SKY66409-11: 2.4 GHz Front-End Module for Zigbee®/Thread/Bluetooth® Signal Applications

Applications

- Wearables
- Trackers
- Beacons
- Sensor networks
- Home automation
- Internet of Things (IoT) devices

Features

- Adjustable gain, output power, and current consumption
- Integrated PA with +13 dBm output power, up to 15 dBm (max). Bluetooth® signal EDR output power: +10.5 dBm
- Integrated LNA (2.5 dB noise figure typ.) and bypass path
- Single-ended transmit/receive interface
- Fast switch on/off time: < 800 ns
- Supply range: 1.8 V to 3.6 V
- Sleep mode current: < 1 µA typical
- Small (1.25 mm x 1.7 mm x 0.35 mm) Chip Scale Package (CSP), MSL1, 260 °C per JEDEC-J-STD-020
- For RoHS and other product compliance information, see the Skyworks Certificate of Conformance.

Figure 1. Functional Block Diagram

Description

The SKY66409-11 is a high-performance, fully integrated RF front-end module (FEM) designed for Zigbee®, Thread, and Bluetooth® (including low energy) applications.

The SKY66409-11 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 1.2 V to 3.6 V CMOS levels. T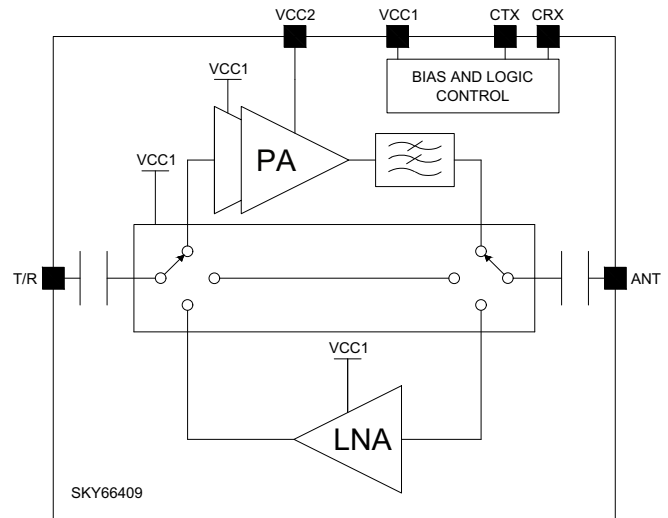he RF blocks operate over a wide supply voltage range from 1.8 V to 3.6 V that allows the SKY66409-11 to be used in battery-powered applications over a wide spectrum of the battery discharge curve.

A functional block diagram is shown in Figure 1, the pinout is shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.
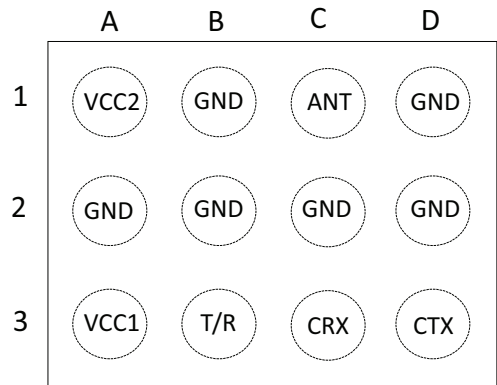
Figure 2. Pinout

Table 1. Signal Descriptions

Pin	Name	Description	Pin	Name	Description
A1	VCC2	Positive power supply	C1	ANT	Connect to 50 Ω antenna
A2	GND	Ground	C2	GND	Ground
A3	VCC1	Positive power supply	C3	CRX	Receive mode control input
B1	GND	Ground	D1	GND	Ground
B2	GND	Ground	D2	GND	Ground
B3	T/R	Connect to 50 Ω transceiver	D3	CTX	Transmit mode control input

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY66409-11 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 SKY66409-11 is determined by the logic provided in Table 6.

Table 2. Absolute Maximum Ratings[1]

Parameter	Symbol	Min	Max	Units
Supply voltage	VCC1	−0.3	+4	V
	VCC2	−0.3	+4	
Control pin voltages	CTX, CRX	−0.3	+4	V
Transmit input power at T/R port	PIN_TX		+8	dBm
Receive input power at ANT ports[2]	PIN_RX		+15	dBm
Bypass input power at ANT ports[2]	PIN_BYP		+20	dBm
Voltage standing wave ratio	VSWR		10:1	
Operating temperature	TA	−40	+105	°C
Storage temperature	TSTG	−40	+125	°C
Electrostatic discharge: Human Body Model (HBM)	ESD		2000	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: *Industry-standard ESD handling precautions must be adhered to at all times to avoid damage to this device.*

Table 3. Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Units
Supply voltage on VCC1 pin	VCC1	1.8	3.3	3.6	V
Supply voltage on VCC2 pin	VCC2	0.6	3.3	3.6	V
Operating temperature	TA	−40	+25	+105	°C

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3   November 12, 2025

Table 4. DC Electrical Specifications[1]
(VCC1 = VCC2 = 3.3 V, TA = +25 °C, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
DC Characteristics						
Transmit operating current	I_{CC_TX}	POUT = +15 dBm POUT = +13 dBm POUT = +10 dBm		23 17 15	28 22 17	mA
Transmit quiescent current	I_{CCQ_TX}			9.5	13	mA
Receive mode current	I_{CC_RX}			1.5	2	mA
Bypass mode current	I_{CC_BYP}			4	15	µA
Sleep mode current	I_{CC_SLEEP}	No RF		0.1	1	µA
Logic Characteristics						
Control voltage CTX, CRX[2] High Low	V_{IH} V_{IL}		1.2 0		VCC1 0.3	V
Control current: CTX control pin current CRX control pin current	$I_{CONTROL\_CTX}$ $I_{CONTROL\_CRX}$			30 30	36 36	µA

1. Performance is assured only under the conditions listed in this table and is not assured over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.
2. Control voltage applied to EVB resistor Rcontrol_CTX and Rcontrol_CRX, not the voltage at CTX_PIN node and CTX_PIN node, see application schematic for more details.

Table 5. AC Electrical Specifications[1]

(Vcc1 = Vcc2 = 3.3 V, TA = +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}	VCC2 = 1.8 V BDR VCC2 = 3.3 V BDR VCC2 = 3.6 V BDR VCC2 = 3.3 V EDR-3 VCC2 = 3.6 V EDR-3	8.5 10.5 11 8 9	9.5 12 12.5 10 10.5		dBm
Saturated gain	G_{SAT}	PIN = 0 dBm	9.5	11		dB
Small signal gain	S21_TX		11	12.5		dB
Saturated output power variation	ΔP_{OUT}		−0.5	0	0.5	dBp-p
Input return loss	S11_TX	T/R port, PIN = −25 dBm		−20	−10	dB
Output return loss	S22_TX	ANT port, PIN = −25 dBm		−17	−10	dB
Second harmonic[2]	2fo	P_{OUT} = +10 dBm, CW signal source		−45	−39	dBm/MHz
Third harmonic[2]	3fo	P_{OUT} = +10 dBm, CW signal source		−35	−30	dBm/MHz
Turn-on time[3]	tON_TX	From 50% of CTX edge to 90% of final RF output power		800	1000	ns
Turn-off time[3]	tOFF_TX	From 50% of CTX edge to 10% of initial RF output power		800	1000	ns
Stability[3]	STAB	CW, PIN = 0 dBm, 0 GHz to 20 GHz, load VSWR = 6:1	All non-harmonically related outputs < −42 dBm/MHz			
Ruggedness[3]	RUG	CW, PIN = 0 dBm, load VSWR = 10:1	No permanent damage			
Receive Characteristics						
Frequency range	f		2400		2483.5	MHz
Receive gain	S21_RX		10	12.5		dB
Receive noise figure	NF			2.5	3	dB
Third order input intercept point	IIP3		−13	−10		dBm
1 dB input compression point	IP1dB		−23	−20		dBm
Input return loss	S11_RX	ANT port		−14	−10	dB
Output return loss	S22_RX	T/R port		−14	−9	dB
Turn-on time[3]	tON_RX	From 50% of CRX edge to 90% of final RF output power		800	1000	ns
Turn-off time[3]	tOFF_RX	From 50% of CRX edge to 10% of initial RF output power		800	1000	ns
Bypass Characteristics						
Frequency range	f		2400		2483.5	MHz
Bypass gain	S21_BYP		−2	−1.5		dB
Input return loss	S11_BYP	ANT port		−16	−10	dB
Output return loss	S22_BYP	T/R port		−23	−10	dB

1. Performance is assured only under the conditions listed in this table and is not assured over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.
2. For output power higher than +10 dBm external harmonic filtering is recommended.
3. Not tested in production. Fully characterized and assured by design.

Table 6. Mode Control Logic

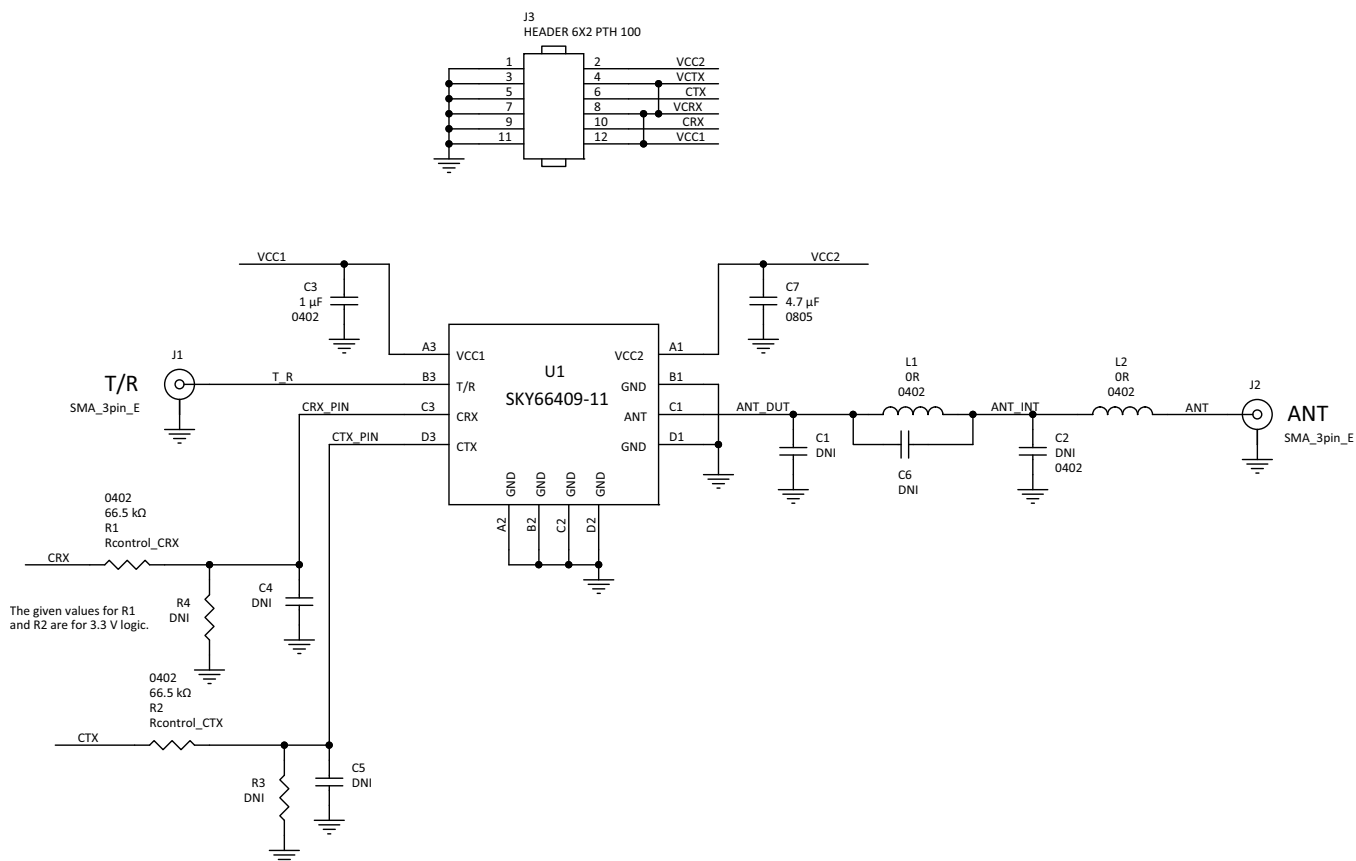| State	CTX	CRX
Sleep	0	0
Tx	1	0
Rx	0	1
BYP	1	1

Evaluation Board

Figure 3. Evaluation Board Schematic Diagram

Note: *VCTX/VCRX jumper setting on EVB: VCTX and VCRX are shorted with VCC1 on EVB.*
To obtain typical performance, VCC1 must be set to 3.3 V with Rcontrol_CTX = Rcontrol_CRX = 66.5 kΩ.
For different CTX/CRX voltage and Rcontrol settings, refer to Table 7.
A harmonic filter may be installed for higher output power. Contact Skyworks for more information.

Figure 4. Reference Design Schematic

Figure 5. Evaluation Board Photograph

Note: *The PCB silkscreen may be incorrect. Pin A1 should be located at the upper right corner, not the upper left.*

Table 7. CTX/CRX Voltage and Rcontrol Settings

Icontrol µA	When CTX/CRX = 1.2 V Rcontrol Value kΩ	When CTX/CRX = 1.8 V Rcontrol Value kΩ	When CTX/CRX = 2.85 V Rcontrol Value kΩ	When CTX/CRX = 3.3 V Rcontrol Value kΩ	When CTX/CRX = 3.6 V Rcontrol Value kΩ	Measured CRX_pin Voltage V
31.75	0.315	19.2	52.3	66.5	75.9	1.19

CTX/CRX Series Control Resistor Value (kΩ) versus Control Voltage (V)

$$R_{CONTROL}(k\Omega) = 0.001 \times \frac{V_{CONTROL}(V) - 1.19V}{31.75uA}$$
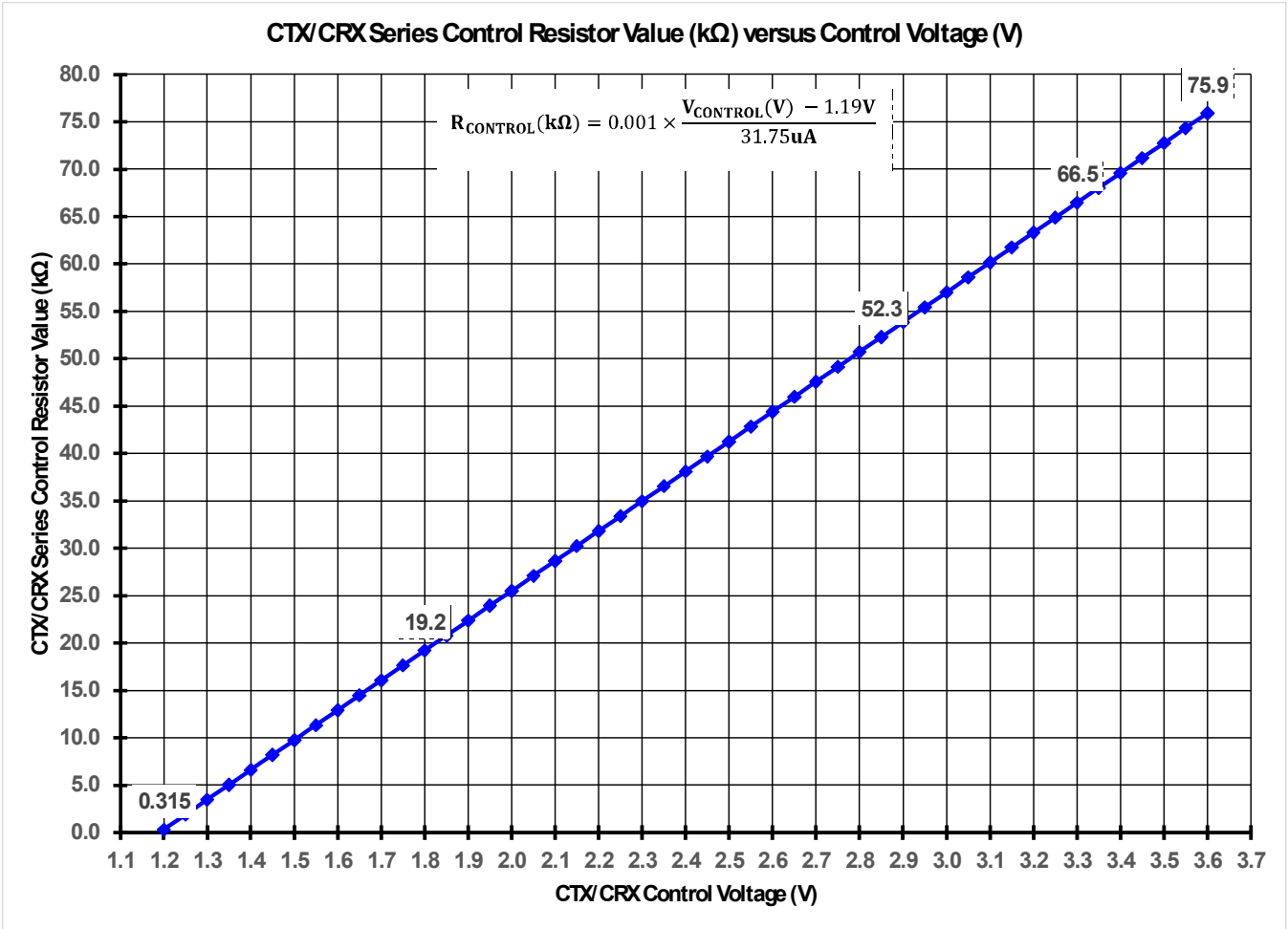
Figure 6. Resistor Control Voltage Graph

Table 8. Evaluation Board Bill of Materials

Reference	Value	Manufacturer	Part Number	Package	Description
C3	1 µF	Murata	GRM155R60J105KE19	0402	Multilayer ceramic
C7	4.7 µF	Murata	GRM21BR71C475KA73L	0805	Capacitor, ceramic 4.7 Ω µF, 16 V X7R
J1, J2	SMA connector	Johnson Components	142-0701-851	End launch	Connector, SMA jack STR 50 Ω, edge mount
J3	Header 6X2 PTH 100	Samtec	TSW-106-07-G-D		Connector, header 12 pos., 100 in. DL gold
L1, L2	0R	Panasonic	ERJ-2GE0R00X	0402	Resistor, SMD 0 Ω jumper, 1/10 W
PCB1	Z1525-A	Skyworks Solutions, Inc	Z1525-A		PCB
R1, R2	66.5 kΩ	Panasonic	ERJ2RKF6652	0402	Resistor, SMD 66.5 kΩ, 1% 1/10 W
U1	SKY66409-11	Skyworks Solutions, Inc	SKY66409-11		2.4 GHz front-end module
C1, C2, R3, R4, C4, C5, C6	DNI			0402	DNI

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 SKY66409-11 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, 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.

PIN 1
INDICATOR

SKYWORKS
PART NUMBER

66409

LLLLLX

WAFER ID:
LLLLL = WAFER
LOT
NUMBER
X   = WAFER
NUMBER

TOP VIEW

(BUMP SIDE DOWN)
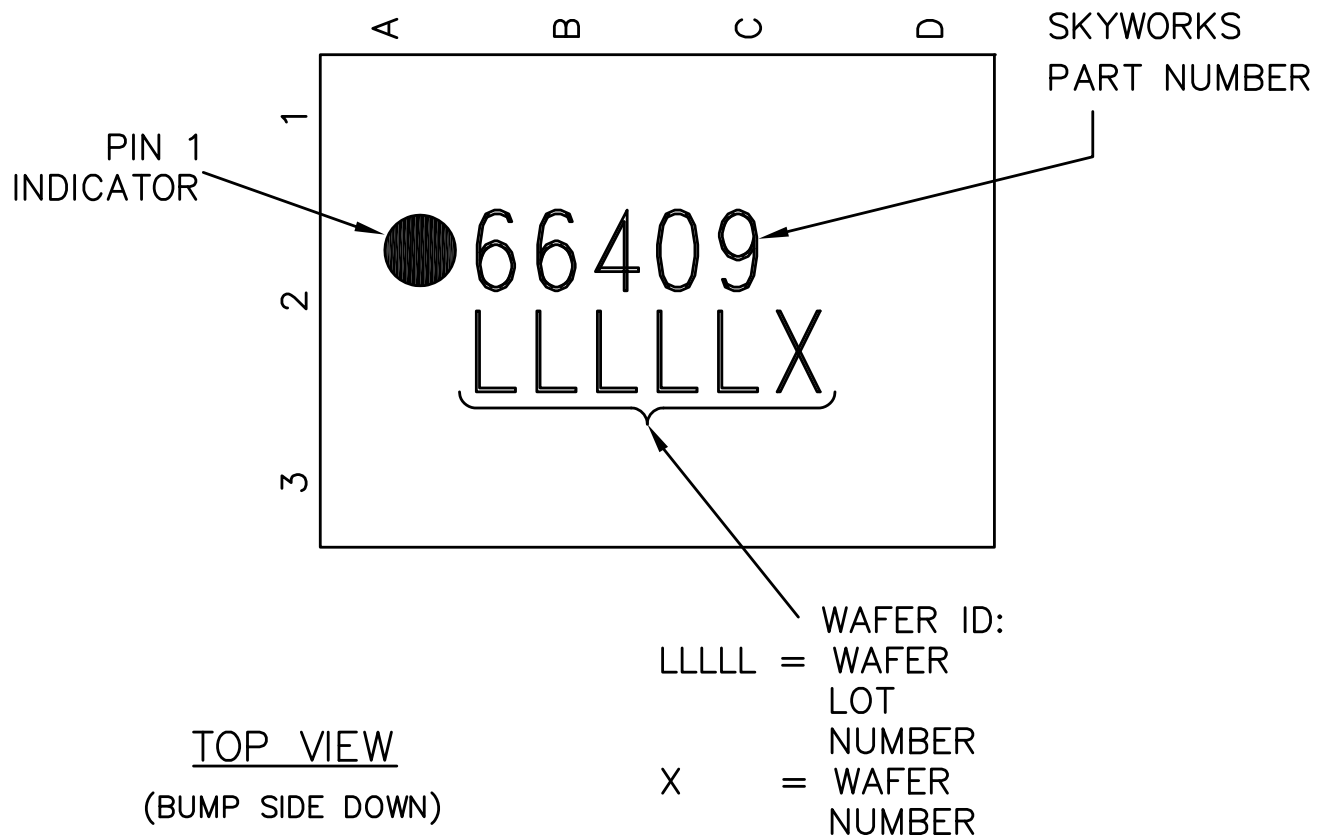
NOTES
DIMENSIONS ARE IN MILLIMETERS.

Figure 7. Typical Part Marking

BUMP SIDE DOWN

BUMP SIDE UP
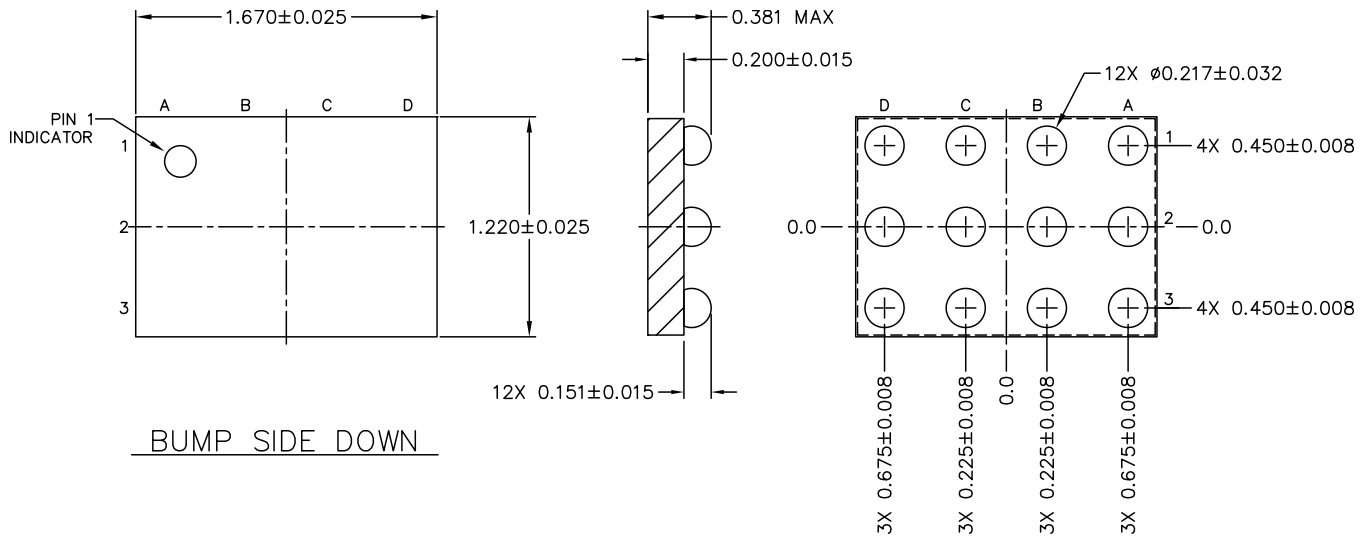
NOTES:
1. DIMENSIONS ARE IN MILLIMETERS.
2. TOLERANCING (UNLESS OTHERWISE SPECIFIED).
   DECIMAL TOLERANCE: ANGULAR TOLERANCE:
   X.X (1 PLC) ± 0.1mm   ± 1/2°
   X.XX (2 PLC) ± 0.05mm
   X.XXX (3 PLC) ± 0.025mm
3. UNLESS SPECIFIED DIMENSIONS ARE SYMMETRICAL
   ABOUT CENTER LINES.

Figure 8. Package Dimensions
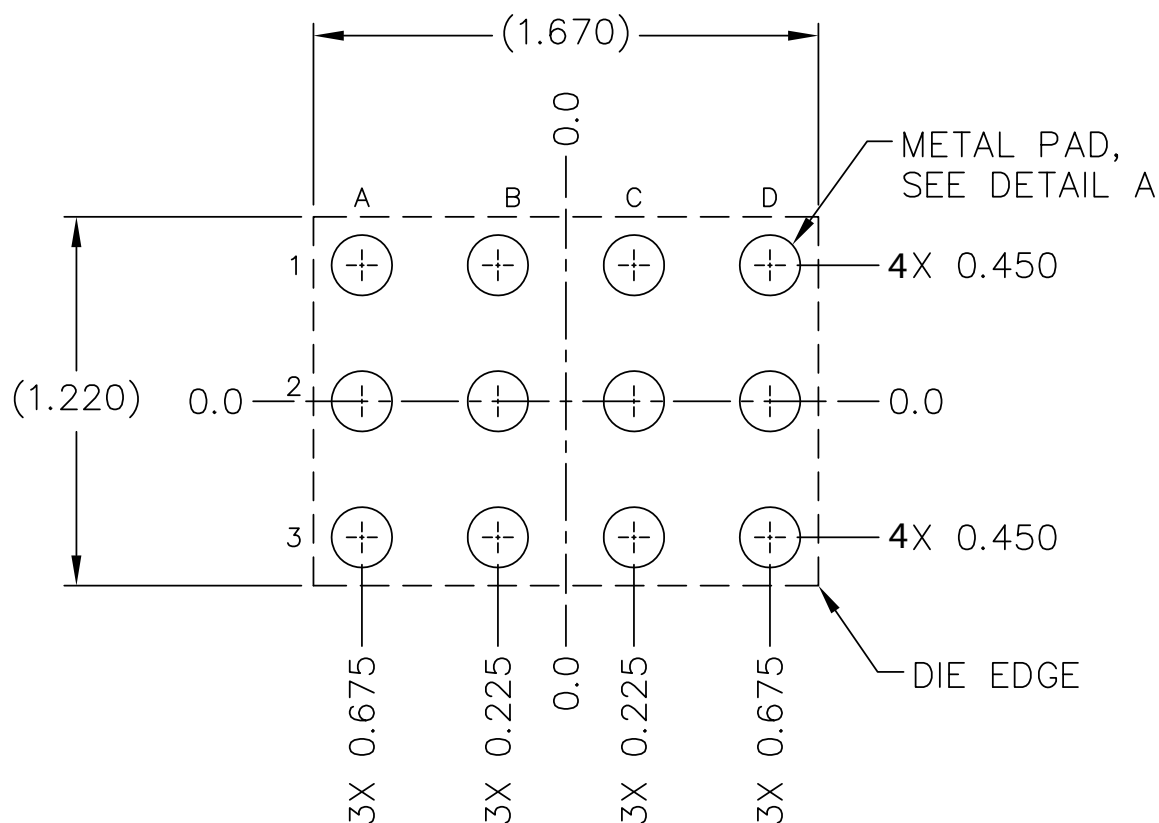
TOP VIEW
(THRU WLCSP DIE, BUMP SIDE DOWN)

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER
   ASME Y14.5M−1994.
3. UNLESS SPECIFIED DIMENSIONS ARE
   SYMMETRICAL ABOUT CENTER LINES.
4. TOLERANCING
   (UNLESS OTHERWISE SPECIFIED).

DECIMAL TOLERANCE:
X.X (1 PLC) ± 0.1mm
X.XX (2 PLC) ± 0.05mm
X.XXX (3 PLC) ± 0.025mm

ANGULAR TOLERANCE:
      ± 1/2°

DETAIL A
(2X SCALE)
12 PLCS

ⵁ0.20
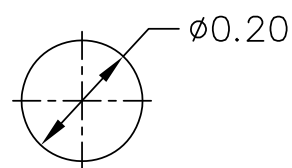
Figure 9. PCB Layout Footprint

4.00 ±0.10

4.00 ±0.10

2.00 ±0.05

$\varnothing$ 1.50 +0.10

1.75 ±0.10

8.00 +0.30 -0.10

3.50 ±0.05

$\varnothing$ 0.50 ±0.05

0.02 RAISED CROSS-BAR

Pin 1

.20 ±0.02

3° MAX

1.38 ±0.05

0.49 ±0.05

1.83 ±0.05

3° MAX

A_0 K_0 B_0
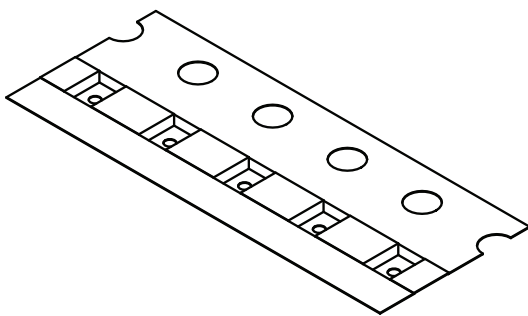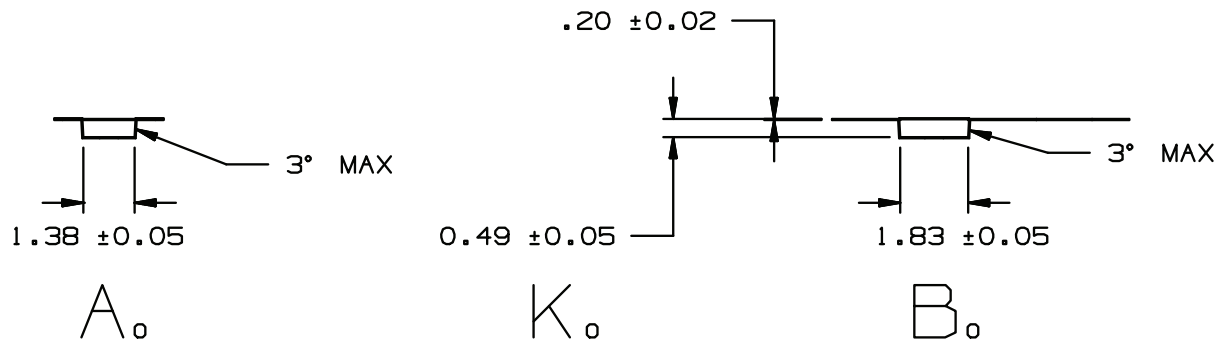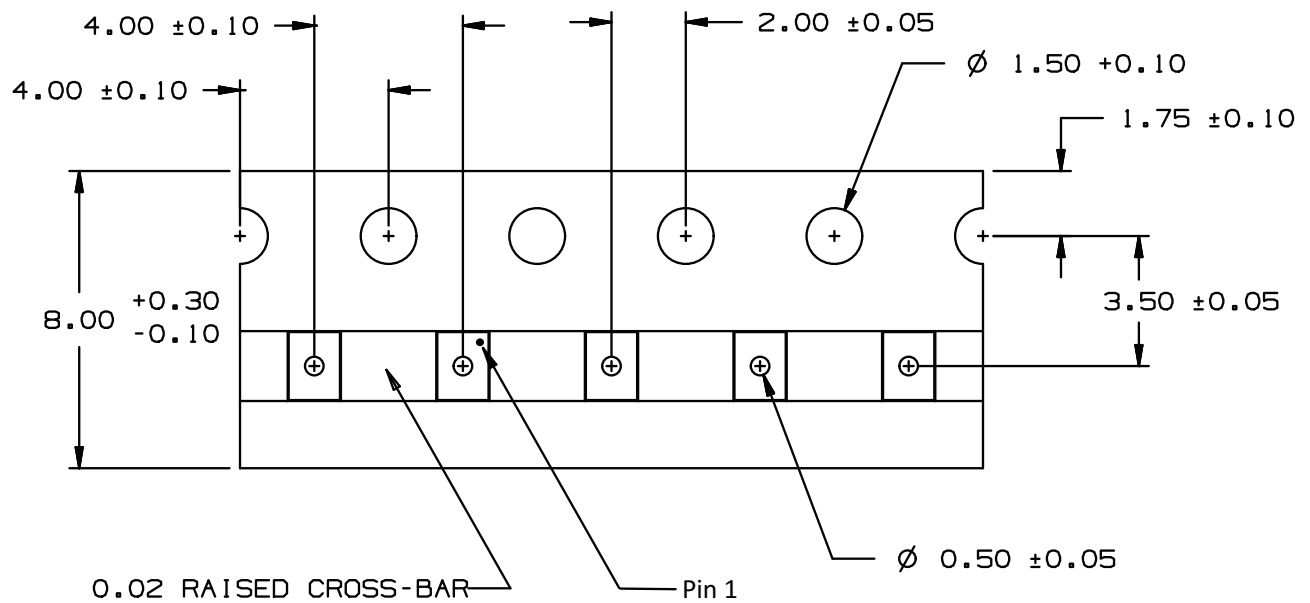
Figure 10. Tape and Reel Information

Ordering Information

Part Number	Description	Evaluation Board Part Number
SKY66409-11	2.4 GHz Front-End Module for Zigbee®/Thread/Bluetooth® Signal Applications	SKY66409-11EK1

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14

November 12, 2025