 (ground)
High isolation	Low insertion loss	5	28	0 (ground)	0 (ground)	28

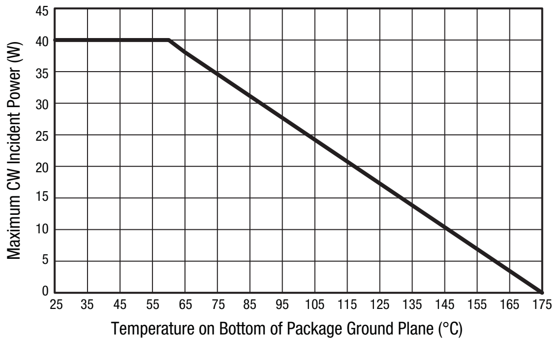


Figure 11. Power Derating, Maximum CW Incident Power (Insertion Loss = 0.2 dB) vs Temperature on Bottom of Package Ground Plane

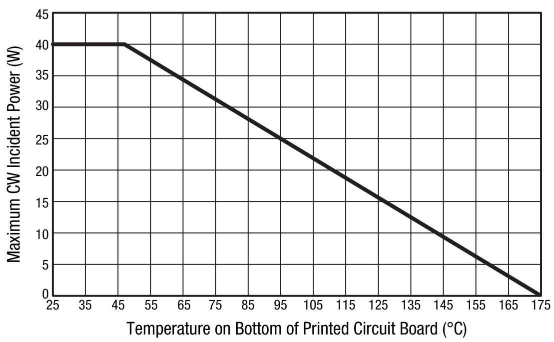


Figure 12. Power Derating, Maximum CW Incident Power (Insertion Loss = 0.2 dB) vs Temperature on Bottom of Printed Circuit Board

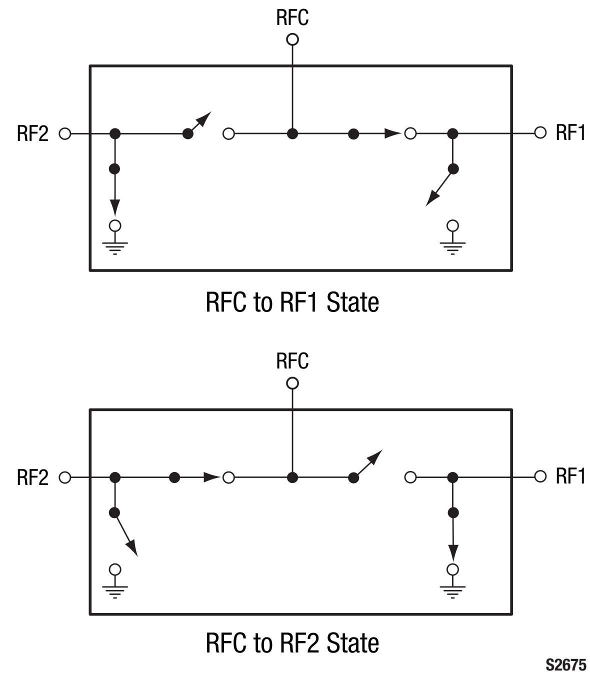


Figure 13. SKY12209-478LF Equivalent Circuit Diagrams

Evaluation Board Description

The SKY12209-478LF Evaluation Board is used to test the performance of the SKY12209-478LF PIN Diode SPDT switch. An assembly drawing for the Evaluation Board is shown in Figure 14. The layer detail is provided in Figure 15.

The SKY12209-478LF 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 11, 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 12.

The evaluation circuit is designed to facilitate control of the SKY12209-478LF SPDT switch with bias signals derived from positive voltages. The state of the PIN diodes within the SKY12209-478LF is controlled with 5 V applied to the RFC port and bias voltages of either 28 V or 0 V applied to the remaining bias inputs (RF1 and RF2 ports). The switch state circuit diagrams are shown in Figure 13.

The values of resistors R2 and R3 (refer to the schematic diagram in Figure 16), which are both nominally 540 Ω, together with the magnitudes of the voltages applied to the RF1 and RF2 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 SKY12209-478LF into the RFC to RF1 low insertion loss state, 0 V is applied to the RF1 port (which forward biases the diode between pins 2 and 14), 28 V is applied to the RF2 port (which reverse biases the diode between pins 2 and 7), 0 V is applied to the RF2_BIAS port (which applies a forward bias through R3 to the diode connected between pins 7 and 9), and 28 V is applied to the RF1_BIAS port (which applies a forward bias through R2 to the diode connected between pins 14 and 11).

The values of R2 and R3 may be adjusted to accommodate other bias voltages. Resistance values of 540 Ω are selected to produce approximately 50 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 16) were selected to optimize performance in the 0.9 to 4.0 GHz band.

Refer to Table 8 for the Evaluation Board Bill of Materials. Table 9 provides voltage, current, and resistor values for bias adjustments.

Package Dimensions

The PCB layout footprint for the SKY12209-478LF is shown in Figure 17. Typical case markings are noted in Figure 18. Package dimensions for the 16-pin QFN 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 SKY12209-478LF 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.

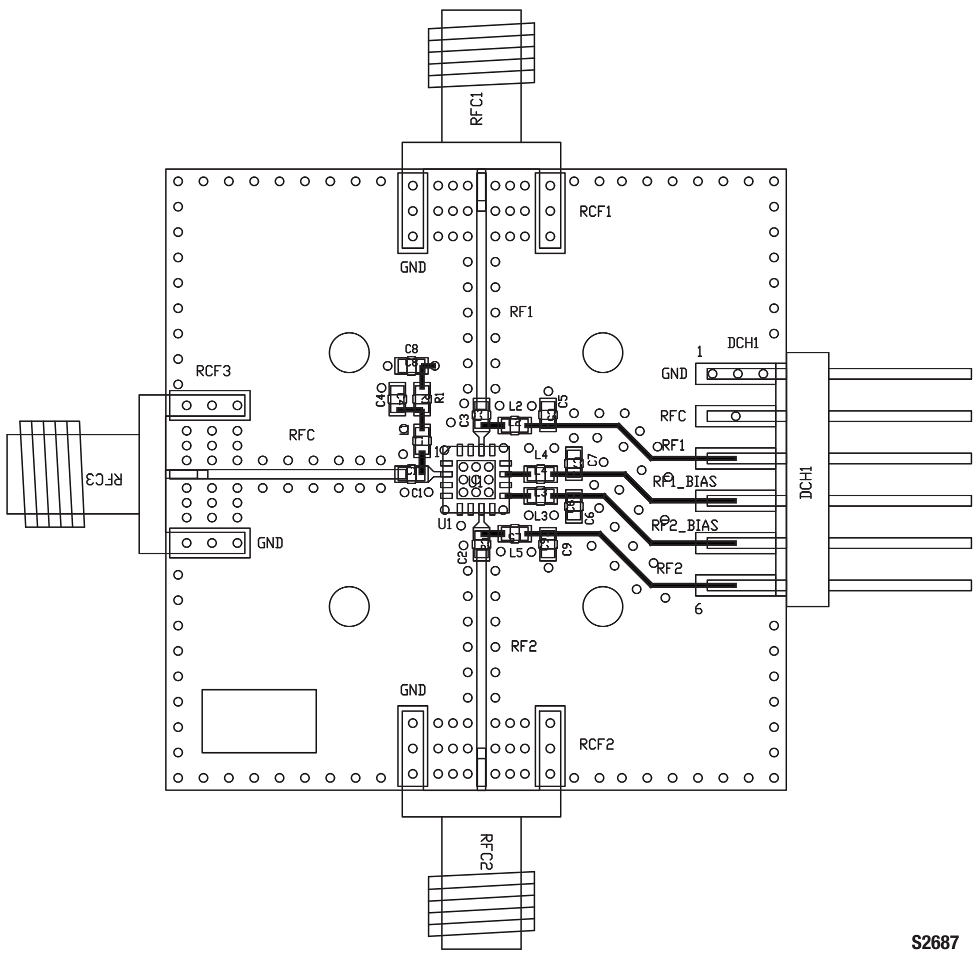
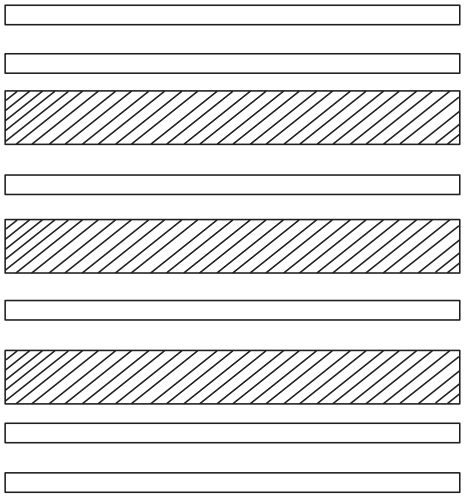


Figure 14. SKY12209-478LF Evaluation Board Assembly Diagram

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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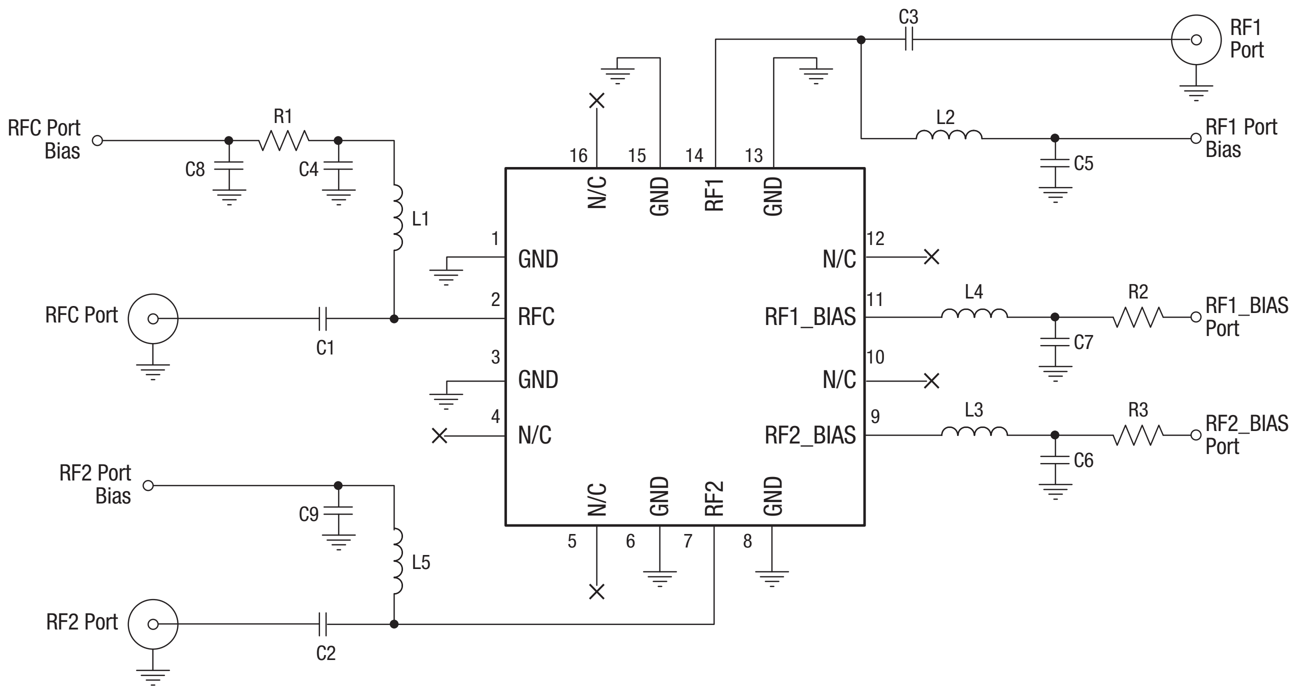
Figure 15. Layer Detail Physical Characteristics



NOTE: The N/C pins (4, 5, 10, 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 8. Evaluation Board Bill of Materials (Note 1)

Component	Value	Size	Manufacturer	Mfr Part Number	Characteristics
C1, C2, C3, C4, C5, C6, C7, C9	1000 pF	0603	TDK	C1608C0G1H102JT	COG, 50 V, ±5%
C8	1 μF	0603	TDK	C2012X7R1H104K	X7R, 50 V, ±10%
L1, L2, L3, L4, L5	22 nH	0603	Taiyo-Yuden	HK160822NJ-T	SRF, 1600 MHz, ±5%
R1 (Note 2)	80 Ω	0603	Panasonic	ERJ-3GEYJ161V	0.1 W, ±5%
R2, R3 (Note 3)	540 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: Two 160 Ω resistors are combined in parallel to achieve a minimum power handling requirement and 80 Ω resistance.

Note 3: Evaluation Board does not include resistors R2 and R3. Operating at 28 V and 50 mA requires R2 and R3 resistors with a power dissipation greater than 1.35 W.

Table 9. Component Calculation Values

V_S (V)	V_{DIODE} (V)	V_{RES} (V)	Current (A)	Resistance (Ω)	Power Dissipation (W)
28	1	27	0.05	540	1.35
28	1	27	0.02	1350	0.54
5	1	4	0.05	80	0.20
5	1	4	0.02	200	0.08

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 – V_{DIODE})/I, where I is the desired bias current.
The power dissipation in R2 and R3 is calculated by I x (V_S – V_{DIODE}). The resistor selected must be safely rated with a power greater than the dissipated power.

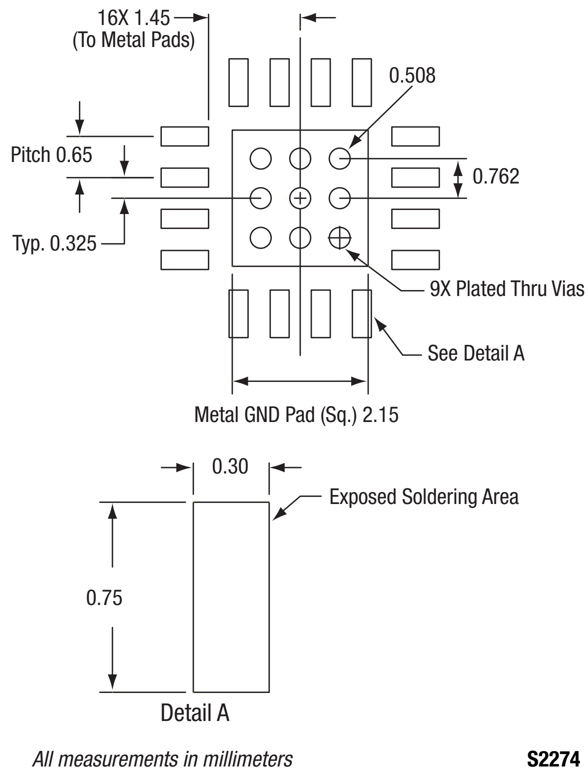


Figure 17. SKY12209-478LF PCB Layout Footprint

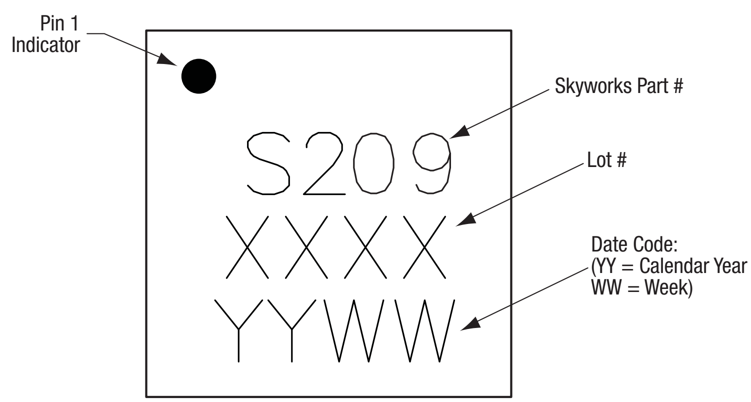
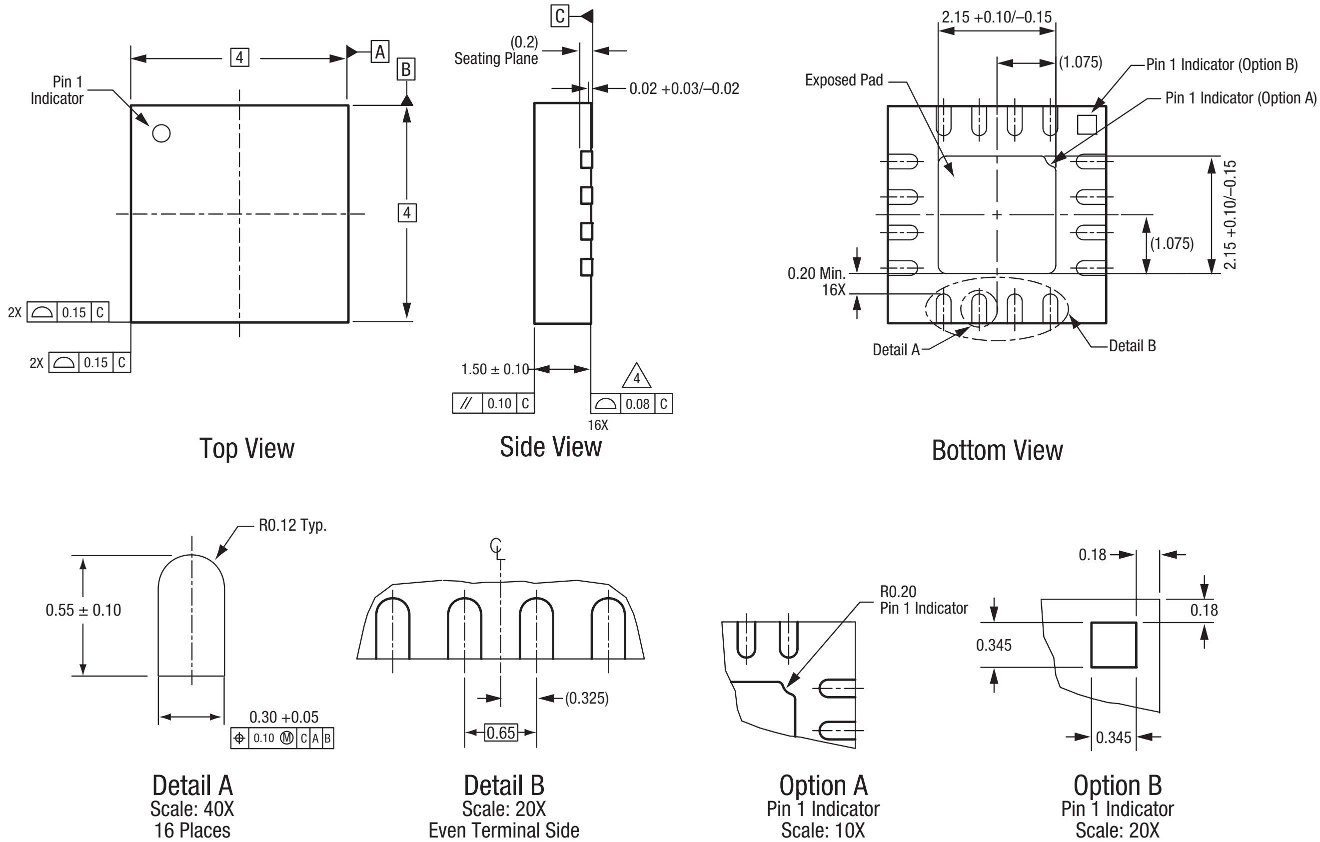


Figure 18. Typical Case Markings



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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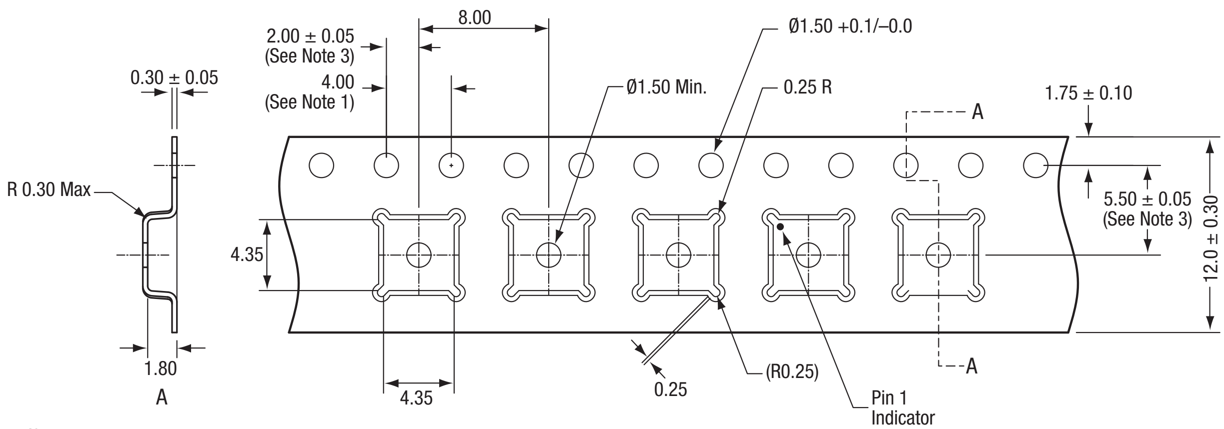
Figure 19. SKY12209-478LF 16-Pin QFN Package Dimensions



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 20. SKY12209-478LF Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY12209-478LF PIN Diode SPDT Switch	SKY12209-478LF	SKY12209-478LF-EVB

OCEAN CHIPS
Океан Электроники
Поставка электронных компонентов

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Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения **«JONHON»**, а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов **«FORSTAR»**.

AVIC JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).

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