SKY66405-11: 2.4 GHz Front-End Module for Zigbee®/Thread/Bluetooth® Applications

Applications

- In-home appliances
- Smart thermostats
- Internet of Things (IoT) devices
- Smart lighting
- Sensors
- Range extender
- Wireless audio

Features

- Integrated PA with +13 dBm output power
- Integrated LNA (2 dB noise figure typical) and bypass path
- Single-ended transmit/receive interface
- Fast switch on/off time: < 800 ns
- Supply range: 1.7 V to 3.6 V
- Sleep mode current: < 1 µA typical
- No external bias resistor is required
- Small MCM (1.9 mm x 1.9 mm x 0.56 mm) package, NiPdAu-plated (MSL3, 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.
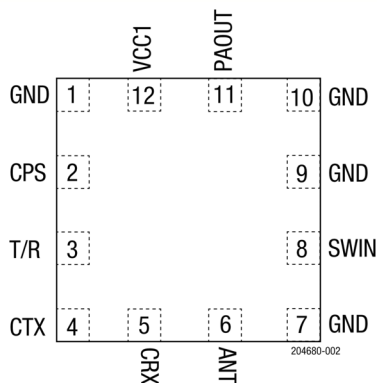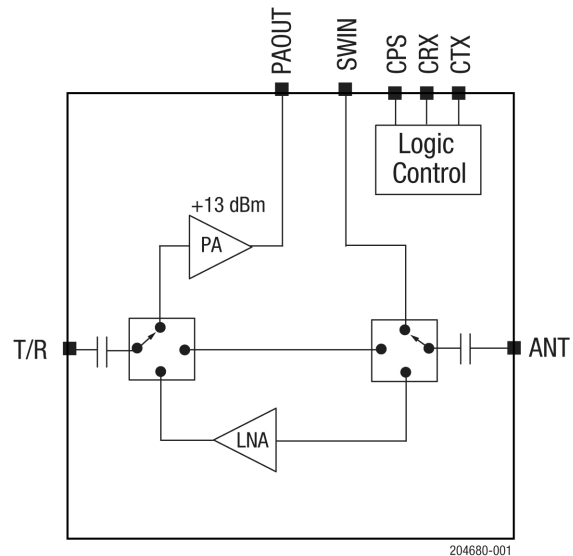

Figure 1. SKY66405-11 Block Diagram

Description

The SKY66405-11 is a high-performance, fully integrated RF front-end module (FEM) designed for Zigbee, Thread, and Bluetooth (including Low Energy) applications.

The SKY66405-11 is designed for ease of use and maximum flexibility. The device provides a power amplifier, low-noise amplifier, low-loss bypass path, transmit/receive switches, and digital controls compatible with 1.6 V to 3.6 V CMOS levels. The RF blocks operate over a wide supply voltage range from 1.7 V to 3.6 V that allows the SKY66405-11 to be used in battery powered applications over a wide spectrum of the battery discharge curve.

A functional block diagram is shown in Figure 1. The SKY66405-11 is provided in a small 1.9 mm x 1.9 mm x 0.56 mm Multi-Chip Module (MCM) package. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.

Figure 2. SKY66405-11 Pinout
(Top View)

Table 1. SKY66405-11 Signal Descriptions

Pin	Name	Description	Pin	Name	Description
1	GND	Ground	7	GND	Ground
2	CPS	Bypass mode control input	8	SWIN	Transmit arm to T/R switch; connect to OMN
3	T/R	Connect to 50 Ω transceiver	9	GND	Ground
4	CTX	Transmit mode control input	10	GND	Ground
5	CRX	Receive mode control input	11	PAOUT	PA output; connect to RF choke and OMN
6	ANT	Connect to 50 Ω antenna	12	VCC1	Connect to positive power supply

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY66405-11 are provided in Table 2. The recommended operating conditions are specified in Table 3.

Electrical specifications are provided in Tables 4 and 5. The state of the SKY66405-11 is determined by the logic provided in Table 6.

Table 2. SKY66405-11 Absolute Maximum Ratings[1]

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	V_{CC1} V_{CC2}	-0.3 -0.3	+3.6 +3.6	V V
Control pin voltages	V_{CTL}	-0.3	+3.6	V
Transmit input power at T/R port	P_{IN_TX}		+8	dBm
Receive input power at ANT ports[2]	P_{IN_RX}		+15	dBm
Bypass input power at ANT ports[2]	P_{IN_BYP}		+20	dBm
Voltage standing wave ratio	VSWR		10:1	
Operating temperature	T_A	-40	+105	°C
Storage temperature	T_{STG}	-40	+125	°C
Electrostatic discharge: Human Body Model (HBM), Pin 11 (PAOUT) Human Body Model (HBM), All other pins	ESD		 500 3000	 V V

[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.

[2] CW test signal.

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.*

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Table 3. Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Units
Supply voltage on VCC1 pin	V_{CC1}	1.7	3.3	3.6	V
Supply voltage on PAOUT pin	V_{CC2}	0.6	3.3	3.6	V
Operating temperature	T_A	-40	+25	+105	°C

Table 4. SKY66405-11 DC Electrical Specifications[1]
(V_{CC1} = V_{CC2} = 3.3 V, T_A = +25 °C, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
DC Characteristics						
Transmit operating current	I_{CC_TX}	P_{OUT} = +13 dBm P_{OUT} = +10 dBm		16 10		mA mA
Transmit quiescent current	I_{CCQ_TX}			4.0		mA
Receive mode current	I_{CC_RX}			3.5	5.5	mA
Bypass mode current	I_{CC_BYP}			5		µA
Sleep mode current	I_{CC_OFF}	No RF			1	µA
Logic Characteristics						

Control voltage:
    High
    Low
	
	V_{IH}
	V_{IL}
			
			1.6
			0
					
					V_{CC1}
					0.3
						
						V
						V

Control current:
    High
    Low
	
	I_{IH}
	I_{IL}
					
					1.0
					1.0
						
						µA
						µA

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

Table 5. SKY66405-11 AC Electrical Specifications[1]
(V_{CC1} = V_{CC2} = 3.3 V, T_A = +25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Transmit Characteristics						
Frequency range	f		2400		2483.5	MHz
Output power at ANT port	P_{OUT}	P_{IN} = -1 dBm P_{IN} = +3 dBm		+10 +13		dBm dBm
Saturated gain	G_{SAT}	P_{IN} = +3 dBm		10		dB
Small signal gain	S_{21_TX}			11		dB
Saturated output power variation	ΔP_{OUT}				1	dBp-p
Input return loss	S_{11_TX}	T/R port		-10		dB
2nd to 10th harmonics[2]	2fo to 10fo	P_{OUT} = +13 dBm, BLE source			-30	dBm/MHz
Turn-on time[2]	t_{ON_TX}	From 50% of CTX edge to 90% of final RF output power		800		ns
Turn-off time[2]	t_{OFF_TX}	From 50% of CTX edge to 10% of initial RF output power		800		ns
Stability[2]	STAB	CW, P_{IN} = +3 dBm, 0 GHz to 20 GHz, load VSWR = 6:1	All non-harmonically related outputs < -42 dBm/MHz			
Ruggedness[2]	RUG	CW, P_{IN} = +3 dBm, load VSWR = 10:1	No permanent damage			
Receive Characteristics						
Frequency range	f		2400		2483.5	MHz
Receive gain	S_{21_RX}		11.5	13.5	16	dB
Receive noise figure	NF			2		dB
Third order input intercept point	IIP3			2		dBm
1 dB input compression point	IP1dB		-14	-8		dBm
Input return loss	S_{11_RX}	ANT port		-10		dB
Output return loss	S_{22_RX}	T/R port		-10		dB
Turn-on time[2]	t_{ON_RX}	From 50% of CRX edge to 90% of final RF output power		800		ns
Turn-off time[2]	t_{OFF_RX}	From 50% of CRX edge to 10% of initial RF output power		800		ns
Bypass Characteristics						
Frequency range	f		2400		2483.5	MHz
Bypass gain	S_{21_BYP}			-2		dB
Input return loss	S_{11_BYP}	ANT port		-10		dB
Output return loss	S_{22_BYP}	T/R port		-10		dB

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

[2] Not tested in production. Fully characterized and guaranteed by design.

Table 6. SKY66405-11 Mode Control Logic

State	CTX	CRX	CPS
Sleep	0	0	X
Tx	1	0	0
Rx	0	1	0
BYP	1	1	0
BYP	1	0	1
BYP	0	1	1
BYP	1	1	1

Evaluation Board Description

An Evaluation Board schematic diagram is shown in Figure 3. A reference design schematic is provided in Figure 4.

A photograph of the Evaluation Board is shown in Figure 5. The Evaluation Board Bill of Materials (BOM) is listed in Table 7.
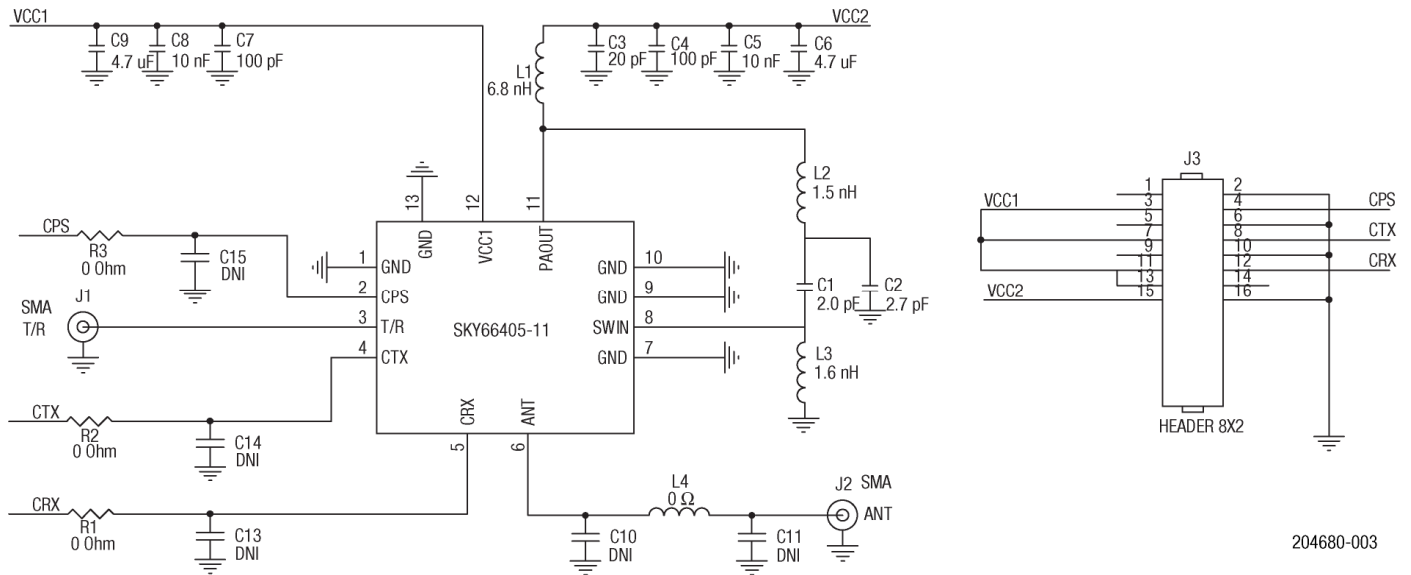

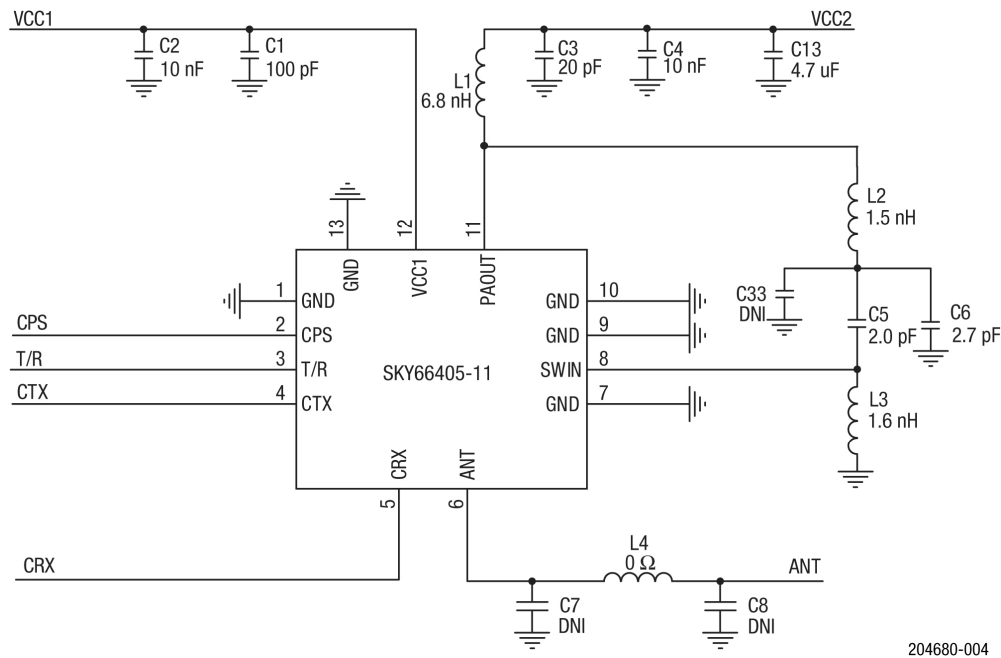Figure 3. SKY66405-11 Evaluation Board Schematic Diagram

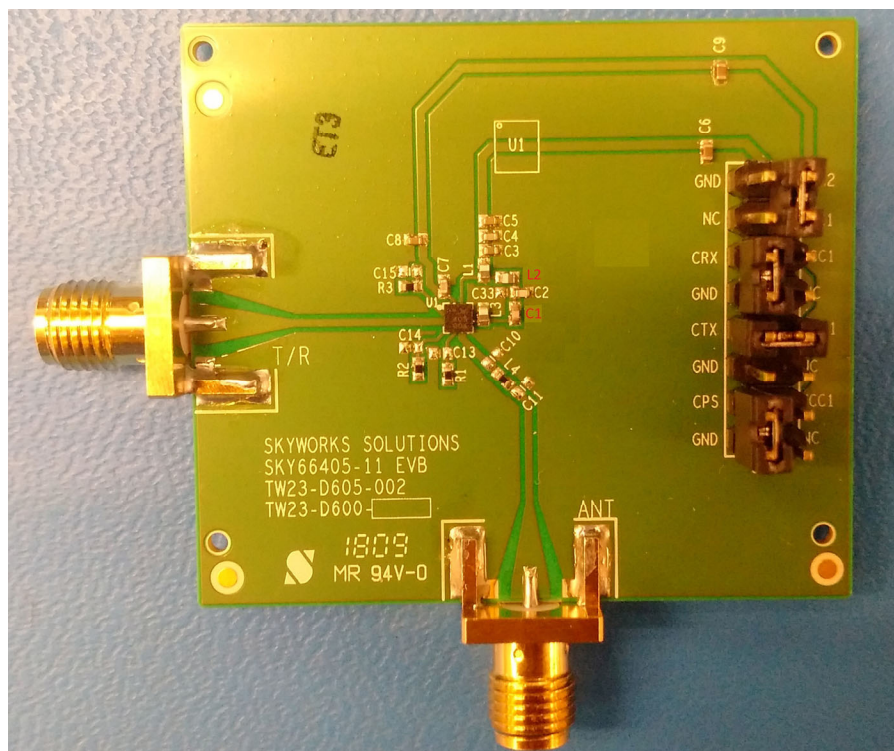Figure 4. SKY66405-11 Reference Design Schematic

Figure 5. SKY66405-11 Evaluation Board Photograph

Table 7. SKY66405-11 Evaluation Board Bill of Materials

Component	Value	Manufacturer	Mfr Part Number	Size	Description
C1	2 pF		GJM1552C1H2R0WB01	0402	2 pF ±0.05 pF 50 Vdc
C2	2.7 pF		GJM1552C1H2R7BB01	0402	2.7 pF ±0.1 pF 50 Vdc
C3	20 pF	Murata	GRM1555C1H200JZ01	0402	Ceramic capacitor, 20 pF, 5%, C0G, 50 V
C4, C7	100 pF	Murata	GRM1555C1H101JZ01	0402	Ceramic capacitor, 100 pF, 5%, C0G, 50 V
C5, C8	10 nF		GRM36X7R103J25D500	0402	Ceramic capacitor, 10000 pF, 10%, X7R,16 V
C6, C9	4.7 uF		C1005X5R1A475KTJ00E	0402	Ceramic capacitor, 4.7 uF, 20%, X5R, 4 V
C10, C11, C13, C14, C15, C33	DNI			0402	
L1	6.8 nH	TDK	MHQ1005P6N8JT000	0402	Inductor, ML-VC, 6.8 nH, 5%, Hi-Q
L2	1.5 nH	TDK	MHQ1005P1N5BT000	0402	Inductor, ML-VC, 1.5 nH, ±0.2 nH, Hi-Q
L3	1.6 nH	TDK	MHQ1005P1N6CT000	0402	Inductor, ML-VC, 1.6 nH, ±0.2 nH, Hi-Q
L4	0 Ω	Panasonic	ERJ2GE0R00	0402	
R1 R2 R3	0 Ω	Panasonic	ERJ2GE0R00	0402	
PCB1	TW23-D605-001-V1	Skyworks	TW23-D605-001-V1		EVB
J3	Header 8×2	Molex		8×2	Header 8×2
U1	SKY66405				

Package Dimensions

The typical part marking is shown in Figure 6. The PCB layout footprint for the SKY66405-11 is provided in Figure 7. Package dimensions are shown in Figure 8, and tape and reel dimensions are provided in Figure 9.

Package and Handling Information

Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. 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 SKY66405-11 is rated to Moisture Sensitivity Level 3 (MSL3) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *PCB Design and SMT Assembly/Rework Guidelines for MCM-L Packages*, document number 101752.

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.

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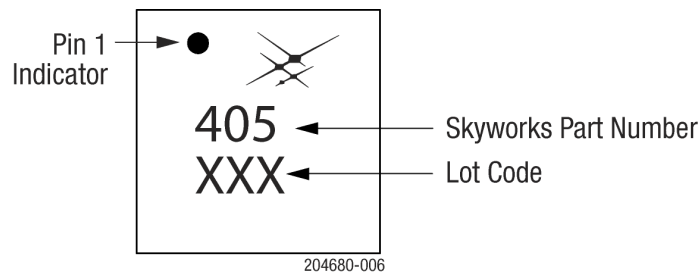
**Figure 6. SKY66405-11 Typical Part Marking
(Top View)**

STENCIL APERTURE
Top View

METALLIZATION
Top View

SOLDER MASK OPENING
Top View
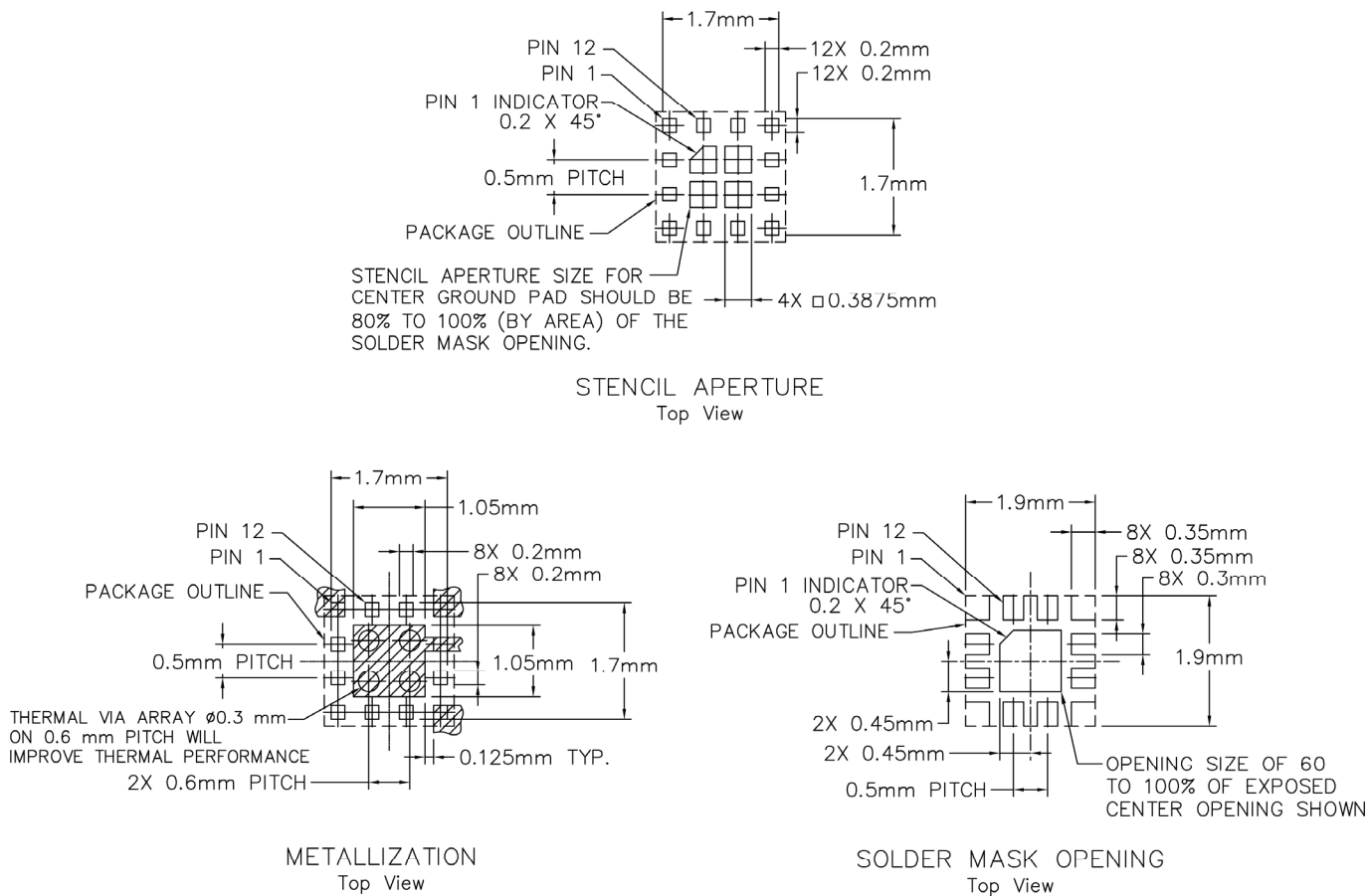
NOTES:
1. DIMENSIONS ARE IN MILLIMETERS, UNLESS OTHERWISE SPECIFIED.
2. THERMAL VIAS SHOULD BE RESIN FILLED AND CAPPED IN
   ACCORDANCE WITH IPC–4761 TYPE VII VIAS. 30–35UM
   Cu THICKNESS IS RECOMMENDED.

204680-007

Figure 7. SKY66405-11 PCB Layout Footprint

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Figure 8. SKY66405-11 Package Dimensions
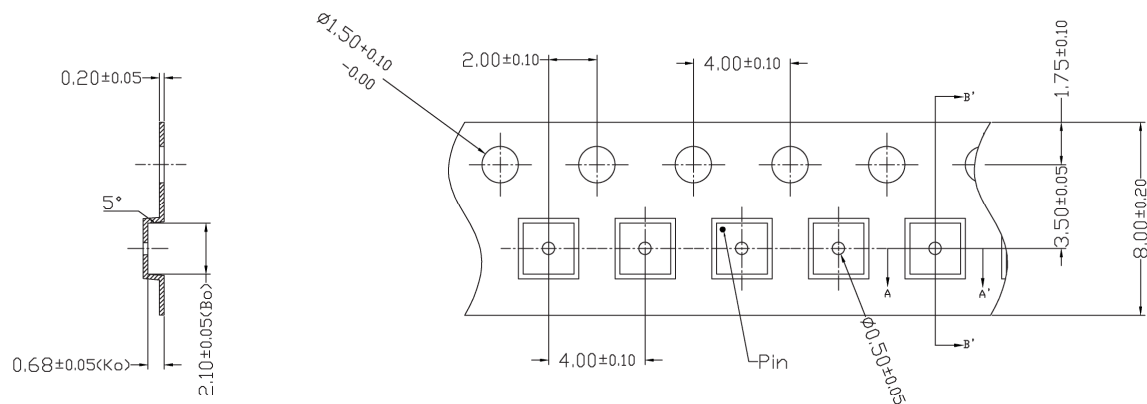
SECTION B–B'

SECTION A–A'

1. CARRIER TAPE MUST MEET ALL SKYWORKS REQUIREMENTS OF GP01-D233 PROCUREMENT SPEC FOR TAPE AND REEL
2. CARRIER TAPE SHALL BE BLACK CONDUCTIVE POLYCARBONATE NON BAKEABLE.
3. COVER TAPE SHALL BE TRANSPARENT CONDUCTIVE MATERIAL
4. ESD-SURFACE RESISTIVITY SHALL MEET GP01-D233
5. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE : ±0.20mm
6. Ao & Bo MEASURED ON PLANE 0.30mm ABOVE THE BOTTOM OF THE POCKET.
7. ALL DIMENSIONS ARE IN MILLIMETERS.
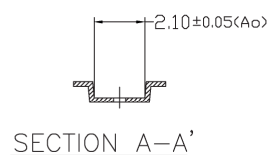
204680-009

Figure 9. SKY66405-11 Tape and Reel Dimensions

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Ordering Information

Part Number	Product Description	Evaluation Board Part Number
SKY66405-11	2.4 GHz Zigbee/Thread/Bluetooth FEM	SKY66405-11EK1