

DATA SHEET

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 μ A 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)



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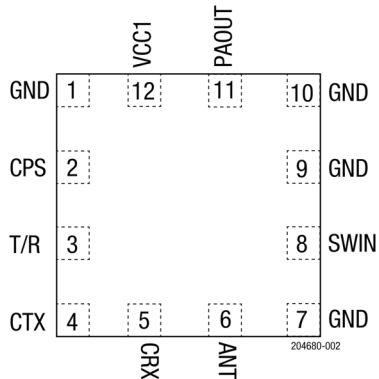


Figure 2. SKY66405-11 Pinout (Top View)

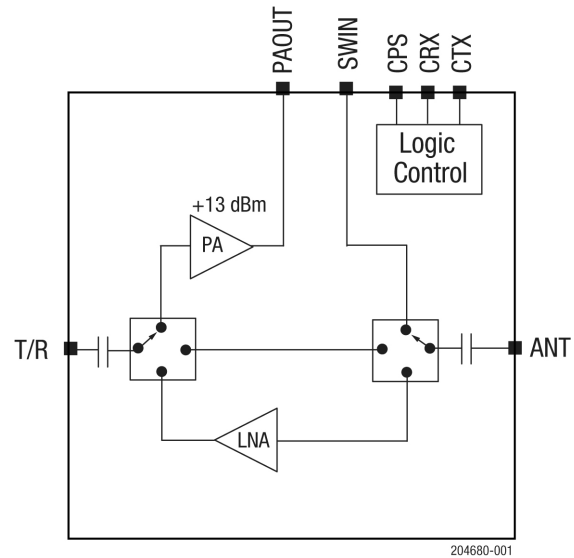


Figure 1. SKY66405-11 Block Diagram

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 1.2 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.

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 Ratings¹

| Parameter | Symbol | Minimum | Maximum | Units |
|---|---------------------|---------|---------|-------|
| Supply voltage | V _{CC1} | -0.3 | +3.6 | V |
| | V _{CC2} | -0.3 | +3.6 | 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: | ESD | | | |
| | | | | |
| Human Body Model (HBM), Pin 11 (PAOUT) | | | 500 | V |
| Human Body Model (HBM), All other pins | | | 3000 | 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.*

Table 3. Recommended Operating Conditions

| Parameter | Symbol | Min | Typ | Max | Units |
|-----------------------------|--------|-----|-----|------|-------|
| Supply voltage on VCC1 pin | Vcc1 | 1.7 | 3.3 | 3.6 | V |
| Supply voltage on PAOUT pin | Vcc2 | 0.6 | 3.3 | 3.6 | V |
| Operating temperature | TA | -40 | +25 | +105 | °C |

Table 4. SKY66405-11 DC Electrical Specifications¹
(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} | 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 | V _{IH} | | 1.2 | | V _{CC1} | V |
| Low | V _{IL} | | 0 | | 0.3 | V |
| Control current: | | | | | | |
| High | I _{IH} | | | | 1.0 | µA |
| Low | I _{IL} | | | | 1.0 | µA |

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

Table 5. SKY66405-11 AC Electrical Specifications¹
(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} | 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 |
| 2 nd to 10 th 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.

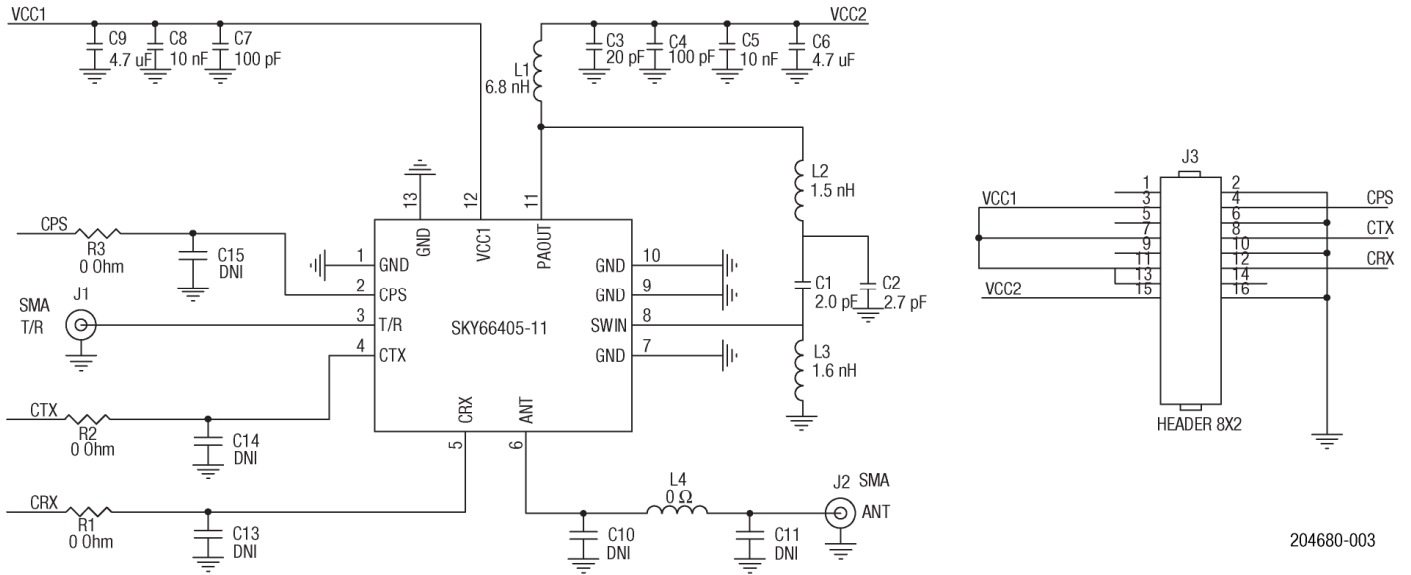


Figure 3. SKY66405-11 Evaluation Board Schematic Diagram

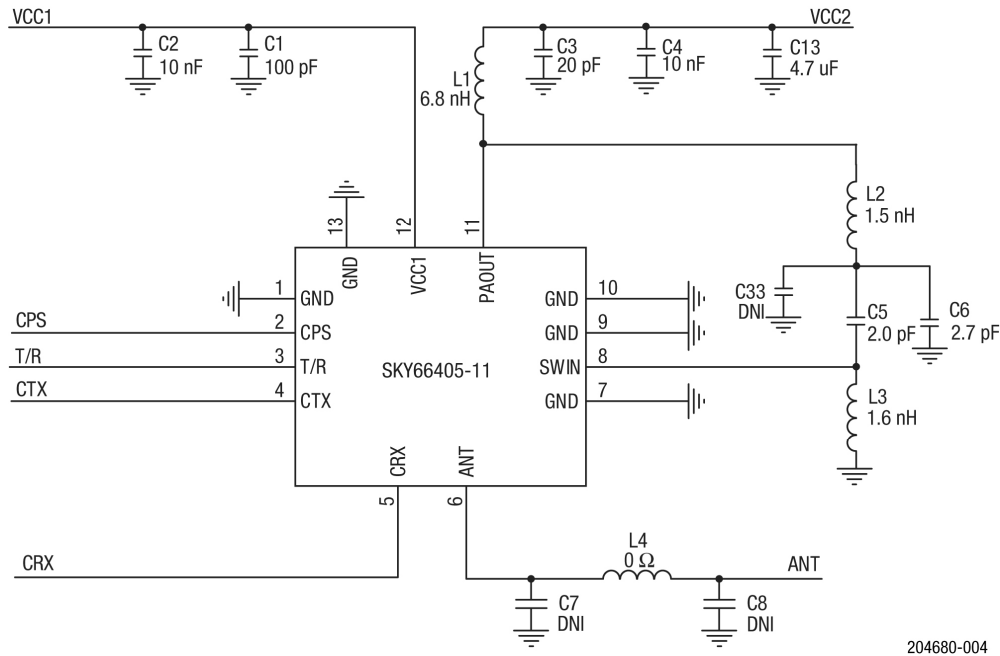


Figure 4. SKY66405-11 Reference Design Schematic

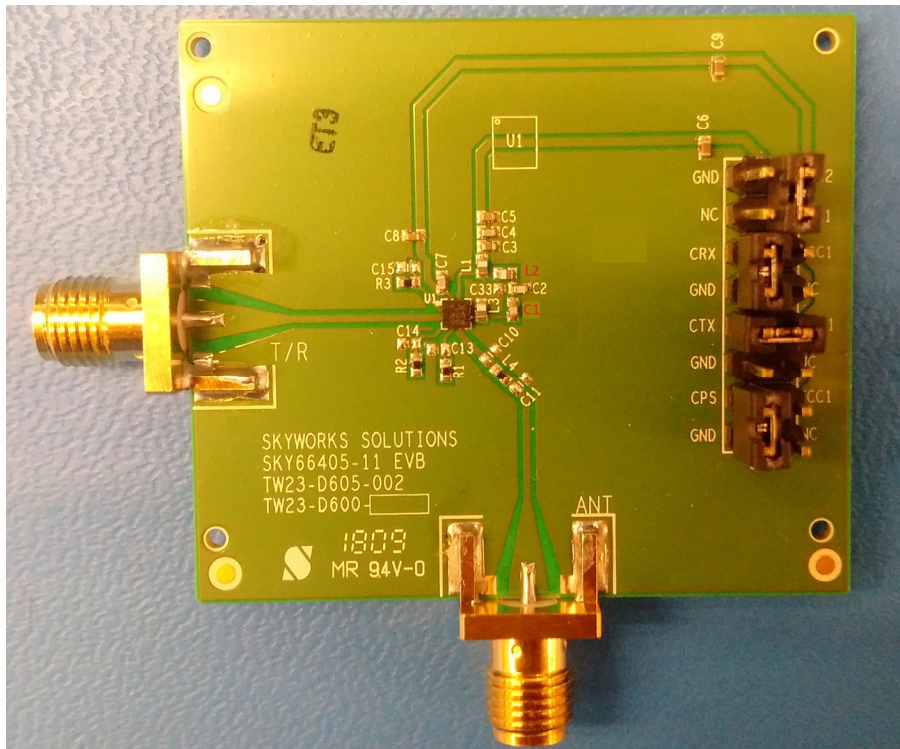


Figure 5. SKY66405-11 Evaluation Board Photograph

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%, COG, 50 V |
| C4, C7 | 100 pF | Murata | GRM1555C1H101JZ01 | 0402 | Ceramic capacitor, 100 pF, 5%, COG, 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.

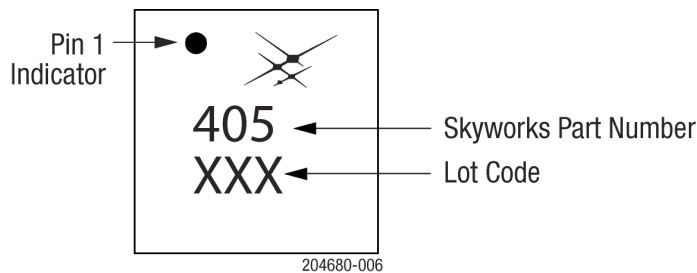
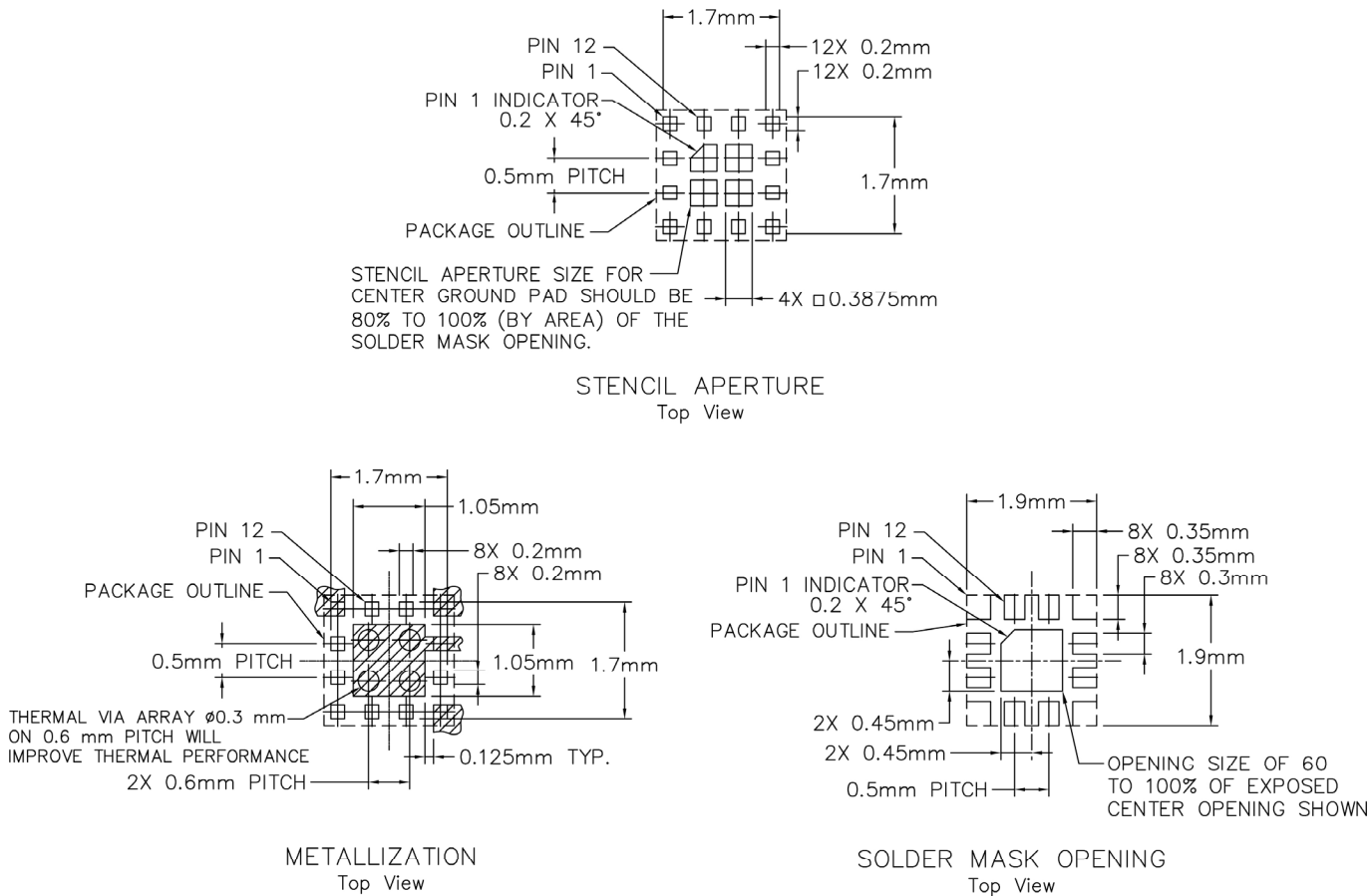


Figure 6. SKY66405-11 Typical Part Marking (Top View)

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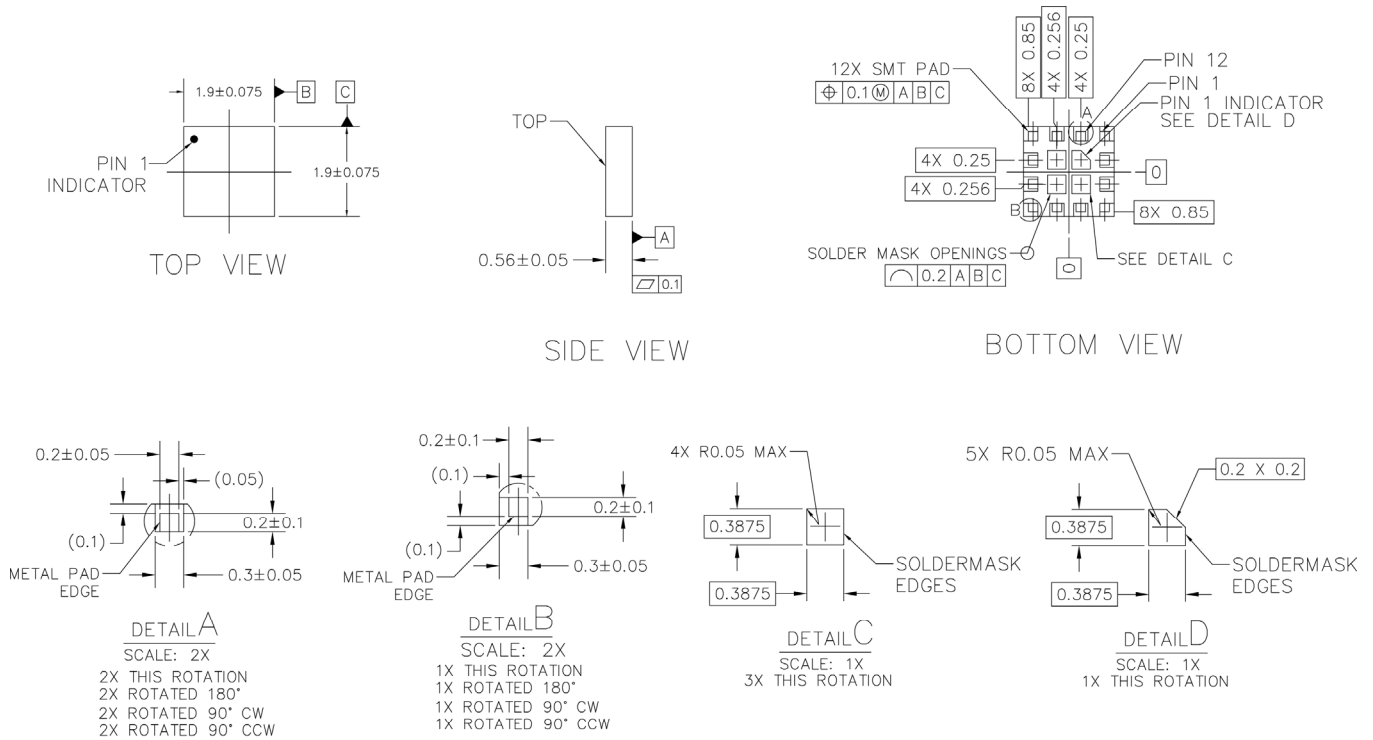
NOTES:

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.

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Figure 7. SKY66405-11 PCB Layout Footprint

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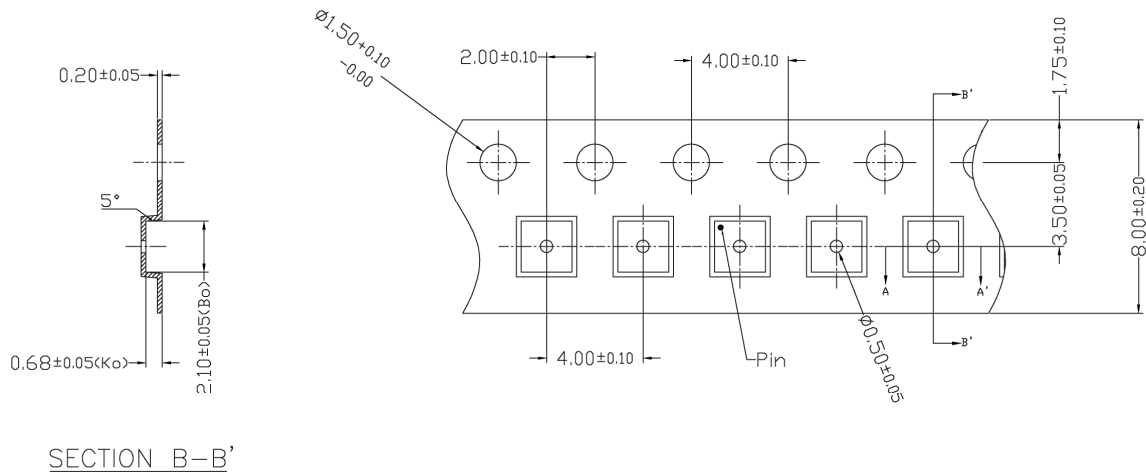


NOTES: UNLESS OTHERWISE SPECIFIED.
1. DIMENSIONING AND TOLERANCING IN ACCORDANCE WITH ASME Y14.5M-1994.
2. DIMENSIONS ARE IN MILLIMETERS

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Figure 8. SKY66405-11 Package Dimensions

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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 : $\pm 0.20\text{mm}$
6. A_0 & B_0 MEASURED ON PLANE 0.30mm ABOVE THE BOTTOM OF THE POCKET.
7. ALL DIMENSIONS ARE IN MILLIMETERS.

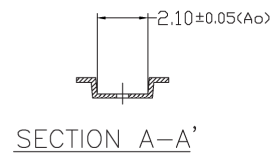


Figure 9. SKY66405-11 Tape and Reel Dimensions

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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 |

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