DATA SHEET

SKY13551-668LF: 0.4 to 3.8 GHz DP10T (SP5T/SP5T) Main/Receive Diversity Switch with MIPI RFFE Interface for Carrier Aggregation

Applications

- 3G/4G multimode cellular handsets (UMTS, CDMA2000, LTE)
- Carrier aggregation diversity

Features

- Broadband frequency range: 0.4 to 3.8 GHz
- Single, positive DC power supply (2.5 to 4.8 V)
- Integrated, programmable MIPI interface using separate registers for ANT_A and ANT_B
- Dual antenna ports can be connected externally to a diplexer
- Small QFN (16-pin, 1.6 x 2.4 x 0.55 mm) 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.

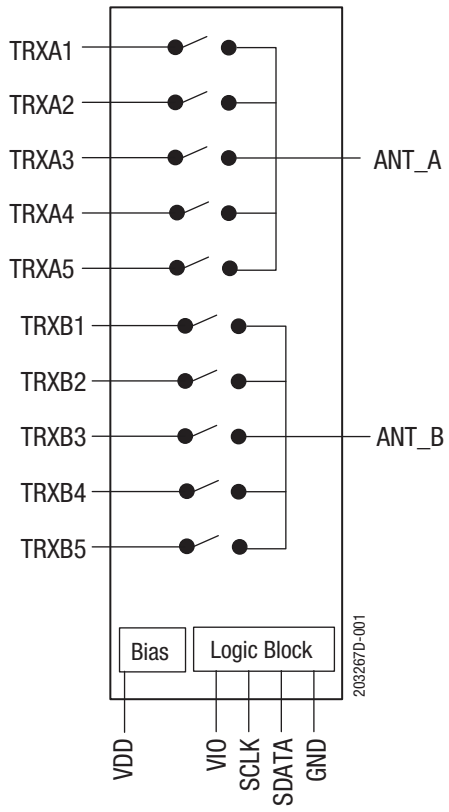


Figure 1. SKY13551-668LF Block Diagram

Description

The SKY13551-668LF is a dual single-pole, five-throw (2xSP5T) Mobile Industry Processor Interface (MIPI) controlled antenna switch designed specifically for receive diversity in carrier aggregation applications.

The 2xSP5T switch is optimized for broadband performance. Using advanced switching technologies, the SKY13551-668LF maintains low insertion loss and high isolation for all switching paths. The high-linearity performance and low insertion loss achieved by the SKY13551-668LF makes it an ideal choice for carrier aggregation applications in both main and diversity antenna switching. The switch also exhibits excellent second/third order intermodulation distortion (IMD2/IMD3) performance.

Switching is controlled by an integrated MIPI decoder. The two switches can be configured independently. There are separate registers for each SP5T switch. No external DC blocking capacitors are required on the RF paths as long as no DC voltage is applied to those paths.

The SKY13551-668LF is manufactured in a compact, 1.6 x 2.4 x 0.55 mm, 16-pin surface-mount 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.

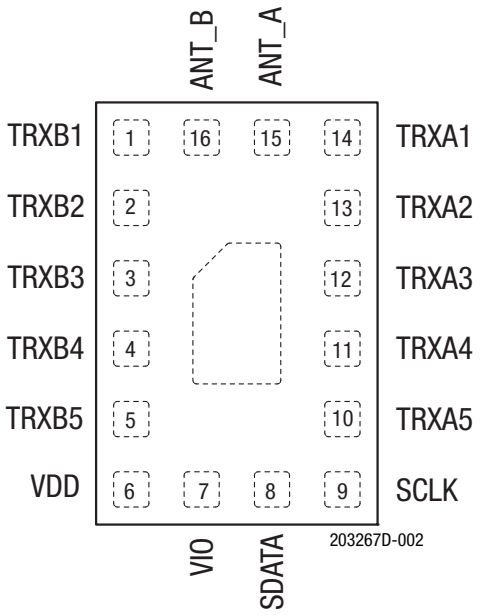


Figure 2. SKY13551-668LF Pinout (Top View)

Table 1. SKY13551-668LF Signal Descriptions[1]

Pin	Name	Description	Pin	Name	Description
1	TRXB1	Ant B transmit/receive port 1	9	SCLK	Clock
2	TRXB2	Ant B transmit/receive port 2	10	TRXA5	Ant A transmit/receive port 5
3	TRXB3	Ant B transmit/receive port 3	11	TRXA4	Ant A transmit/receive port 4
4	TRXB4	Ant B transmit/receive port 4	12	TRXA3	Ant A transmit/receive port 3
5	TRXB5	Ant B transmit/receive port 5	13	TRXA2	Ant A transmit/receive port 2
6	VDD	DC power supply	14	TRXA1	Ant A transmit/receive port 1
7	VIO	MIPI interface DC supply voltage	15	ANT_A	Ant A port
8	SDATA	Data	16	ANT_B	Ant B port

[1] Bottom ground paddles must be connected to ground.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY13551-668LF are provided in Table 2. Electrical specifications are provided in Tables 3 and 4.

IMD2 and IMD3 test conditions for various frequencies are listed in Tables 5 and 6, respectively.

Figure 3 illustrates the test setup used to measure intermodulation products. This industry standardized test is used to simulate the WCDMA linearity of the antenna switch. A +20 dBm continuous wave (CW) signal, f_{FUND}, is sequentially applied to the TRX ports, while a –15 dBm CW blocker signal, f_{BLK}, is applied to the ANT port.

The resulting third order intermodulation distortion (IMD3), f_{RX}, is measured over all phases of f_{FUND}. The SKY13551-668LF exhibits exceptional performance for all RF ports.

Table 7 describes the register content and programming read/write sequences. Refer to the *MIPI Alliance Specification for RF Front-End Control Interface (RFFE)*, v1.10 (26 July 2011) for additional information on MIPI programming sequences and MIPI bus specifications.

Figure 4 provides the timing diagram for register write commands. Figure 5 provides the timing diagram for register read commands.

Register descriptions and programming information is provided in Table 8. Tables 9 and 10 provide the Register_0 and Register_1 logic, respectively.

Table 2. SKY13551-668LF Absolute Maximum Ratings[1]

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	V_{DD}	2.5	5.0	V
Digital control signal	V_{IO}		2	V
SCLK port voltage	V_{SCLK}		V_{IO}	V
SDATA port voltage	V_{SDATA}		V_{IO}	V
LTE input power	P_{IN}		+31	dBm
Storage temperature	T_{STG}	–55	+150	°C
Operating temperature	T_{OP}	–30	+90	°C

[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.

***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. SKY13551-668LF RF Electrical Specifications[1] (1 of 2)
(V_{DD} = 2.85 V, T_{OP} = +25 °C, Characteristic Impedance [Z_O] = 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Operating frequency	f		0.4		3.8	GHz
Insertion loss	IL	ANT_A to any TRxA port ANT_B to any TRxB port:				
		400 to 824 MHz		0.40	0.60	dB
		824 to 960 MHz		0.45	0.60	dB
		1427 to 1511 MHz		0.5	0.7	dB
		1710 to 2170 MHz		0.80	1.0	dB
		2170 to 2690 MHz		1.0	1.2	dB
		3400 to 3800 MHz		1.3	1.6	dB
Isolation	ISO	ANT_A or ANT_B to any "off" TRx port:				
		Up to 787 MHz	31	34		dB
		Up to 960 MHz	30	33		dB
		Up to 1511 MHz	24	29		dB
		Up to 1990 MHz	22	25		dB
		Up to 2170 MHz	21	24		dB
		Up to 2690 MHz	18	21		dB
		Up to 3800 MHz	15	18		dB
		ANT_A to any TRxB port ANT_B to any TRxA port:				
		Up to 787 MHz	40	42		dB
		Up to 960 MHz	38	40		dB
		Up to 1511 MHz	34	37		dB
		Up to 1990 MHz	32	33		dB
		Up to 2170 MHz	31	32		dB
		Up to 2690 MHz	29	30		dB
		Up to 3800 MHz	26	27		dB
		ANT_A to ANT_B:				
		400 to 960 MHz	31	32		dB
		1427 to 1511 Mhz	26	28		dB
		1710 to 1990 MHz	25	26		dB
		1980 to 2690 MHz	22	23		dB
		3400 to 3800 MHz	18	19		dB
"On" state match	VSWR	400 to 2170 MHz		1.6:1	2:1	
Second order intermodulation distortion	IMD2	See Table 5		–105	–100	dBm
Third order intermodulation distortion	IMD3	See Table 6		–105	–100	dBm
Low-band 2nd and 3rd harmonic	2fo, 3fo	Any TRx port, P_{IN} = +26 dBm, f = 900 MHz		–70	–64	dBm
		Any TRx port, P_{IN} = +26 dBm, f0 = 900 MHz, VSWR = 5:1		–65	–60	dBm
Middle-band 2nd and 3rd harmonics	2fo, 3fo	Any TRxA and any TRxB port, P_{IN} = +26 dBm, f1 = 1462 MHz, f2 = 1910 MHz		–70	–65	dBm
		Any TRxA and any TRxB port, P_{IN} = +26 dBm, f1 = 1462 MHz, f2 = 1910 MHz, VSWR = 5:1		–65	–58	dBm
High-band 2nd and 3rd harmonic	2fo, 3fo	Any TRxA and any TRxB port, P_{IN} = +26 dBm, f0 = 2690 MHz		–61	–55	dBm
		Any TRxA and any TRxB port, P_{IN} = +26 dBm, f0 = 2690 MHz, VSWR = 5:1		–59	–53	dBm

Table 3. SKY13551-668LF RF Electrical Specifications[1] (2 of 2)
(V_{DD} = 2.85 V, T_{OP} = +25 °C, Characteristic Impedance [Z_O] = 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Band 13 2nd harmonic	2fo	Any TRx port, P_{IN} = +25 dBm, f0 = 782 MHz		–77		dBm
Band 17 3rd harmonic	3fo	Any TRx port, P_{IN} = +25 dBm, f = 707 MHz		–77		dBm
Turn-on time	t_{ON}	From application of V_{DD} and V_{IO} or transition from low power mode			20	µs
Wake-up time	t_W	From isolation state		2	5	µs
Switching speed	t_{SW}	Any state to any other state		2	5	µs

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

Table 4. SKY13551-668LF DC Electrical Specifications[1]
(V_{DD} = 2.85 V, V_{IO} = 1.8 V, T_{OP} = +25 °C, Characteristic Impedance [Z_O] = 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Supply voltage	V_{DD}		2.50	2.85	4.8	V
Supply current, active mode	I_{DD}			35	100	µA
Interface supply voltage level	V_{IO}		1.65	1.80	1.95	V
Digital data and clock signals: High Low	V_{SDATA}, V_{SCLK}		 $0.8 \times V_{IO}$ 0		 V_{IO} $0.2 \times V_{IO}$	 V V
Interface supply current	I_{VIO}			5	50	µA

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

Table 5. IMD2 Test Conditions

Band	Transmit Frequency (MHz)	Transmit Power (dBm)	Frequency Blocker, Low (MHz)	Frequency Blocker, High (MHz)	Power Blocker (dBm)	Receive Frequency (MHz)
1	1950	+20	190	4090	–15	2140
2	1880		80	3840		1960
4	1732		400	3864		2132
5	836.5		45	1718		881.5
7	2535		120	5187		2655
8	897		45	1839		942
11/21	1452			2952		1500

Table 6. IMD3 Test Conditions

Band	Transmit Frequency (MHz)	Transmit Power (dBm)	Frequency Blocker (MHz)	Power Blocker (dBm)	Receive Frequency (MHz)
1	1950	+20	1760	–15	2140
2	1880		1800		1960
4	1732		1332		2132
5	836.5		791.5		881.5
7	2535		2415		2655
8	897		852		942
11/21	1452		1404		1500

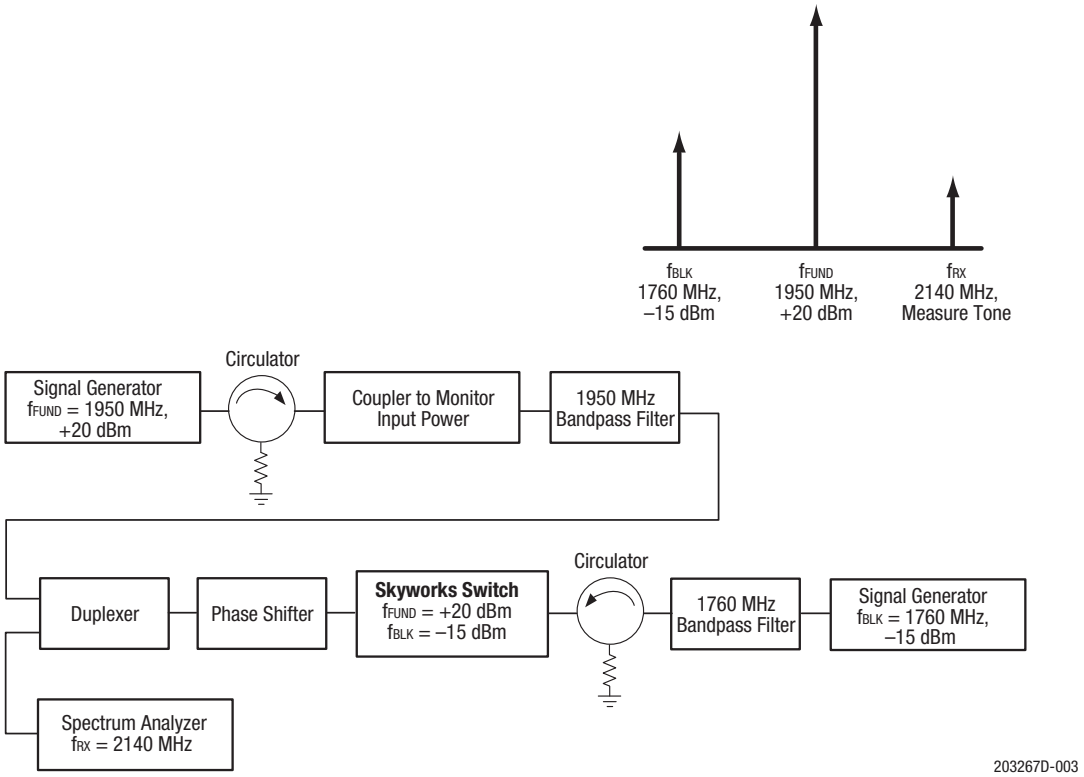


Figure 3. Typical Third Order Intermodulation Test Setup

Table 7. Command Sequence Bit Definitions

Type	SSC	C11-C8	C7	C6-C5	C4	C3-C0	Parity Bits	BPC	Extended Operation					
									DA7(1)-DA0(1)	Parity Bits	BPC	DA7(n)-DA0(n)	Parity Bits	BPC
Reg_0 Write, Short Command	Y	SA[3:0]	1b	Data[6:5]	Data[4]	Data{3:0]	Y	Y	–	–	–	–	–	–
Reg_0 Write, Long Command	Y	SA[3:0]	0	10b	Addr[4]	Addr[3:0]	Y	–	Data[7:0]	–	–	–	Y	Y
Reg_1 Write	Y	SA[3:0]	0	10b	Addr[4]	Addr[3:0]	Y	–	Data[7:0]	–	–	–	Y	Y
Reg Read	Y	SA[3:0]	0	11b	Addr[4]	Addr[3:0]	Y	Y	Data[7:0]	–	–	–	Y	Y

Legend:
SSC = Sequence start command
C = Command frame bits
DA = Data/address frame bits
BPC = Bus park cycle
BC = Byte count (# of consecutive addresses)

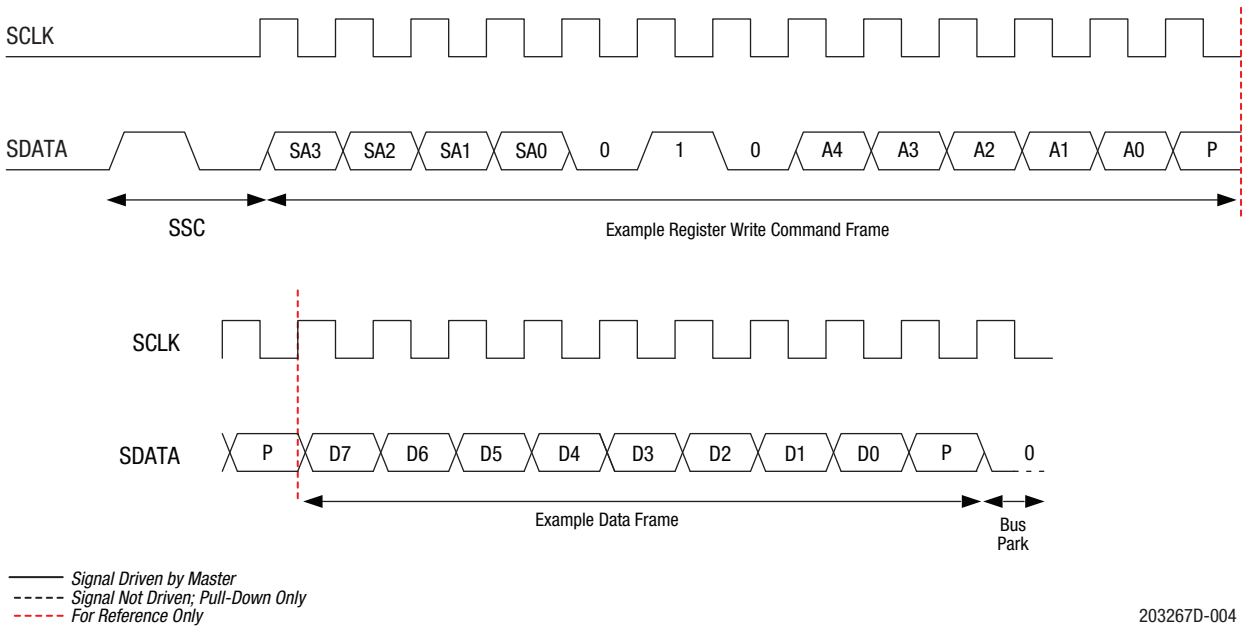


Figure 4. Register Write Command Timing Diagram

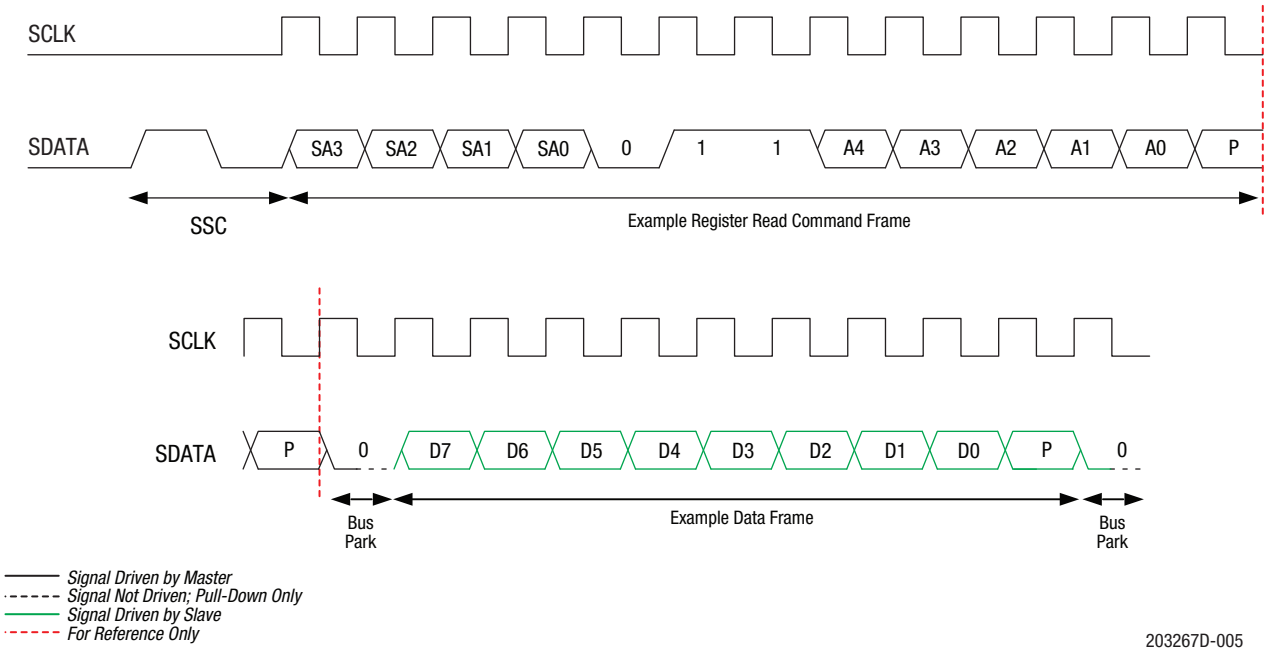


Figure 5. Register Read Command Timing Diagram

Table 8. Register Description and Programming

Register				
Name	Address (Hex)	Parameter	Description	Default (Binary)
Register_0	0000	MODE_CTRL	Bits[6:0]: See Table 10 for logic	0000000
Register_1	0001	MODE_CTRL	Bits[7:0]: See Table 11 for logic	00000000
PM_TRIG (Note 1)	001C	PWR_MODE	Bits[7:6]: 00 = Normal operation (active) 01 = Default settings (startup) 10 = Low power (low power) 11 = Reserved	00
		Trigger_Mask_2	Bit[5]: If this bit is set, trigger 2 is disabled. When all triggers are disabled, if writing to a register that is associated with trigger 2, the data goes directly to the destination register.	0
		Trigger_Mask_1	Bit[4]: If this bit is set, trigger 1 is disabled. When all triggers are disabled, if writing to a register that is associated with trigger 1, the data goes directly to the destination register.	0
		Trigger_Mask_0	Bit[3]: If this bit is set, trigger 0 is disabled. When all triggers are disabled, if writing to a register that is associated with trigger 0, the data goes directly to the destination register.	0
		Trigger_2	Bit[2]: If this bit is set, data is loaded into the trigger 2 registers.	0
		Trigger_1	Bit[1]: If this bit is set, data is loaded into the trigger 1 registers.	0
		Trigger_0	Bit[0]: If this bit is set, data is loaded into the trigger 0 registers.	0
PRODUCT_ID	001D	PRODUCT_ID	Bits[7:0]: This is a read-only register. However, during the programming of the Unique Slave Identifier (USID), a write command sequence is performed on this register but the value is not changed.	11010110
MANUFACTURER_ID	001E	MANUFACTURER_ID	Bits[7:0]: Read-only register	10100101
MAN_USID	001F	Reserved	Bits[7:6]: Reserved	00
		MANUFACTURER_ID	Bits[5:4]: Read-only register	01
		USID	Bits[3:0]: Programmable USID. A write to these bits programs the USID.	1010

[1] Unlike the complete independence between triggers 0, 1, and 2, and also between the associated trigger masks 0, 1, and 2, respectively, as described in the MIPI RFFE Specification, this device uses additional interactions between the provided trigger functions.

The delayed application of updated data to all triggerable registers in this device may be accomplished using any of the three triggers (0, 1, or 2), provided that the particular trigger used is not currently masked off. If multiple triggers are enabled, any or all of those are sufficient to cause the data to be transferred from shadow registers to destination registers for all triggerable registers in the device.

It is also necessary to disable all three triggers (i.e., set all three trigger masks) to ensure that data written to any triggerable register will immediately be written to the destination register at the conclusion of the RFFE command sequence where the data is written.

Table 9. Register_0 Truth Table (Ant B)

On State	Register 0 Bits							
	D7	D6	D5	D4	D3	D2	D1	D0
All isolation				0	0	0	0	0
TRxB1				0	0	0	0	1
TRxB2				0	0	0	1	0
TRxB3				0	0	0	1	1
TRxB4				0	0	1	0	0
TRxB5				0	0	1	0	1
Isolation				0	0	1	1	0
TRxB5				0	0	1	1	1
TRxB4				0	1	0	0	0
TRxB3				0	1	0	0	1
TRxB2				0	1	0	1	0
TRxB1				0	1	0	1	1
TRxB5+4				0	1	1	0	0
TRxB5+3				0	1	1	0	1
TRxB5+2				0	1	1	1	0
TRxB5+1				0	1	1	1	1
TRxB4+3				1	0	0	0	0
TRxB4+2				1	0	0	0	1
TRxB4+1				1	0	0	1	0
TRxB3+2				1	0	0	1	1
TRxB3+1				1	0	1	0	0
TRxB2+1				1	0	1	0	1
All isolation				1	0	1	1	0
All isolation				1	0	1	1	1
All isolation				1	1	0	0	0
All isolation				1	1	0	0	1
All isolation				1	1	0	1	0
All isolation				1	1	0	1	1
All isolation				1	1	1	0	0
All isolation				1	1	1	0	1
All isolation				1	1	1	1	0
All isolation				1	1	1	1	1

Table 10. Register_1 Truth Table (Band A)

On State	Register 0 Bits							
	D7	D6	D5	D4	D3	D2	D1	D0
All isolation				0	0	0	0	0
TRxA1				0	0	0	0	1
TRxA2				0	0	0	1	0
TRxA3				0	0	0	1	1
TRxA4				0	0	1	0	0
TRxA5				0	0	1	0	1
Isolation				0	0	1	1	0
TRxA5				0	0	1	1	1
TRxA4				0	1	0	0	0
TRxA3				0	1	0	0	1
TRxA2				0	1	0	1	0
TRxA1				0	1	0	1	1
TRxA5+4				0	1	1	0	0
TRxA5+3				0	1	1	0	1
TRxA5+2				0	1	1	1	0
TRxA5+1				0	1	1	1	1
TRxA4+3				1	0	0	0	0
TRxA4+2				1	0	0	0	1
TRxA4+1				1	0	0	1	0
TRxA3+2				1	0	0	1	1
TRxA3+1				1	0	1	0	0
TRxA2+1				1	0	1	0	1
All isolation				1	0	1	1	0
All isolation				1	0	1	1	1
All isolation				1	1	0	0	0
All isolation				1	1	0	0	1
All isolation				1	1	0	1	0
All isolation				1	1	0	1	1
All isolation				1	1	1	0	0
All isolation				1	1	1	0	1
All isolation				1	1	1	1	0
All isolation				1	1	1	1	1

Evaluation Board Description

The SKY13551-668LF Evaluation Board is used to test the performance of the SKY13551-668LF DP10T Switch. An Evaluation Board schematic diagram is provided in Figure 6. A recommended ESD protection circuit diagram is provided in Figure 7. An assembly drawing for the Evaluation Board is shown in Figure 8.

Package Dimensions

The PCB layout footprint for the SKY13551-668LF is provided in Figure 9. Typical part markings are shown in Figure 10. Package dimensions are shown in Figure 11, and tape and reel dimensions are provided in Figure 12.

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 SKY13551-668LF 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.

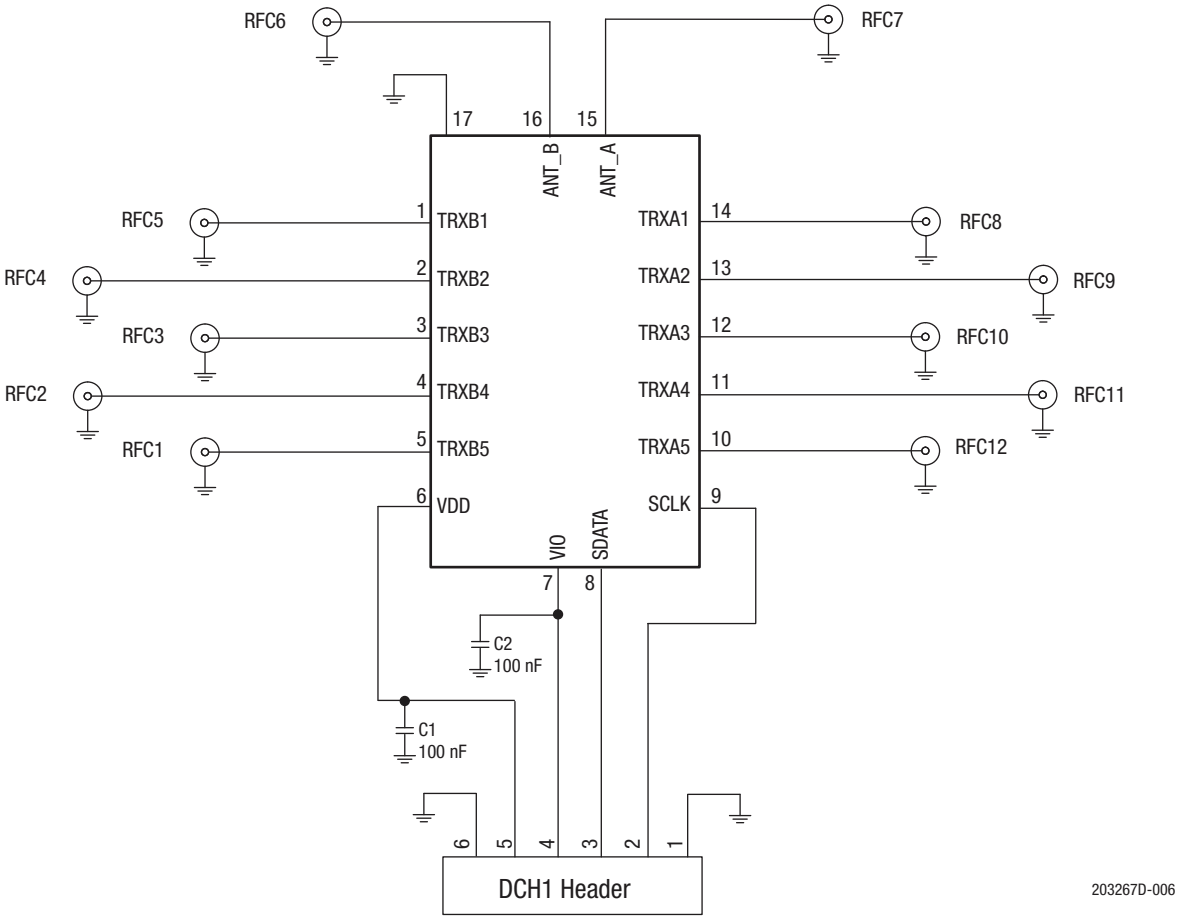
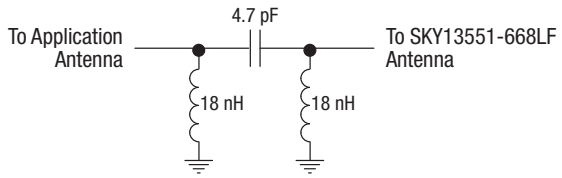
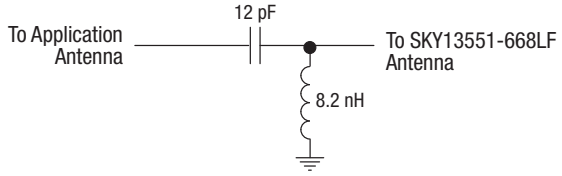


Figure 6. SKY13551-668LF Evaluation Board Schematic



ESD Circuit 1



ESD Circuit 2

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Figure 7. SKY13551-668LF Recommended ESD Protection Circuits

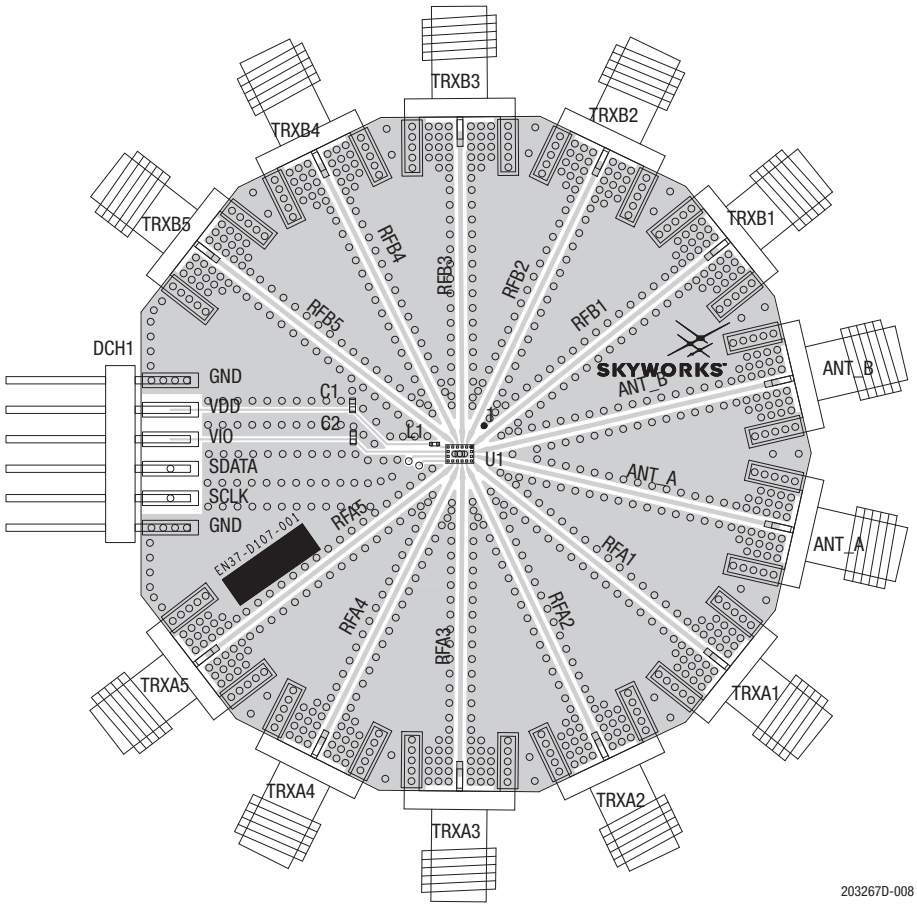
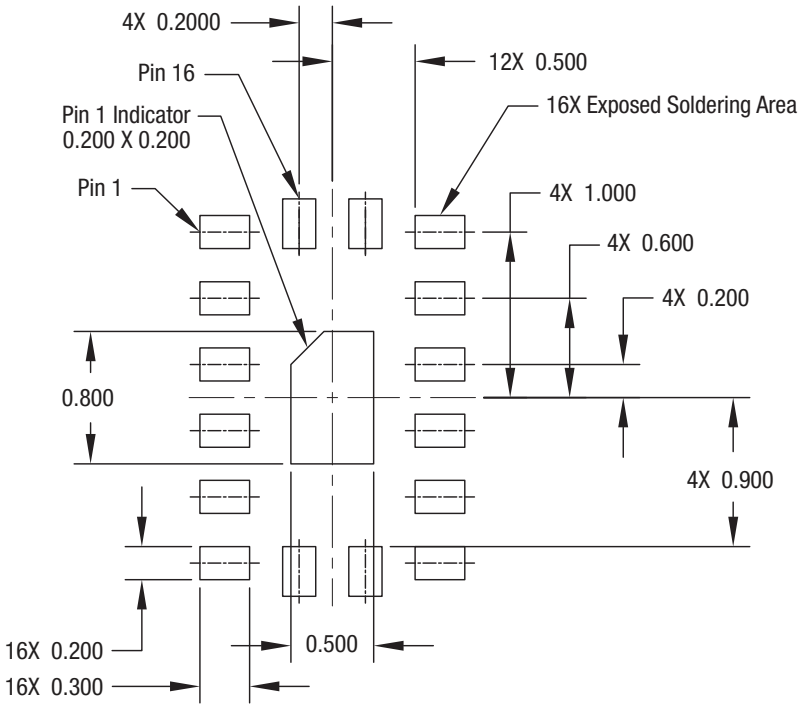


Figure 8. SKY13551-668LF Evaluation Board Assembly Diagram



All dimensions are in millimeters.

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Figure 9. SKY13551-668LF PCB Layout Footprint (Top View)

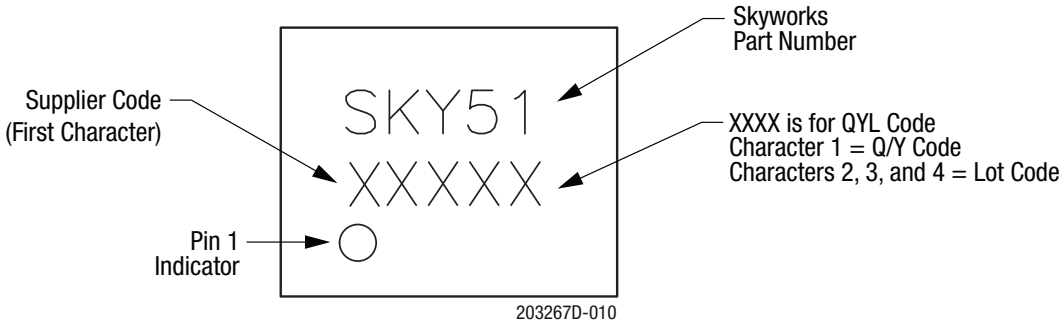
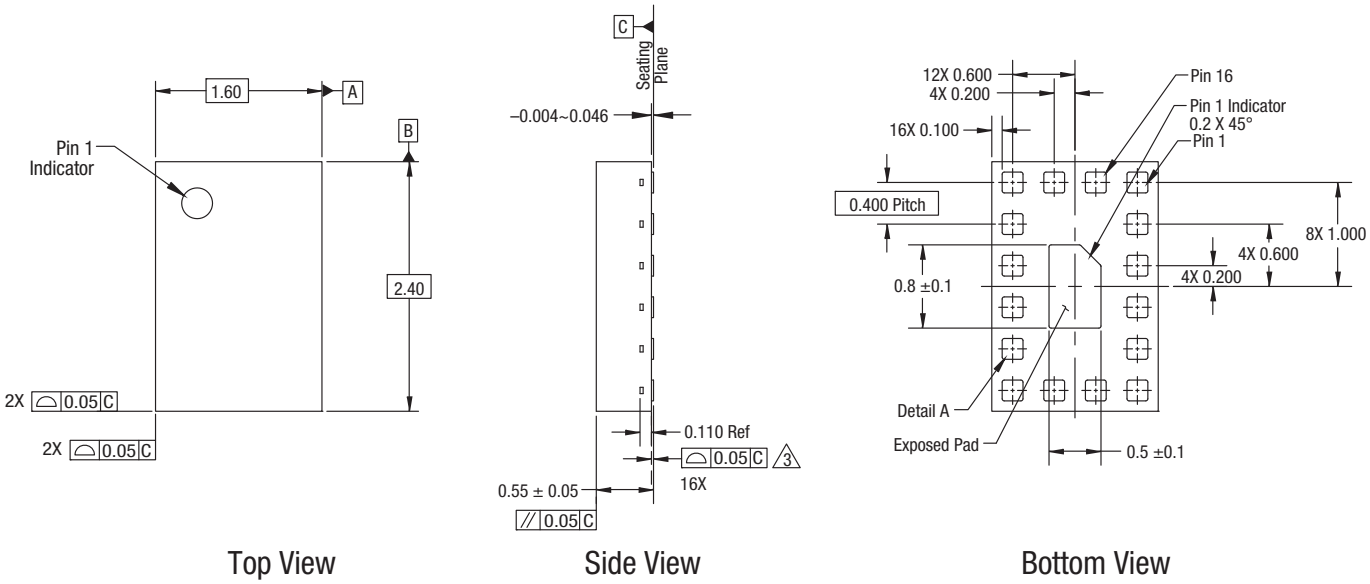


Figure 10. Typical Part Markings (Top View)



Notes:

1. *Dimensions and tolerances according to ASME Y14.5M-1994.*
2. *All measurements are in millimeters.*
3. *Coplanarity applies to the terminals as well as all other bottom surface metallization.*
4. *Plating requirements per source control drawing (SCD) 2504.*
5. *Dimension applies to metallized terminal. If terminal tip has a radius, dimension should not be measured in that radius area.*
6. *Unless otherwise specified, the following values apply:*

Decimal Tolerance:	*Angular Tolerance:*
X.X (1 place) ± 0.1 mm	*± 0.5°*
X.XX (2 places) ± 0.05 mm	
X.XXX (3 places) ± 0.025 mm	

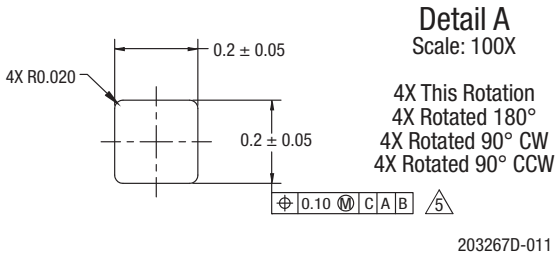
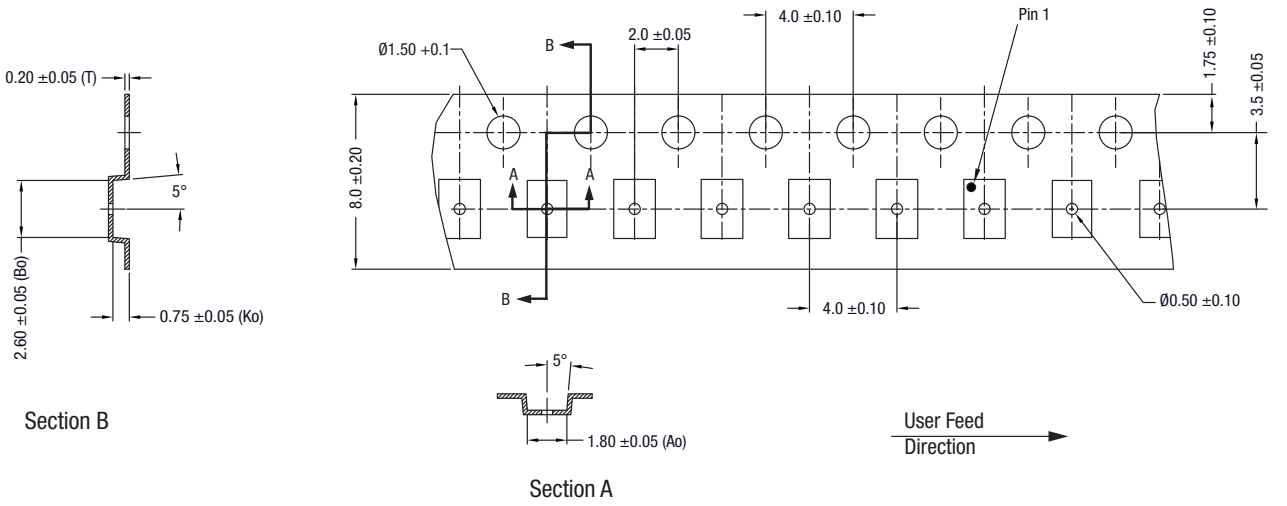


Figure 11. SKY13551-668LF Package Dimensions



Notes:

1. *Carrier tape material: black conductive polystyrene or polycarbonate.*
2. *Cover tape material: transparent conductive.*
3. *ESD surface resistivity shall be ≤1 x 10^{10} Ohms/square per EIA, JEDEC TNR specification.*
4. *10-sprocket hole pitch cumulative tolerance:* ±0.20 mm.
5. *Ao and Bo measured on plane 0.30 mm above the bottom of the pocket.*
6. *All dimensions are in millimeters.*

203267D-012

Figure 12. SKY13551-668LF Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY13551-668LF: 0.4 to 3.8 GHz DP10T Switch	SKY13551-668LF	SKY13551-668LF-EVB