

DATA SHEET

# SKY13415-485LF: 0.1 to 3.8 GHz SP5T Antenna Switch

## Applications

- Any 2G/3G/4G antenna diversity or LTE (TDD/FDD) transmit/receive system

## Features

- Broadband frequency range: 0.1 to 3.8 GHz
- Low insertion loss: 0.45 dB typical @ 2.7 GHz
- High isolation: >30 dB @ 2.7 GHz
- Internal 50 Ω port to control diversity antenna impedance when device is not in use
- Integrated logic
- Small QFN (14-pin, 2.0 x 2.0 mm) package (MSL1, 260 °C per JEDEC J-STD-020)



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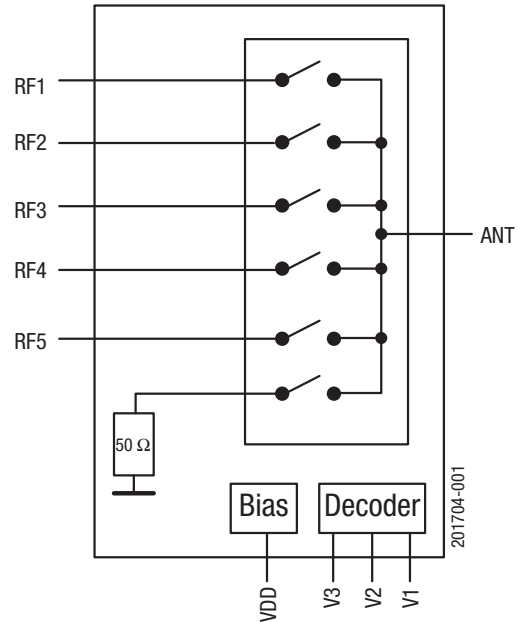


Figure 1. SKY13415-485LF Block Diagram

## Description

The SKY13415-485LF is a single pole, five-throw (SP5T) antenna switch with an internal 50 Ω termination. The high linearity performance and low insertion loss achieved by the SKY13415-485LF make it an ideal choice for main/diversity switching commonly used in LTE-based handsets, data cards, and tablets that use antenna diversity solutions.

The SKY13415-485LF is part of a scalable family of products that covers SP4T through SP8T switches that allow up to eight bands of WCDMA/LTE:

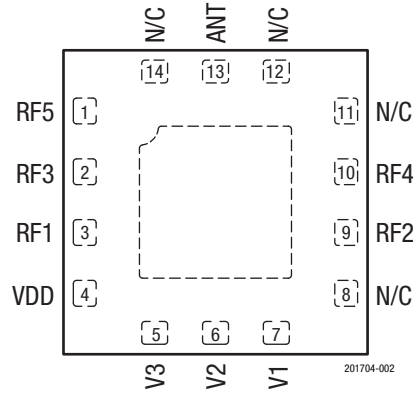
- SKY13414-485LF SP4T Antenna Switch (Data Sheet #201689)
- SKY13415-485LF SP5T Antenna Switch (this Data Sheet)
- SKY13416-485LF SP6T Antenna Switch (Data Sheet #201679)
- SKY13417-485LF SP7T Antenna Switch (Data Sheet #201661)
- SKY13418-485LF SP8T Antenna Switch (Data Sheet #201712)

The symmetric port designs provide flexibility in signal routing for both receive diversity and higher power TD-SCDMA/TDD-LTE, WCDMA/FDD, and LTE transmit/receive applications.

Switching is controlled by three CMOS/TTL-compatible control voltage inputs (V1, V2, and V3). Depending on the logic voltage level applied to the control pins, the ANT pin is connected to one of five switched RF outputs (RF1 to RF5) using a low insertion loss path, while the paths between the ANT pin and the other RF pins are in a high isolation state. The antenna path can also be closed on a 50 Ω load when it needs to be terminated. The 50 Ω load is internally grounded. No external blocking capacitors are required on the RF paths unless VDC is externally applied.

The SKY13415-485LF is manufactured in a compact, 14-pin 2.0 x 2.0 mm, 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. SKY13415-485LF Pinout (Top View)**

**Table 1. SKY13415-485LF Signal Descriptions<sup>1</sup>**

Pin	Name	Description	Pin	Name	Description
1	RF5	RF I/O path 5	8	N/C	Not connected
2	RF3	RF I/O path 3	9	RF2	RF I/O path 2
3	RF1	RF I/O path 1	10	RF4	RF I/O path 4
4	VDD	DC power supply	11	N/C	Not connected
5	V3	DC control voltage 3	12	N/C	Not connected
6	V2	DC control voltage 2	13	ANT	Antenna port
7	V1	DC control voltage 1	14	N/C	Not connected

<sup>1</sup> Bottom ground paddles must be connected to ground.

**Table 2. SKY13415-485LF Absolute Maximum Ratings<sup>1</sup>**

Parameter	Symbol	Min	Max	Units
Supply voltage	V <sub>DD</sub>	2.5	5.0	V
Control voltage (V1, V2, and V3)	V <sub>CTL</sub>	-0.5	+3.0	V
RF input power (RF1 to RF5): 0.1 to 2.7 GHz (RF1 to RF5 arm) 3.4 to 3.8 GHz (RF2 to RF5 arm)	P <sub>IN</sub>		+37.5 +35	dBm dBm
RF power applied to antenna in the 50 Ω switched RF output state	P <sub>IN</sub>		+27	dBm
Operating temperature	T <sub>OP</sub>	-40	+85	°C
Storage temperature	T <sub>STG</sub>	-55	+150	°C
Electrostatic discharge: Human Body Model (HBM), Class 1C	ESD		1000	V

<sup>1</sup> 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:** *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 when handling or transporting. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD handling precautions should be used at all times.*

## Functional Description

The SKY13415-485LF includes an internal negative voltage generator and decoder that eliminate the need for external DC blocking capacitors on the RF ports. No external components are required for proper operation. DC decoupling capacitors may be added on the VDD and control lines if necessary.

Switching is controlled by three control voltage inputs, V1, V2, and V3. Depending on the logic voltage level applied to the control pins, the antenna pin is connected to one of five switched RF outputs or a 50 Ω termination.

Shutdown mode is enabled by connecting all three control pins (V1, V2, and V3) to logic high. This mode reduces the overall current consumption of the device to 5 μA typical.

## Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY13415-485LF are provided in Table 2. Electrical specifications are provided in Table 3.

The state of the SKY13415-485LF is determined by the logic shown in Table 4.

The isolation matrix shown in Table 5 provides the port-to-port and antenna-to-port isolation for all available RF states at four different frequencies: 1.0 GHz, 2.0 GHz, 2.7 GHz, and 3.8 GHz.

**Table 3. SKY13415-485LF General Electrical Specifications<sup>1</sup>**  
**(V<sub>DD</sub> = 2.6 V, V<sub>1</sub> = V<sub>2</sub> = V<sub>3</sub> = 0/1.8 V, P<sub>IN</sub> = 0 dBm, T<sub>OP</sub> = +25 °C, Characteristic Impedance [Z<sub>0</sub>] = 50 Ω, Unless Otherwise Noted)**

Parameter	Symbol	Test Condition (Note 2)	Min	Typ	Max	Units
<b>DC Specifications</b>						
Supply voltage	V <sub>DD</sub>		2.5	3.0	4.8	V
Supply current	I <sub>DD</sub>			40	50	μA
Control voltage: High Low	V <sub>CTL_H</sub> V <sub>CTL_L</sub>		1.35	1.80	2.70 0.4	V V
Control current	I <sub>CTL</sub>	V <sub>CTL</sub> = 1.8 V		0.5	1.0	μA
Shutdown mode supply current	I <sub>off</sub>	V <sub>1/2/3</sub> = 1.8 V, V <sub>DD</sub> = 3 V		5	10	μA
Turn-on switching time	t <sub>ON</sub>	50% of control voltage to 90% of final RF power, switching between RF1/2/3/4/5/50_0HM		1.75	2.20	μs
<b>RF Specifications</b>						
Insertion loss (ANT pin to RF1/2/3/4/5 pins)	IL	0.1 to 1.0 GHz		0.40	0.50	dB
		1.0 to 2.0 GHz		0.40	0.50	dB
		2.0 to 2.7 GHz		0.45	0.60	dB
		3.4 to 3.8 GHz		0.60	0.80	dB
Isolation (ANT pin to RF1/2/3/4/5 pins)	Iso	0.1 to 1.0 GHz	38	42		dB
		1.0 to 2.0 GHz	32	34		dB
		2.0 to 2.7 GHz	27	31		dB
		3.4 to 3.8 GHz	20	26		dB
Input return loss (ANT pin to RF1/2/3/4/5 pins)	RL	0.1 to 1.0 GHz	21	24		dB
		1.0 to 2.0 GHz	23	25		dB
		2.0 to 2.7 GHz	15	18		dB
		3.4 to 3.8 GHz	12	15		dB
Second harmonics (ANT pin to RF1/2/3/4/5 pins)	2fo	P <sub>IN</sub> = +26 dBm, 0.1 to 3.0 GHz		+95		dBc
Third harmonics (ANT pin to RF1/2/3/4/5 pins)	3fo	P <sub>IN</sub> = +26 dBm, 0.1 to 3.0 GHz		+104		dBc
Harmonics (ANT to RF2/3/4/5)	2fo	3.4-3.8 GHz, VSWR = 1:1, P <sub>IN</sub> = +26 dBm		-55		dBm
Harmonics (ANT to RF2/3/4/5)	3fo	3.4 to 3.8 GHz, VSWR = 1:1, P <sub>IN</sub> = +26 dBm		-65		dBm
Harmonics (ANT to RF2/3/4/5)	2fo	3.4 to 3.8 GHz, VSWR = 5:1, P <sub>IN</sub> = +26 dBm		-50		dBm
Harmonics (ANT to RF2/3/4/5)	3fo	3.4 to 3.8 GHz, VSWR = 5:1, P <sub>IN</sub> = +26 dBm		-60		dBm
GSM harmonics: High band Low band	2fo, 3fo	P <sub>IN</sub> = +33 dBm, 50 Ω P <sub>IN</sub> = +33 dBm, 3:1 VSWR  P <sub>IN</sub> = +34.5 dBm, 50 Ω P <sub>IN</sub> = +34.5 dBm, 3:1 VSWR		-48 -42  -50 -44		dBm dBm  dBm dBm
0.1 dB compression point (ANT pin to RF1/2/3/4/5 pins)	P0.1dB	0.8 GHz to 3.0 GHz		+37.5		dBm
Third order input intercept point	IIP3	@ 2.0 GHz, P <sub>IN</sub> = +26 dBm, Δf = 1 MHz		+70		dBm
50 Ω power handling		0.1 GHz to 3.0 GHz			+27	dBm

**Table 4. SKY13415-485LF Control Logic<sup>1</sup>**

Control Pins			Switched RF Outputs					
V1 (Pin 7)	V2 (Pin 6)	V3 (Pin 5)	RF1 (Pin 3)	RF2 (Pin 9)	RF3 (Pin 2)	RF4 (Pin 10)	RF5 (Pin 1)	50 Ω
0	0	0	Insertion Loss	Isolation	Isolation	Isolation	Isolation	Isolation
0	0	1	Isolation	Insertion Loss	Isolation	Isolation	Isolation	Isolation
0	1	0	Isolation	Isolation	Insertion Loss	Isolation	Isolation	Isolation
0	1	1	Isolation	Isolation	Isolation	Insertion Loss	Isolation	Isolation
1	0	0	Isolation	Isolation	Isolation	Isolation	Insertion Loss	Isolation
1	0	1	Isolation	Isolation	Isolation	Isolation	Isolation	50 Ω
1	1	0	Isolation	Isolation	Insertion Loss	Isolation	Insertion Loss	Isolation
1	1	1	Shutdown mode					

<sup>1</sup> “1” = 1.8 V; “0” = 0 V. Any state other than that described in this table places the switch into an undefined state. An undefined state will not damage the device. Insertion loss in the V1/2/3 = 110 state is 3 dB lower than typical insertion loss with only one arm “on.”

**Table 5. Isolation Matrix (1 of 2)**

“On” Port	Frequency (GHz)	Isolation (dB)				
		RF1	RF2	RF3	RF4	RF5
<i>Antenna-to-Port</i>						
RF1	1.0		-48	-40	-42	-39
RF1	2.0		-40	-32	-35	-30
RF1	2.7		-36	-28	-32	-26
RF1	3.8		-32	-25	-27	-21
RF2	1.0	-46		-40	-40	-36
RF2	2.0	-39		-34	-32	-30
RF2	2.7	-35		-31	-28	-27
RF2	3.8	-32		-27	-24	-23
RF3	1.0	-38	-47		-42	-42
RF3	2.0	-31	-39		-35	-30
RF3	2.7	-28	-35		-32	-26
RF3	3.8	-25	-31		-27	-21
RF4	1.0	-45	-38	-41		-37
RF4	2.0	-38	-31	-34		-30
RF4	2.7	-35	-28	-31		-27
RF4	3.8	-31	-24	-27		-23
RF5	1.0	-48	-47	-38	-43	
RF5	2.0	-36	-39	-30	-36	
RF5	2.7	-31	-36	-27	-32	
RF5	3.8	-27	-31	-24	-28	

**Table 5. Isolation Matrix (2 of 2)**

"On" Port	Frequency (GHz)	Isolation (dB)				
		RF1	RF2	RF3	RF4	RF5
<i>Port-to-Port</i>						
RF1	1.0		-53	-31	-52	-45
RF1	2.0		-43	-25	-44	-35
RF1	2.7		-39	-22	-40	-30
RF1	3.8		-33	-18	-36	-26
RF2	1.0	-54		-48	-31	-40
RF2	2.0	-42		-41	-25	-35
RF2	2.7	-38		-37	-22	-32
RF2	3.8	-32		-34	-18	-30
RF3	1.0	-31	-56		-53	-33
RF3	2.0	-24	-45		-44	-26
RF3	2.7	-21	-40		-40	-23
RF3	3.8	-18	-35		-37	-19
RF4	1.0	-54	-30	-48		-41
RF4	2.0	-43	-24	-41		-35
RF4	2.7	-39	-21	-38		-32
RF4	3.8	-34	-17	-34		-30
RF5	1.0	-37	-55	-30	-55	
RF5	2.0	-30	-44	-24	-44	
RF5	2.7	-27	-40	-21	-39	
RF5	3.8	-23	-35	-17	-35	

**Evaluation Board Description**

The SKY13415-485LF Evaluation Board is used to test the performance of the SKY13415-485LF SP5T Switch. An Evaluation Board schematic diagram is provided in Figure 3. An assembly drawing for the Evaluation Board is shown in Figure 4.

**Package Dimensions**

The PCB layout footprint for the SKY13415-485LF is provided in Figure 5. Typical part markings are shown in Figure 6. Package dimensions are shown in Figure 7, and tape and reel dimensions are provided in Figure 8.

**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 SKY13415-485LF 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.

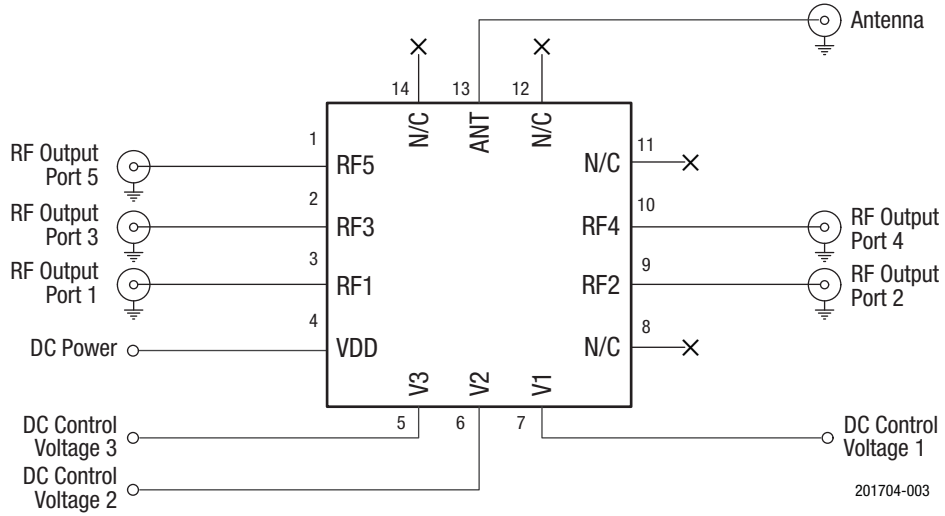


Figure 3. SKY13415-485LF Evaluation Board Schematic

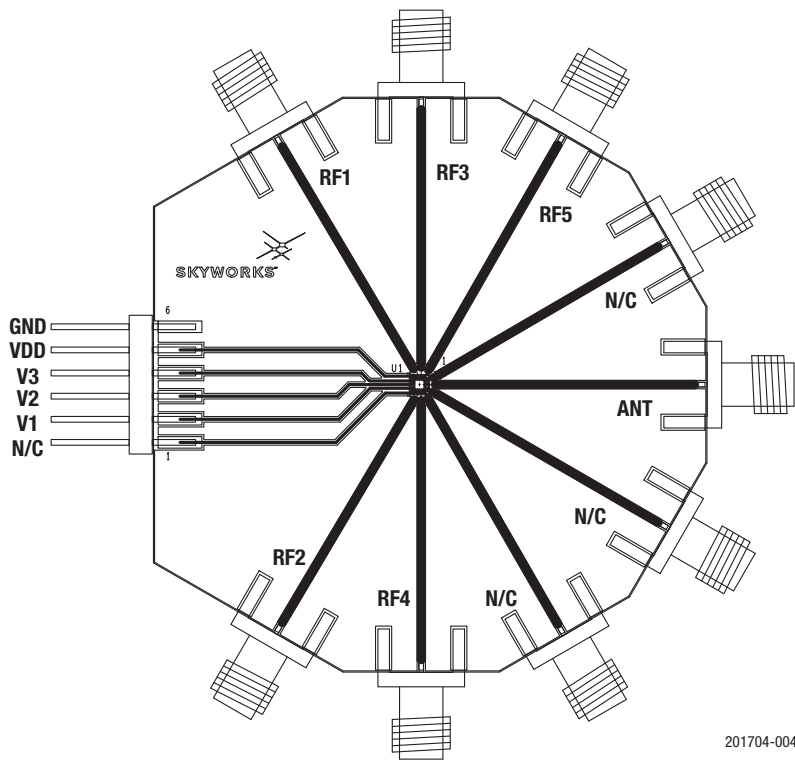
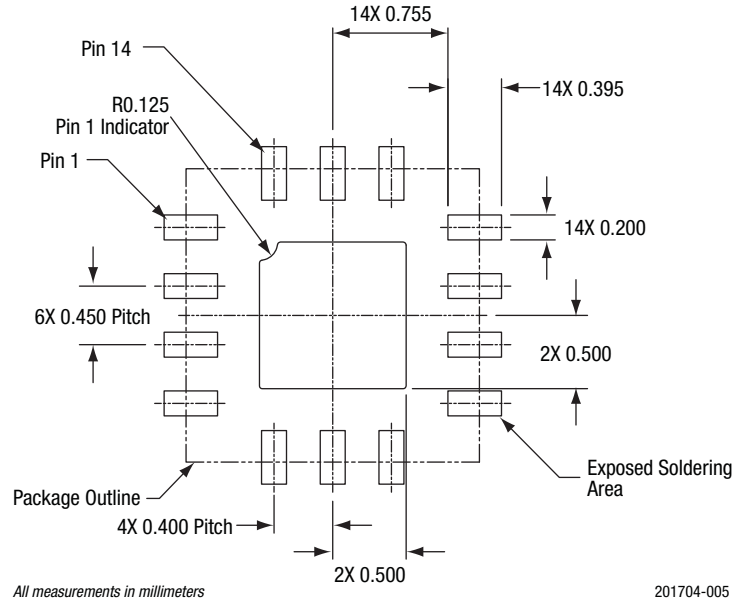
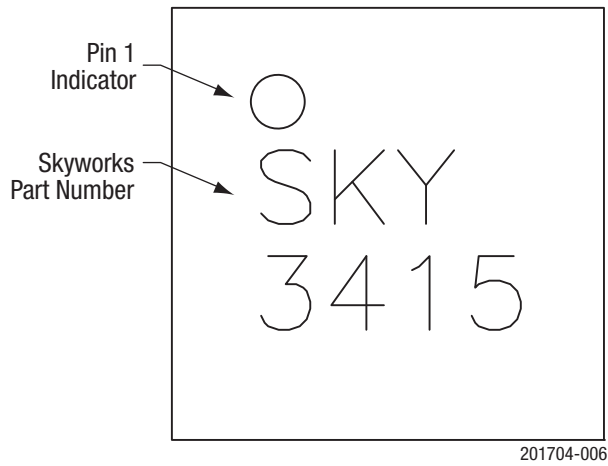


Figure 4. SKY13415-485LF Evaluation Board Assembly Diagram



**Figure 5. SKY13415-485LF PCB Layout Footprint (Top View)**



**Figure 6. Typical Part Markings (Top View)**



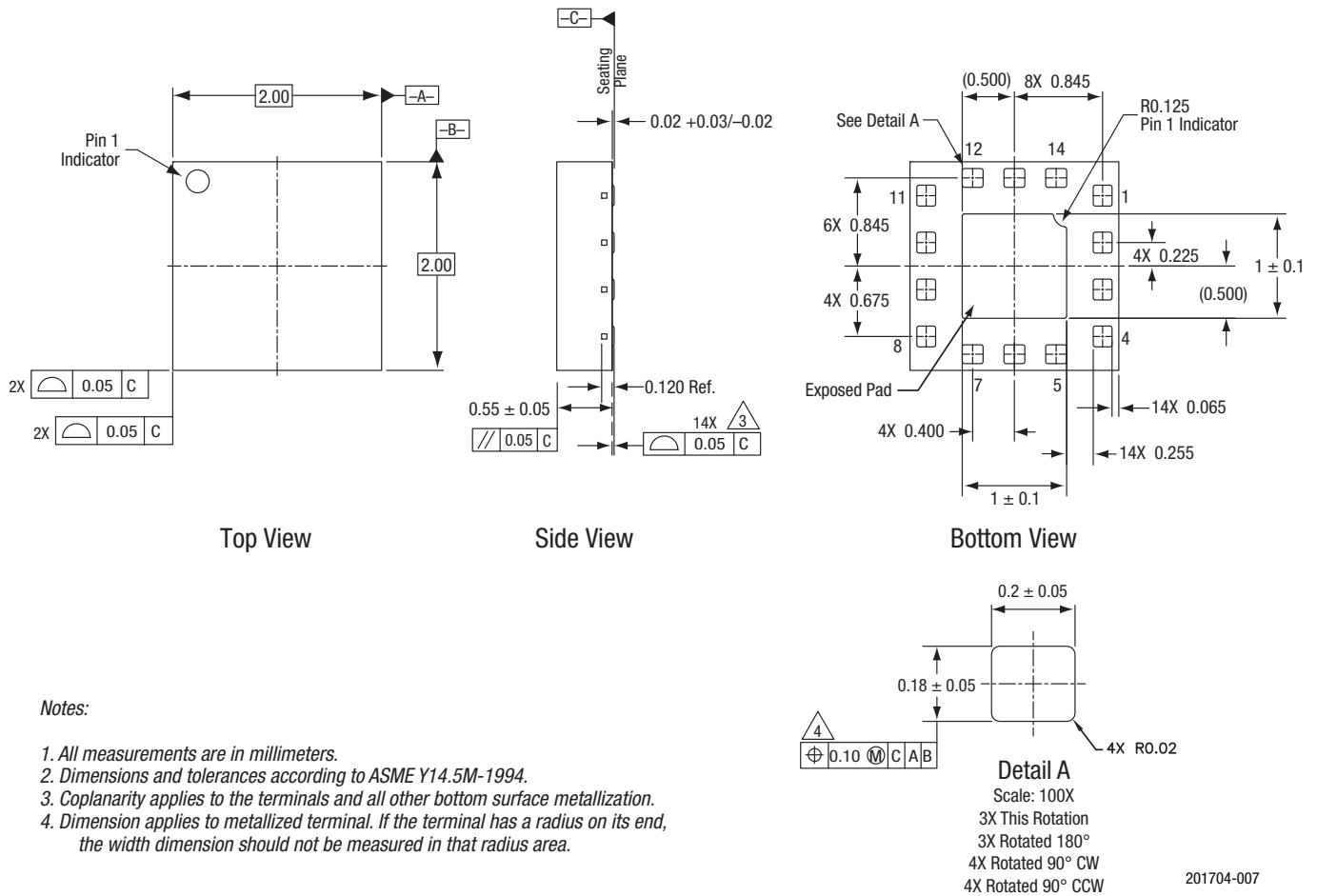
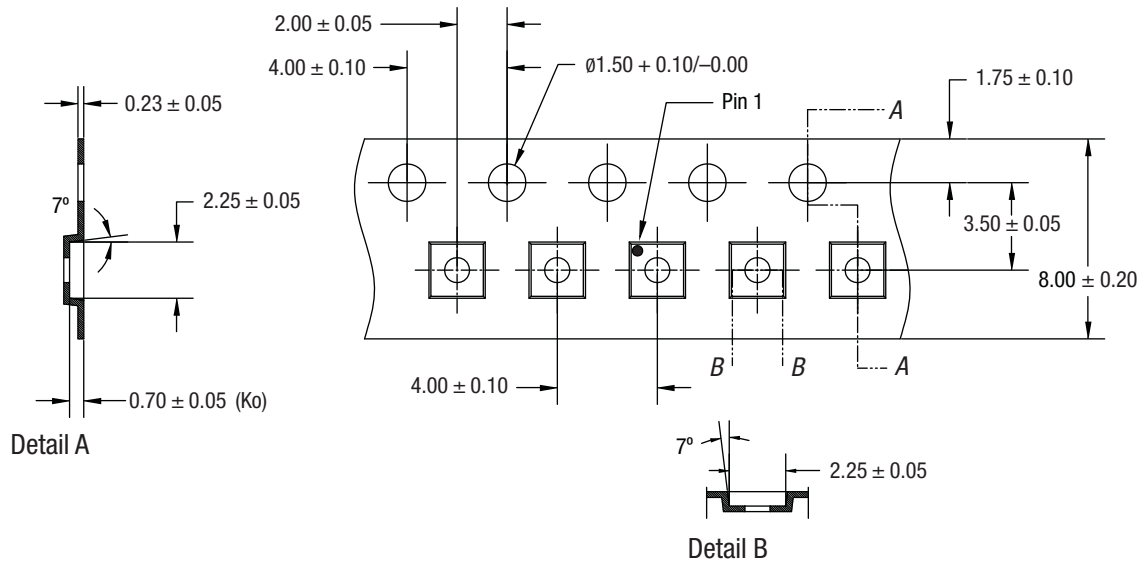


Figure 7. SKY13415-485LF Package Dimensions



Notes:

1. Carrier tape must meet all requirements of Skyworks GP01-D232 procurement spec for tape and reel shipping.
2. Carrier tape shall be black conductive polycarbonate bakeable material at 125 °C temperature.
3. Cover tape shall be transparent conductive with 5.40 mm width.
4. ESD-surface resistivity must meet all ESD requirements of Skyworks specified on GP01-D232.
5. All measurements are in millimeters.

201704-008

**Figure 8. SKY13415-485LF Tape and Reel Dimensions**

## Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY13415-485LF: 0.1 to 3.8 GHz SP5T Switch	SKY13415-485LF	SKY13415-485LFEK1

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