

DATA SHEET

SKY12215-478LF: 0.9 to 4.0 GHz, 125 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: 125 W CW
- Low insertion loss: 0.4 dB typical
- High antenna to receive isolation: 43 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.

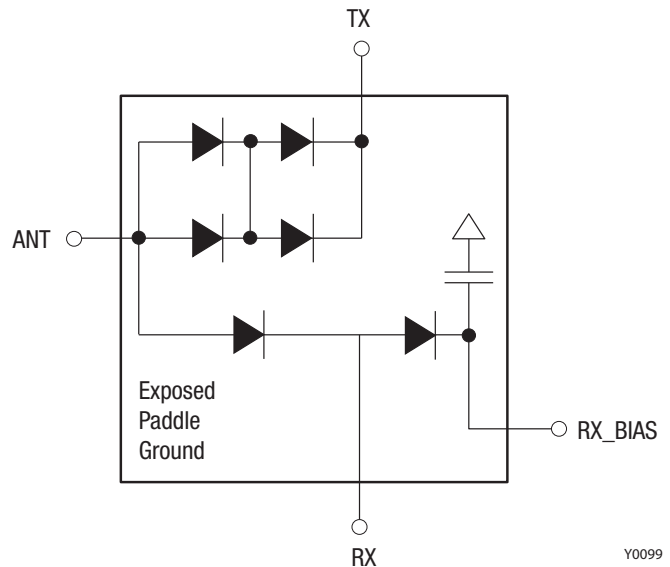


Figure 1. SKY12215-478LF Block Diagram

Description

The SKY12215-478LF 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 SKY12215-478LF 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.

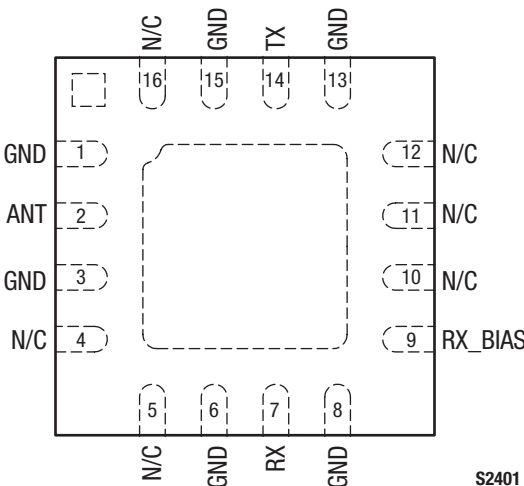


Figure 2. SKY12215-478LF Pinout – 16-Pin QFN (Top View)

Table 1. SKY12215-478LF Signal Descriptions

| Pin | Name | Description | Pin | Name | Description |
|-----|------|---|-----|---------|---|
| 1 | GND | Ground on the Evaluation Board. May be N/C or GND. | 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 on the Evaluation Board. May be GND or N/C. |
| 3 | GND | Ground on the Evaluation Board. May be N/C or GND. | 11 | N/C | No connection on the Evaluation Board. May be GND or N/C. |
| 4 | N/C | No connection on the Evaluation Board. May be GND or N/C. | 12 | N/C | No connection on the Evaluation Board. May be GND or N/C. |
| 5 | N/C | No connection on the Evaluation Board. May be GND or N/C. | 13 | GND | Ground on the Evaluation Board. May be N/C or GND. |
| 6 | GND | Ground on the Evaluation Board. May be N/C or GND. | 14 | TX | Transmit RF input port and DC bias input port. |
| 7 | RX | Receive output port and DC bias input port. | 15 | GND | Ground on the Evaluation Board. May be N/C or GND. |
| 8 | GND | Ground on the Evaluation Board. May be N/C or GND. | 16 | N/C | No connection on the Evaluation Board. May be GND or N/C. |

Note: Center paddle must be grounded. See Figure 13 for recommended via pattern.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY12215-478LF 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 SKY12215-478LF are illustrated in Figures 3 through 6.

The state of the SKY12215-478LF is determined by the logic provided in Table 5. Table 6 provides the logic for use with the SKY12215-478LF Evaluation Board.

Power derating data is plotted against temperature in Figures 7 and 8. Equivalent circuit diagrams for transmit and receive are shown in Figure 9.

Table 2. SKY12215-478LF Absolute Maximum Ratings

| Parameter | Symbol | Minimum | Maximum | Units |
|--|------------------|---------|---------|--------------------|
| RF CW input power, TX and ANT ports ($T_{\text{SUBSTRATE}} = 25^{\circ}\text{C}$) | P_{IN} | | 190 | W |
| RF peak input power, TX and ANT ports ($T_{\text{SUBSTRATE}} = 25^{\circ}\text{C}$, RF burst width = 10 μs , RF burst repetition rate = 25 kHz) | P_{IN} | | 760 | W |
| RF CW input power, RX port ($T_{\text{SUBSTRATE}} = 25^{\circ}\text{C}$) | P_{IN} | | 60 | W |
| RF peak input power, RX port ($T_{\text{SUBSTRATE}} = 25^{\circ}\text{C}$, 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 | $^{\circ}\text{C}$ |
| Storage temperature | T_{STG} | -55 | +200 | $^{\circ}\text{C}$ |
| Electrostatic discharge: | ESD | | | |
| Charged Device Model (CDM), Class 4 | | | 1000 | V |
| Human Body Model (HBM), Class 1B | | | 500 | 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 (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. SKY12215-478LF Electrical Specifications (1 of 2) (Note 1)**(T_{OP} = +25 °C, Characteristic Impedance [Z₀] = 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 1.80 GHz 2.00 GHz 2.60 GHz 3.55 GHz | | 0.40 0.50 0.60 0.70 0.70 | 0.90 | dB dB dB dB 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 1.80 GHz 2.00 GHz 2.60 GHz 3.55 GHz | | 0.50 0.30 0.35 0.45 0.38 | 0.60 | dB dB dB dB 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 1.80 GHz 2.00 GHz 2.60 GHz 3.55 GHz | 40 | 31 36 37 44 36 | | dB dB dB dB 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 1.80 GHz 2.00 GHz 2.60 GHz 3.55 GHz | 19 | 29 24 24 23 21 | | dB dB dB dB 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 1.80 GHz 2.00 GHz 2.60 GHz 3.55 GHz | 40 | 31 36 37 43 34 | | dB dB dB dB dB |
| Input return loss | ANT _{RL} | 1.8 to 3.5 GHz: RX insertion loss state, ANT port (@ pin 2) TX insertion loss state, TX port (@ pin 14) | | 17 13 | | dB dB |

Table 4. SKY12215-478LF Electrical Specifications (2 of 2) (Note 1)**(TOP = +25 °C, Characteristic Impedance [Z₀] = 50 Ω, EVB Optimized for 2.6 GHz Operation, Unless Otherwise Noted)**

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|--|-----------------|---|-----|----------------------------------|-----|-------------------------------------|
| Transmit 2 nd harmonic | 2fo | TX insertion loss state, TX port P _{IN} @ pin 14 = +30 dBm: 900 MHz 1.80 GHz 2.00 GHz 2.60 GHz 3.55 GHz | | -72 -85 -85 -84 -89 | | dBc dBc dBc dBc dBc |
| Transmit 3 rd harmonic | 3fo | TX insertion loss state, TX port P _{IN} @ pin 14 = +30 dBm: 900 MHz 1.80 GHz 2.00 GHz 2.60 GHz 3.55 GHz | | -76 -86 -86 -98 -102 | | dBc dBc dBc dBc dBc |
| Transmit 3 rd 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 | | +71 | | dBm |
| Transmit 0.1 dB Input Compression Point | TX_P0.1dB | V _{PIN_2} = 2 V, I _{PIN_14} = -100 mA, I _{PIN_9} = -100 mA, V _{PIN_7} = 28 V: @ 2.6 GHz | | 50 | | W |
| Receive 0.1 dB Input Compression Point | RX_P0.1dB | V _{PIN_2} = 1 V, V _{PIN_14} = 28 V, I _{PIN_7} = -100 mA, V _{PIN_9} = 28 V: @ 2.6 GHz | | 50 | | W |
| Maximum transmit CW input power | TX_PIN_CW | 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 | | 125 | | W |
| Maximum receive CW input power | RX_PIN_CW | 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 | | 50 | | W |
| Transmit RF switching time | t _{sw} | 10% to 90% RF on, repetition rate = 0.1 MHz, @ 2.6 GHz | | 250 | | ns |
| Thermal resistance (junction to case) | Θ _{JC} | | | 9 | | °C/W |

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

Typical Performance Characteristics

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

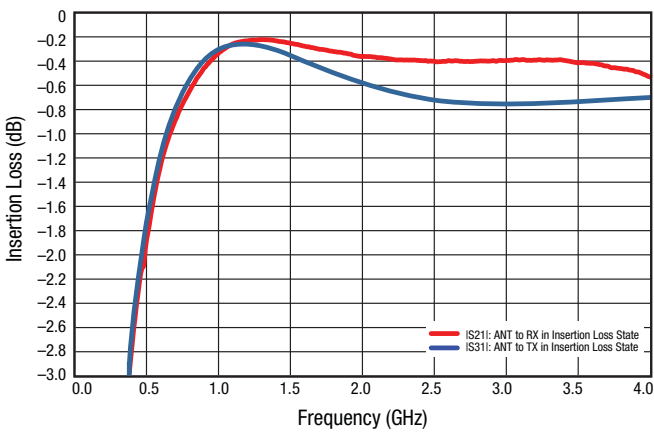


Figure 3. Insertion Loss vs Frequency

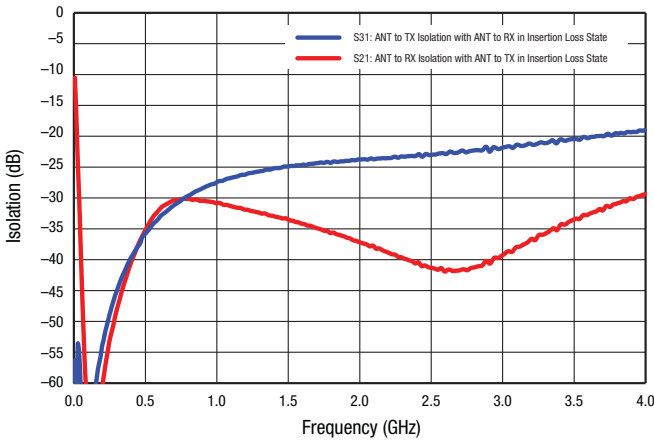


Figure 4. Isolation vs Frequency

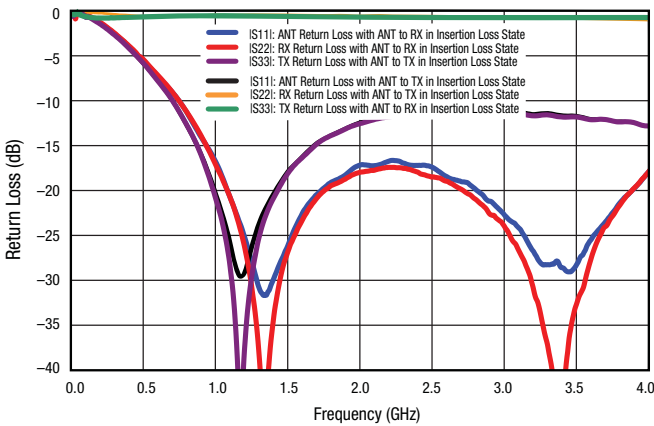


Figure 5. Return Loss vs Frequency

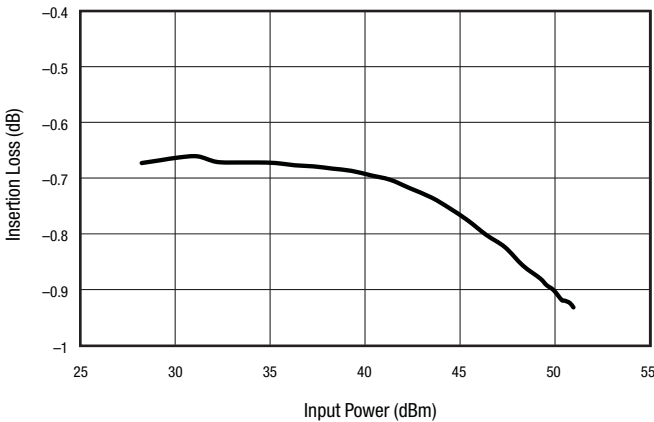


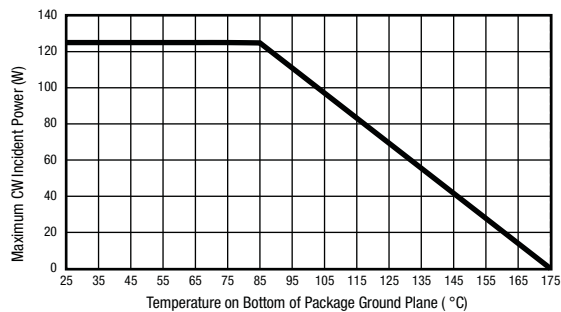
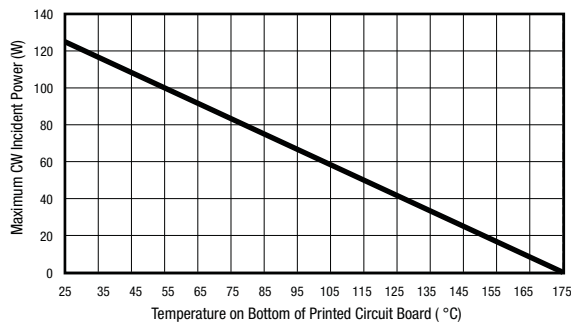
Figure 6. Insertion Loss vs CW Input Power
(TX to ANT Port, f = 2600 MHz, 28 V, 100 mA, EVB Loss Included)

Table 5. SKY12215-478LF 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. SKY12215-478LF Evaluation Board Truth Table

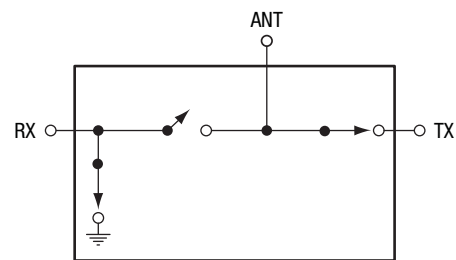
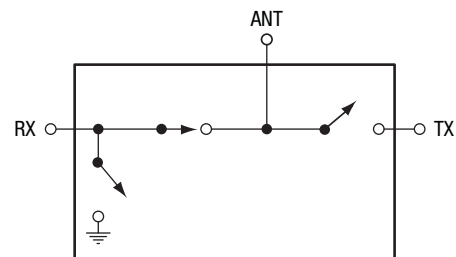
| Switch State | Path | | Control Conditions | | | |
|----------------------------|--------------------------|-----------------------------|-------------------------|----------------------|-----------------------------|---------------|
| | Antenna-to-Receiver Port | Transmitter-to-Antenna Port | Antenna 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 7. Transmit Power Derating, Maximum CW Incident Power (Frequency = 1.8 to 2.6 GHz) vs Ground Plane Temperature****Figure 8. Transmit Power Derating, Maximum CW Incident Power (Frequency = 1.8 to 2.6 GHz) vs Printed Circuit Board Temperature**

Evaluation Board Description

The SKY12215-478LF Evaluation Board is used to test the performance of the SKY12215-478LF PIN Diode SPDT switch. An assembly drawing for the Evaluation Board is shown in Figure 10. The layer detail physical characteristics are provided in Figure 11.

The SKY12215-478LF 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.

**Transmit State****Receive State**

S2398

Figure 9. SKY12215-478LF Equivalent Circuit Diagrams

As indicated in Figure 7, 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 8.

The evaluation circuit is designed to facilitate control of the SKY12215-478LF transmit/receive switch with bias signals derived from positive voltages. The state of the PIN diodes within the SKY12215-478LF 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 9.

The value of resistor R1, $31\ \Omega$, 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 $262\ \Omega$ is selected to produce approximately 100 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 ports determine which of the RX or TX series diodes is biased into forward conduction. For example, to place the SKY12215-478LF 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 circuit diagram (Figure 12) 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

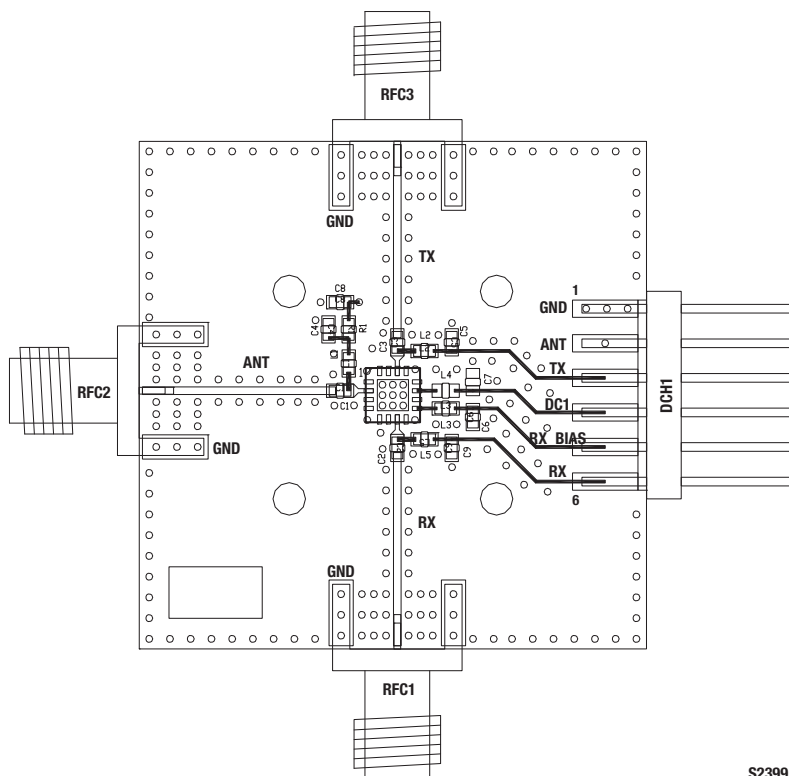
The PCB layout footprint for the SKY12215-478LF is shown in Figure 13. Typical case markings are noted in Figure 14. Package dimensions for the 16-pin QFN are shown in Figure 15, and tape and reel dimensions are provided in Figure 16.

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.



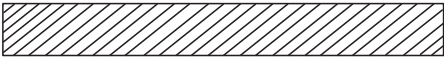

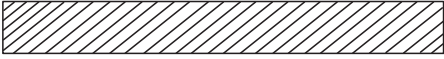

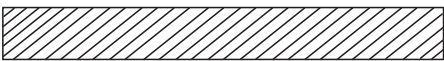


The SKY12215-478LF is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *Solder Reflow Information*, document number 200164.

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.



S2399

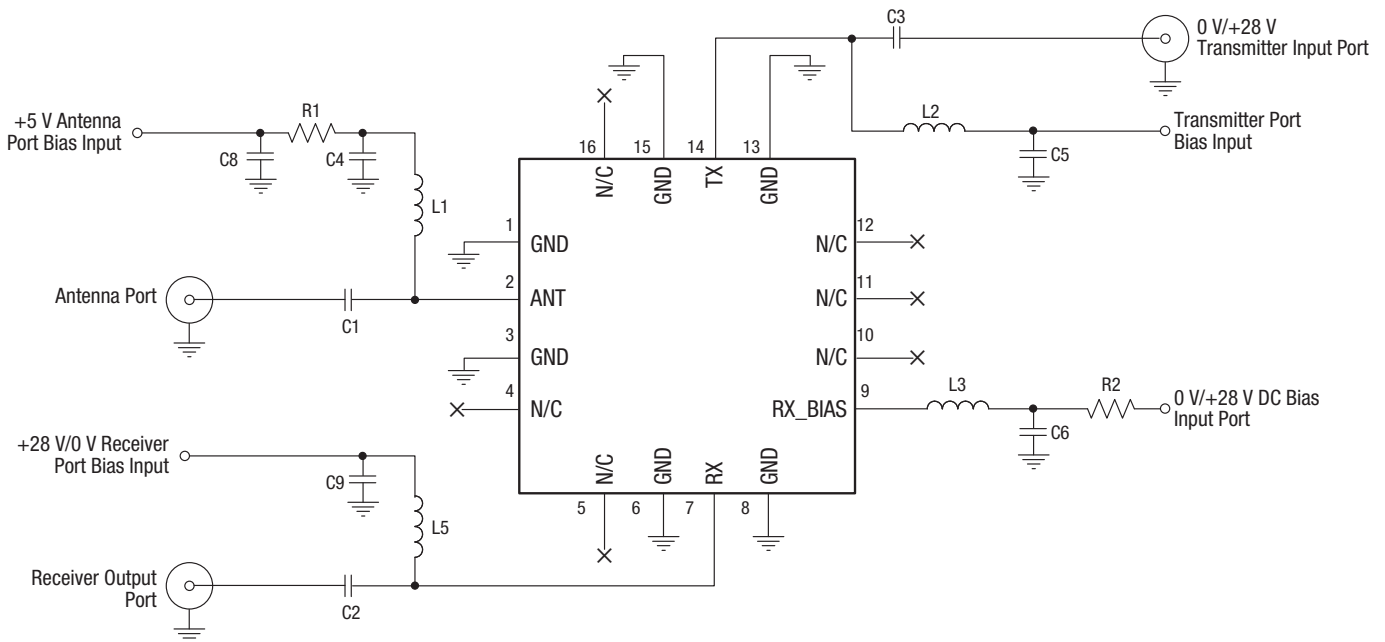
Figure 10. SKY12215-478LF Evaluation Board Assembly Diagram

| 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 11. 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.

S2402

Figure 12. Evaluation Board Schematic

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

| Component | Value | Size | Manufacturer | Manufacturer Part Number | Characteristics |
|--------------------|--------------|------|--------------|--------------------------|--------------------------|
| C1, C3 | 1000 pF | 0805 | TDK | C2012C0G2E102J | COG, 250 V, $\pm 5\%$ |
| C2, C4, C5, C6, C9 | 1000 pF | 0603 | TDK | C1608C0G1H102JT | COG, 50 V, $\pm 5\%$ |
| C8 | 0.1 μ F | 0805 | TDK | C2012X7R1H104K | X7R, 50 V, $\pm 10\%$ |
| L1, L2, L5 | 22 nH | 0603 | Taiyo-Yuden | HK160822NJ-T | SRF, 1600 MHz, $\pm 5\%$ |
| L3 | 560 nH | 0603 | Coil Craft | 0603LS-561XJLB | SRF, 525 MHz, $\pm 5\%$ |
| R1 (Note 2) | 62 Ω | 0603 | Panasonic | ERJ-3GEYJ620V | 0.2 W, $\pm 5\%$ |
| R2 (Note 3) | 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: Two 62 Ω resistors are combined in parallel to achieve a minimum power handling requirement and 31 Ω resistance.

Note 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.

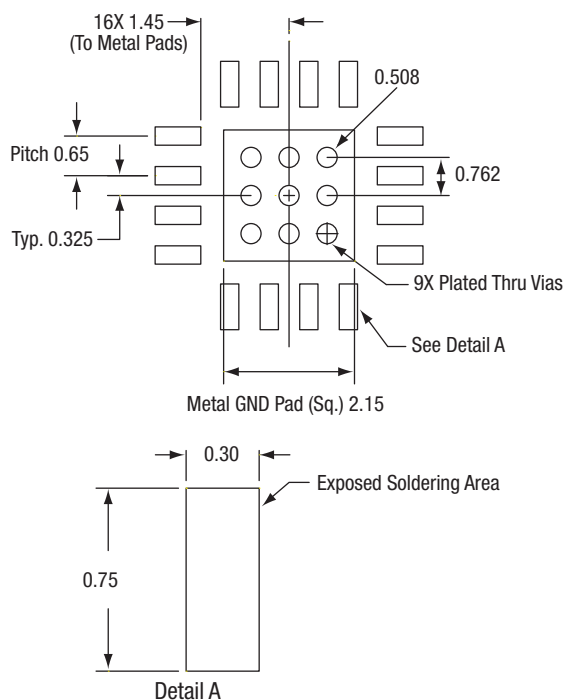
Table 8. Component Calculation Values

| Vs (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 |

Notes: Vs = 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 $I \times (V_s - V_{DIODE})$. The resistor selected must be safely rated with a power greater than the dissipated power.



All measurements in millimeters

S2274

Figure 13. SKY12215-478LF PCB Layout Footprint

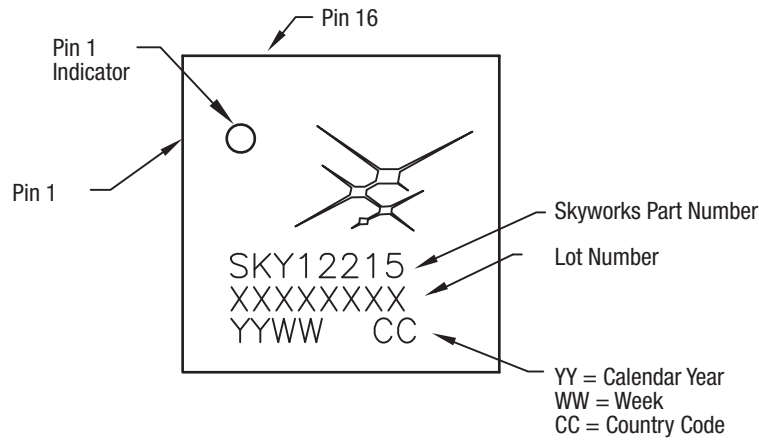
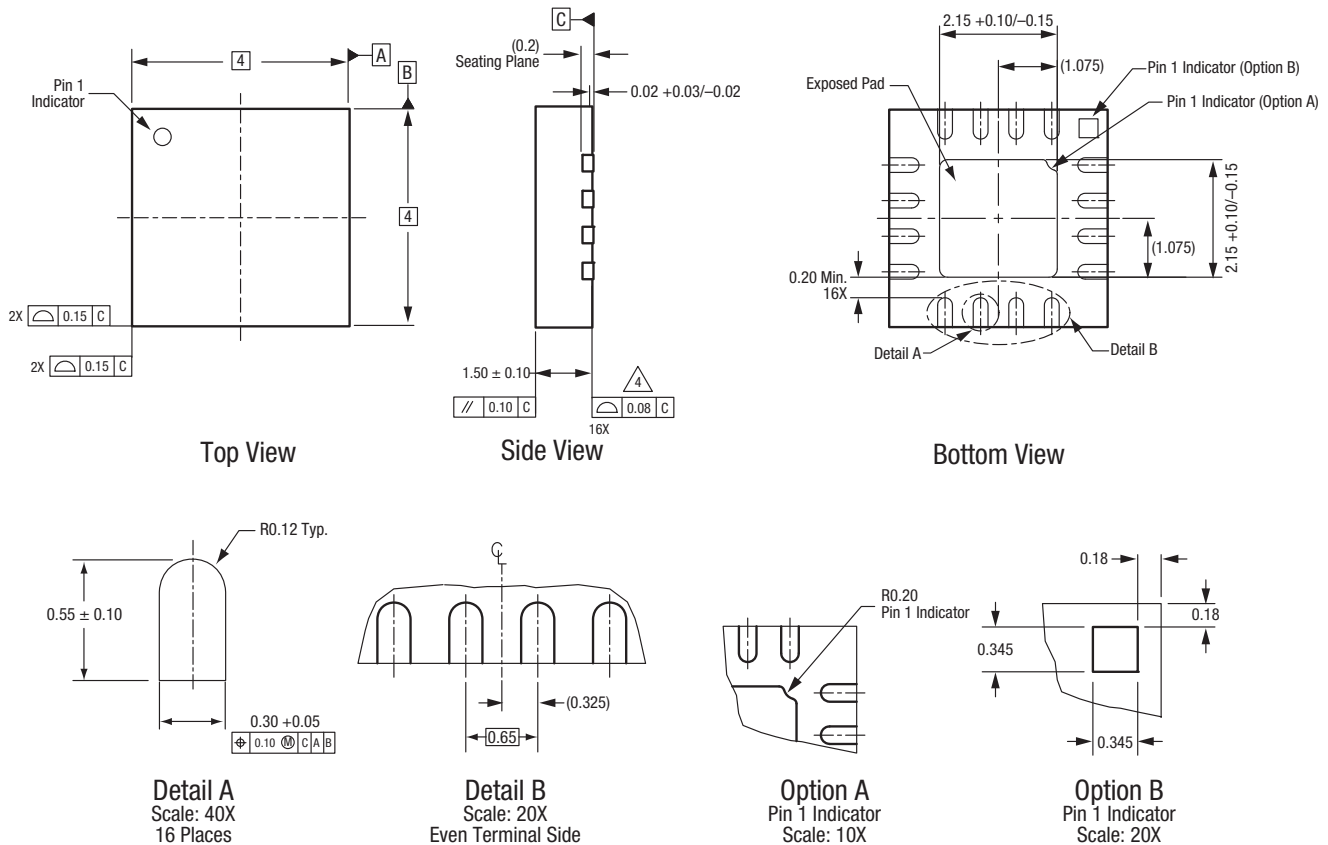


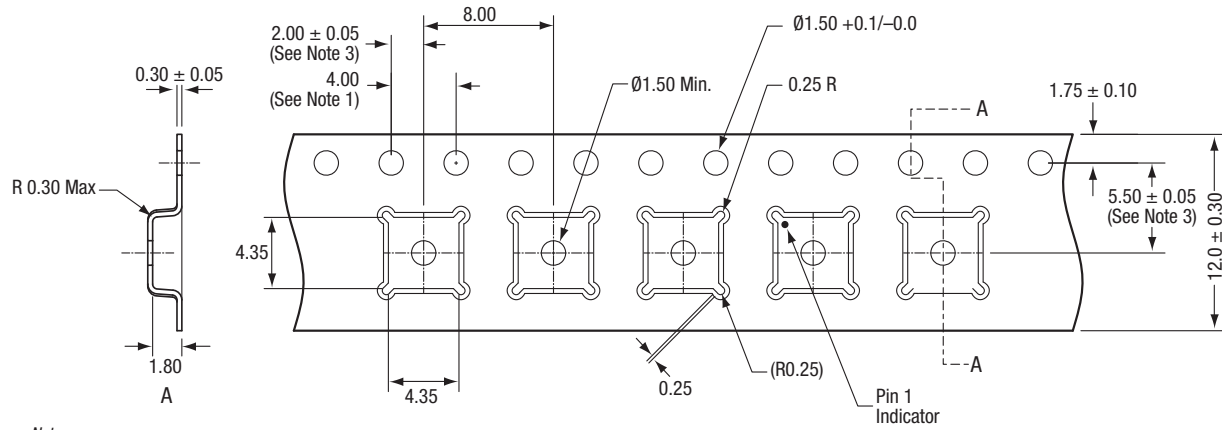
Figure 14. Typical Case Markings (Top View)



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 15. SKY12215-478LF 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.

S2817

Figure 16. SKY12215-478LF Tape and Reel Dimensions

Ordering Information

| Model Name | Manufacturing Part Number | Evaluation Board Part Number |
|--------------------------------------|---------------------------|------------------------------|
| SKY12215-478LF PIN Diode SPDT Switch | SKY12215-478LF | SKY12215-478LF-EVB |

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