



SKYWORKS®

DATA SHEET

# SKY66122-11: 863 to 928 MHz Front-End Module for Wi-SUN® Applications

## Applications

- Range extenders
- Smart meters
- In-home appliances
- Smart thermostats

## Features

- Output power: +30 dBm, Wi-SUN OFDM Option 1 MCS0
- Output power: +30 dBm, Wi-SUN OFDM Option 1 MCS3
- Output power: +25 dBm, Wi-SUN OFDM Option 3 MCS6
- Integrated LNA with 2.5 dB noise figure (typical)
- TX and RX power limiters for maximum ruggedness
- Integrated power detector
- Single-ended 50 Ω RF interface
- Supply voltage: 3.0 V to 5.0 V
- Sleep mode current: < 1 μA
- Small MCM (6 x 6 x 0.9 mm [nominal]) package (MSL3, 260 °C per JEDEC J-STD-020)

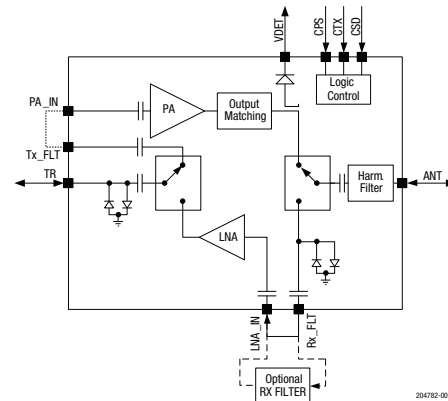


Figure 1. SKY66122-11 Block Diagram

## Description

The SKY66122-11 is a high-performance, highly integrated RF front-end module (FEM) designed for high-power Industrial, Scientific, Medical (ISM) band, Wi-SUN®, and other IoT applications operating in the 863 to 928 MHz frequency range.

The SKY66122-11 is designed for ease of use and maximum flexibility with fully matched, 50 Ω RF input and output, and digital controls compatible with 1.6 to 3.6 V CMOS levels.

The RF blocks operate over a wide supply voltage range from 3.0 to 5.0 V that allows the SKY66122-11 to be used in battery powered applications over a wide spectrum of the battery discharge curve.

The SKY66122-11 is packaged in a 36-pin, 6 x 6 x 0.9 mm (nominal) Multi-Chip Module (MCM), which allows for a highly manufacturable, low-cost solution.

A functional block diagram of the SKY66122-11 is shown in Figure 1. The package and pinout are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.



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.

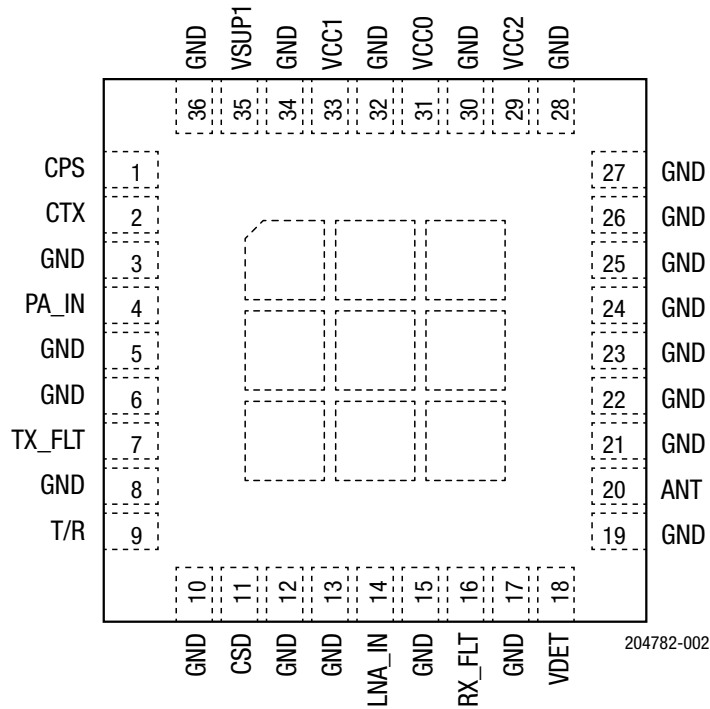


Figure 2. SKY66122-11 Pinout (Top View)

Table 1. SKY66122-11 Signal Descriptions

| Pin | Name   | Description                   | Pin | Name  | Description                             |
|-----|--------|-------------------------------|-----|-------|---|
| 1   | CPS    | Path select control           | 19  | GND   | Ground                                  |
| 2   | CTX    | Transmit/receive control      | 20  | ANT   | Antenna (integrated harmonic filtering) |
| 3   | GND    | Ground                        | 21  | GND   | Ground                                  |
| 4   | PA_IN  | Input to PA                   | 22  | GND   | Ground                                  |
| 5   | GND    | Ground                        | 23  | GND   | Ground                                  |
| 6   | GND    | Ground                        | 24  | GND   | Ground                                  |
| 7   | TX_FLT | Source for external TX filter | 25  | GND   | Ground                                  |
| 8   | GND    | Ground                        | 26  | GND   | Ground                                  |
| 9   | T/R    | Transmit and receive          | 27  | GND   | Ground                                  |
| 10  | GND    | Ground                        | 28  | GND   | Ground                                  |
| 11  | CSD    | Mode control                  | 29  | VCC2  | PA voltage supply                       |
| 12  | GND    | Ground                        | 30  | GND   | Ground                                  |
| 13  | GND    | Ground                        | 31  | VCC0  | Decoupling capacitor                    |
| 14  | LNA_IN | LNA input                     | 32  | GND   | Ground                                  |
| 15  | GND    | Ground                        | 33  | VCC1  | PA voltage supply                       |
| 16  | RX_FLT | Source for external RX filter | 34  | GND   | Ground                                  |
| 17  | GND    | Ground                        | 35  | VSUP1 | General voltage supply                  |
| 18  | VDET   | Voltage detector output       | 36  | GND   | Ground                                  |

## Technical Description

The SKY66122-11 consists of a complete transmit and receive (T/R) chain with T/R switches contained in the module. An SP2T switch selects between transmit and receive paths. The module has a shutdown mode to minimize power consumption.

Three digital input control pins (CSD, CTX, and CPS) are used to select between shutdown, transmit, and receive modes.

## Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY66122-11 are provided in Table 2. The DC electrical specifications, recommended operating conditions and other parameters are shown in the tables that follow.

**Table 2. SKY66122-11 Absolute Maximum Ratings<sup>1</sup>**

| Parameter  | Symbol     | Minimum | Maximum          | Units |
|--|------------|---------|------------------|-------|
| Supply voltage (no RF)                                       | Vsupply    | -0.3    | +5.5             | V     |
| Control pin (CSD, CTX) voltages                              |            | -0.3    | 3.6              | V     |
| Operating temperature  | Ta         | -40     | +85 <sup>2</sup> | °C    |
| Storage temperature  | Tstg       | -40     | +125             | °C    |
| Transmit RF input power                                      | Pin_tx_max |         | +16              | dBm   |
| Receive RF input power (ANT port)                            | Pin_rx_max |         | +15              | dBm   |
| Voltage standing wave ratio (ANT port)                       | VSWR       |         | 10:1             |       |
| Electrostatic discharge:<br>Human Body Model (HBM), Class 1C | ESD        |         | 1000             | V     |

1. Exposure to maximum rating conditions for extended periods may reduce device reliability. Exceeding any of the limits listed here may result in permanent damage to the device.
2. Tested with 30% duty cycle at POUT = 30 dBm.

**ESD Handling:** Industry-standard ESD handling precautions must be adhered to at all times to avoid damage to this device.

**Table 3. SKY66122-11 Recommended Operating Conditions**

| Parameter             | Symbol | Min | Typ | Max | Units |
|-----------------------|--------|-----|-----|-----|-------|
| Supply voltage        | Vcc    | 3.0 | 3.3 | 5.0 | V     |
| Operating temperature | Ta     | -40 | +25 | +85 | °C    |

**Table 4. SKY66122-11 DC Electrical Specifications<sup>1</sup>**

(VCC = +5.0 V, TA = +25 °C, as Measured on the SKY66122-11 Evaluation Board [De-Embedded to Device], Unless Otherwise Noted)

| Parameter  | Symbol   | Test Condition   | Min | Typ  | Max  | Units |
|--|----------|------------------|-----|------|------|-------|
| Total supply current, transmit mode <sup>2</sup> | ICC_TX30 | POUT = +30 dBm   |     | 640  |      | mA    |
|  | ICC_TX28 | POUT = +27.5 dBm |     | 500  |      | mA    |
|  | ICC_TX23 | POUT = +23.5 dBm |     | 325  |      | mA    |
| Total supply current, receive mode               | ICC_RX   |                  |     | 6.5  |      | mA    |
| Quiescent current                                | ICQ_TX   | No RF            |     | 55   |      | mA    |
| Sleep supply current                             | ICC_OFF  | No RF            |     | 0.05 | 1.00 | µA    |

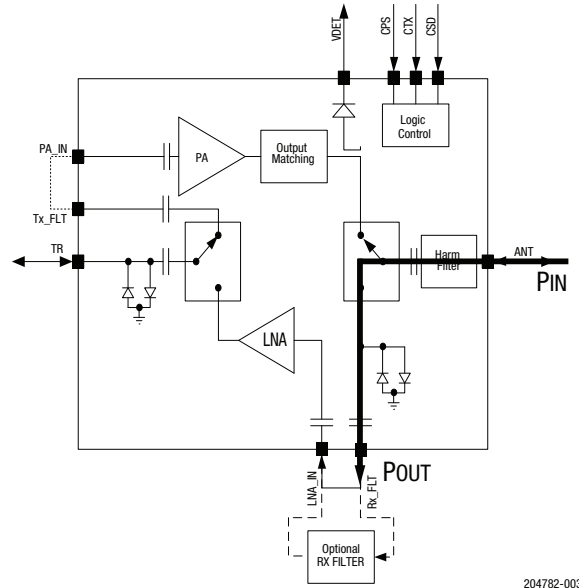
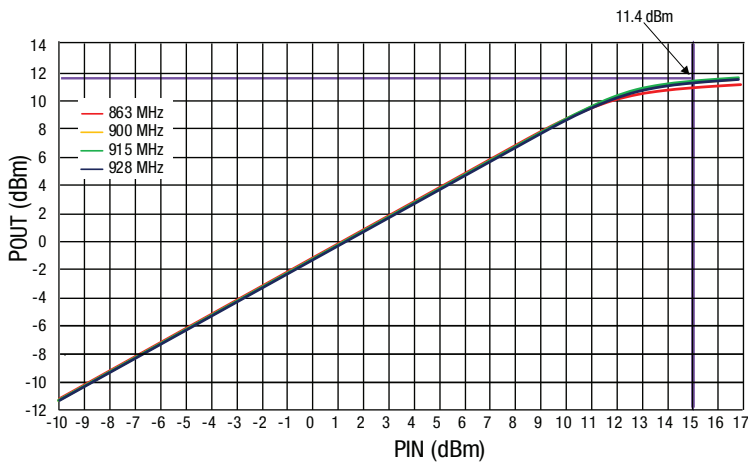
1. Performance is assured only under the conditions listed in this Table and is not invariant over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.
2. ICC\_TX28 and ICC\_TX23 are not production tested.

**Table 5. SKY66122-11 Receive Mode Electrical Specifications<sup>1</sup>**

(VCC = +3.3 V or +5.0 V, TA = +25 °C, as Measured on the Evaluation Board [De-Embedded to Device], All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

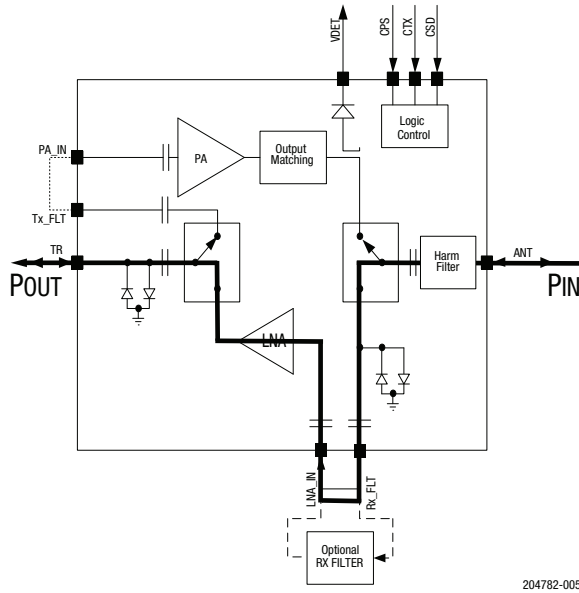
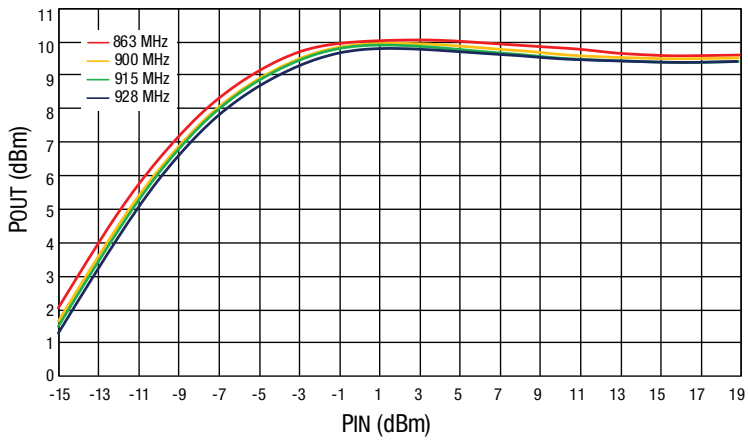
| Parameter                         | Symbol      | Test Condition                                       | Min               | Typ  | Max | Units |
|-----------------------------------|-------------|--|-------------------|------|-----|-------|
| Frequency range                   | fo          |  | 863               |      | 928 | MHz   |
| Gain                              | RX_gain     |  |                   | 16   |     | dB    |
| Noise figure                      | NF          |  |                   | 2.6  |     | dB    |
| Third order input intercept point | IIP3        |  |                   | -1.5 |     | dBm   |
| 1 dB input compression point      | IP1dB       |  |                   | -10  |     | dBm   |
| Antenna port return loss          | S11         | Measured as test setup in Figure 15                  |                   | 10   |     | dB    |
| Turn-on time                      | TON         | From 50% of CTX edge to 90% of final RF output power |                   |      | 3   | us    |
| Turn-off time                     | TOFF        | From 50% of CTX edge to 10% of final RF output power |                   |      | 1   | us    |
| Max power RX_FLT                  | PMAX_RX_FLT |  | Refer to Figure 3 |      |     |       |
| Max power T/R RX mode             | PMAX_TR_RX  |  | Refer to Figure 4 |      |     |       |

1. Performance is assured only under the conditions listed in this Table and is not invariant over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.



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Figure 3. P<sub>IN</sub> and P<sub>OUT</sub> at RX\_FLT Port



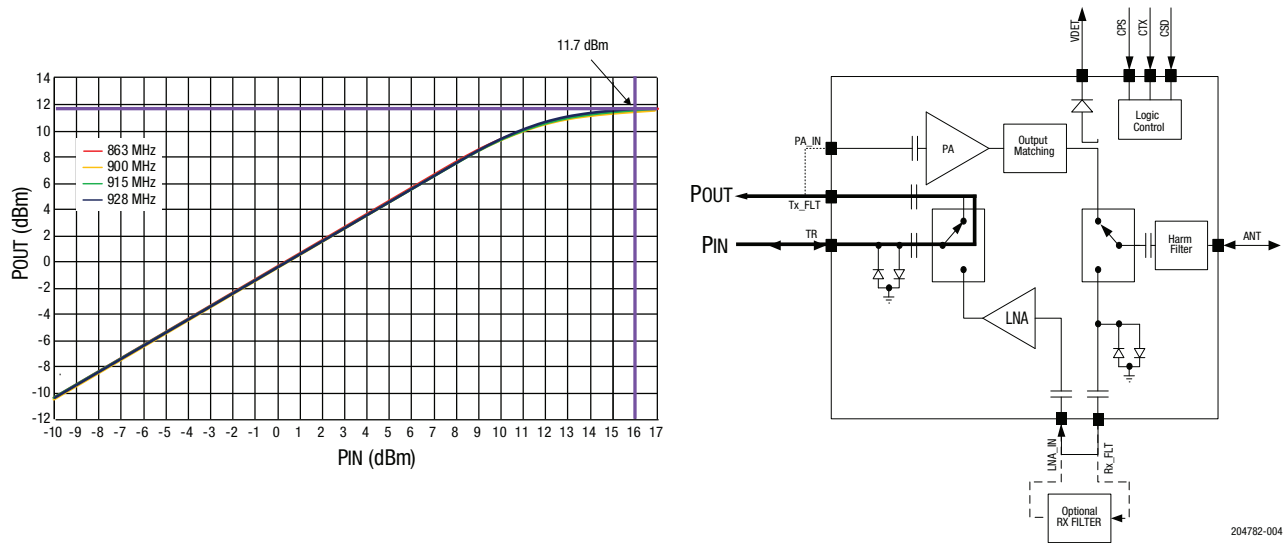
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Figure 4. P<sub>IN</sub> and P<sub>OUT</sub> at T/R Port in Rx Mode

**Table 6. SKY66122-11 Transmit Mode Electrical Specifications for 3.3 V Operation<sup>1</sup>**  
 (VCC = +3.3 V, TA = +25 °C, POUT = +27 dBm CW, as Measured on the Evaluation Board [De-Embedded to Device],  
 All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

| Parameter                                | Symbol      | Test Condition  | Min  | Typ                      | Max | Units                    |
|--|-------------|---|--|--------------------------|-----|--------------------------|
| Frequency range                          | fo          |   | 863  |                          | 928 | MHz                      |
| RMS output power (ANT port) <sup>2</sup> | POUT        | Saturated (FSK mode) Option 1<br>MCS0, -10 dB EVM<br>Option 1 MCS3, -10 dB EVM<br>Option 3 MCS6, -19 dB EVM |  | +27<br>+26<br>+27<br>+22 |     | dBm<br>dBm<br>dBm<br>dBm |
| Small signal gain                        | S21         | 863 to 928 MHz  |  | 30                       | 33  | dB                       |
| Output return loss                       | S22         | Measured as test setup in Figure 15   |  | 9                        |     | dB                       |
| 2nd harmonic                             | 2fo         | Measured as test setup in Figure 15   |  |                          | -22 | dBc                      |
| 3rd to 10th harmonic                     | 3fo to 10fo |   |  |                          | -69 | dBc                      |
| Power detection range                    | Vdet_range  |   | +10  |                          | +27 | dBm                      |
| Turn-on time                             | ton         | From 50% of CTX edge to 90% of final RF output power  |  | 1                        |     | us                       |
| Turn-off time                            | toff        | From 50% of CTX edge to 10% of final RF output power  |  |                          | 1   | us                       |
| Stability                                | Stab        | DC to 20 GHz, CW, POUT = +27 dBm into 50 ohms, load VSWR = 6:1  | All non-harmonically related outputs < -42 dBm |                          |     |                          |
| Ruggedness                               | RU          | CW, POUT = +27 dBm into 50 ohms load, VSWR = 10:1   | No permanent damage                            |                          |     |                          |
| Max power TX_FLT                         | PMAX_TX_FLT |   | Refer to Figure 5                              |                          |     |                          |

1. Performance is assured only under the conditions listed in this Table and is not invariant over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.
2. POUT maximum = 28 dBm.



**Figure 5. PIN and POUT at TX\_FLT Port**

**Table 7. SKY66122-11 Transmit Mode Electrical Specifications for 5.0 V Operation<sup>1</sup>**  
 (VCC = +5.0 V, TA = +25 °C, POUT = +30 dBm CW, as Measured on the Evaluation Board [De-Embedded to Device],  
 All Unused Ports Terminated with 50 ohms, Unless Otherwise Noted)

| Parameter                   | Symbol      | Test Condition   | Min  | Typ                      | Max | Units                    |
|-----------------------------|-------------|--|--|--------------------------|-----|--------------------------|
| Frequency range             | fo          |  | 863  |                          | 928 | MHz                      |
| RMS output power (ANT port) | POUT        | Saturated (FSK mode) Option 1 MCS0, -10 dB EVM<br>Option 1 MCS3, -10 dB EVM<br>Option 3 MCS6, -19 dB EVM |  | +30<br>+30<br>+30<br>+25 |     | dBm<br>dBm<br>dBm<br>dBm |
| Small signal gain           | S21         | 863 to 928 MHz   |  | 33                       |     | dB                       |
| Output return loss          | S22         | Measured as test setup in Figure 15  |  | 9                        |     | dB                       |
| 2nd harmonic                | 2fo         | Measured as test setup in Figure 15  |  |                          | -22 | dBc                      |
| 3rd to 10th harmonic        | 3fo to 10fo |  |  |                          | -72 | dBc                      |
| Power detection range       | Vdet_range  |  | +10  |                          | +30 | dBm                      |
| Turn-on time                | ton         | From 50% of CTX edge to 90% of final RF output power   |  | 1                        |     | us                       |
| Turn-off time               | toff        | From 50% of CTX edge to 10% of final RF output power   |  |                          | 1   | us                       |
| Stability                   | Stab        | DC to 20 GHz, CW, POUT = +30 dBm into 50 ohms, load VSWR = 6:1   | All non-harmonically related outputs < -42 dBm |                          |     |                          |
| Ruggedness                  | RU          | CW, POUT = +30 dBm into 50 ohms load, VSWR = 10:1  | No permanent damage                            |                          |     |                          |
| Max power TX_FLT            | PMAX_TX_FLT |  | Refer to Figure 5                              |                          |     |                          |

1. Performance is assured only under the conditions listed in this Table and is not invariant over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.

**Table 8. SKY66122-11 Transmit Mode Electrical Specifications, Control Logic Characteristics<sup>1</sup>**  
 (TA = +25 °C, as Measured on the SKY66122-11 Evaluation Board, Unless Otherwise Noted)

| Parameter                      | Symbol     | Test Condition | Min      | Typ | Max        | Units    |
|--------------------------------|------------|----------------|----------|-----|------------|----------|
| Control voltage<br>High<br>Low | Vih<br>Vil |                | 1.6<br>0 |     | 3.6<br>0.3 | V<br>V   |
| Input current<br>High<br>Low   | Iih<br>Iil |                |          |     | 1<br>1     | μA<br>μA |

1. Performance is assured only under the conditions listed in this Table and is not invariant over the full operating or storage temperature ranges. Operation at elevated temperatures may reduce reliability of the device.

**Table 9. SKY66122-11 Mode Control Logic<sup>1</sup>**

| Mode | Description    | CSD | CTX (FEA) | CPS (FEB) | Notes  |
|------|----------------|-----|-----------|-----------|--|
| 0    | Shutdown/sleep | 1   | 0         | 0         |  |
| 1    | RX LNA         | 1   | 0         | 1         |  |
| 2    | TX             | 1   | 1         | 1         |  |
| 3    | Unsupported    | 1   | 1         | 0         |  |
| 4    | Shutdown/sleep | 0   | 0         | 0         | Only condition where 1 μA of leakage current is guaranteed |
| 5    | Shutdown/sleep | 0   | 0         | 1         |  |
| 6    | Shutdown/sleep | 0   | 1         | 1         |  |
| 7    | Shutdown/sleep | 0   | 1         | 0         |  |

1. Make sure each control logic has the proper pull-up and pull-down in the application circuit.



### Typical Performance Characteristics

(Vcc0 = Vcc1 = 3.3 V, f = 915 MHz, TA = +25 °C, Unless Otherwise Noted)

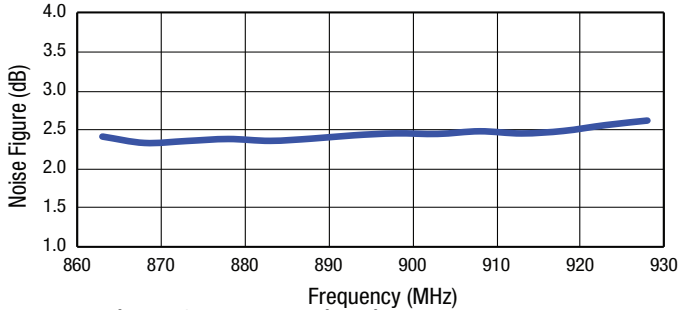


Figure 6. RX LNA Noise Figure vs Frequency

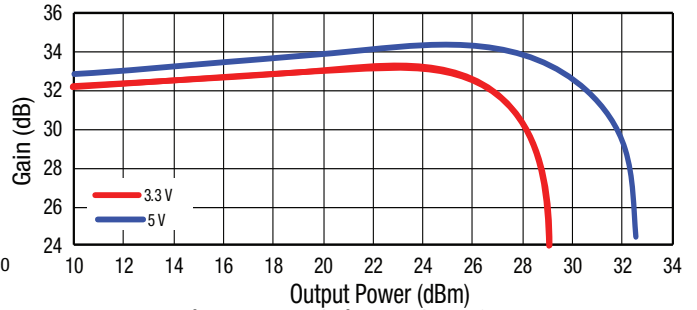


Figure 7. TX Gain vs POUT, CW

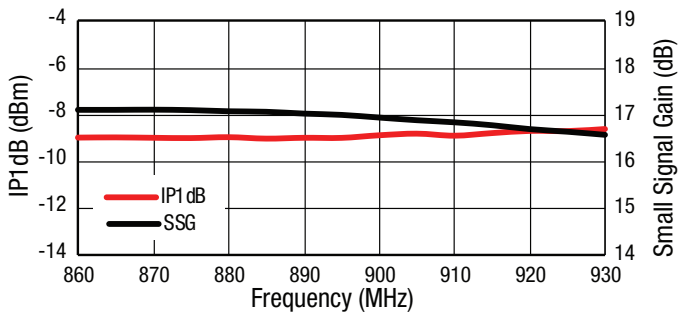


Figure 8. RX IP1dB and Small Signal Gain vs Frequency

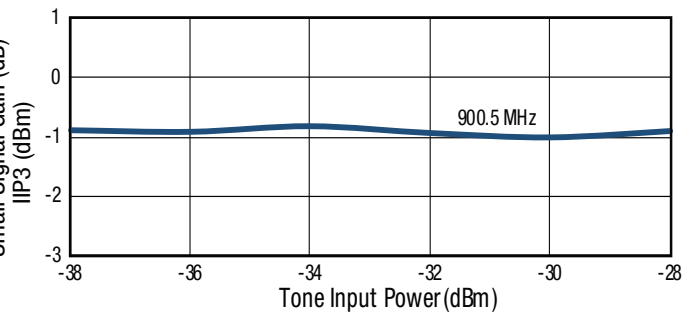


Figure 9. RX IIP3 vs Input Power

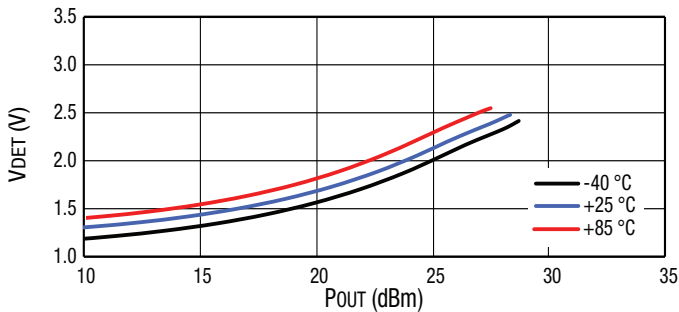


Figure 10. VDET vs POUT over Temp, VCC = 3.3 V

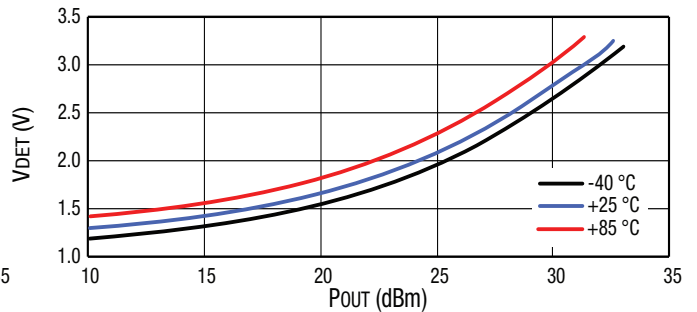


Figure 11. VDET vs POUT over Temp, VCC = 5.0 V

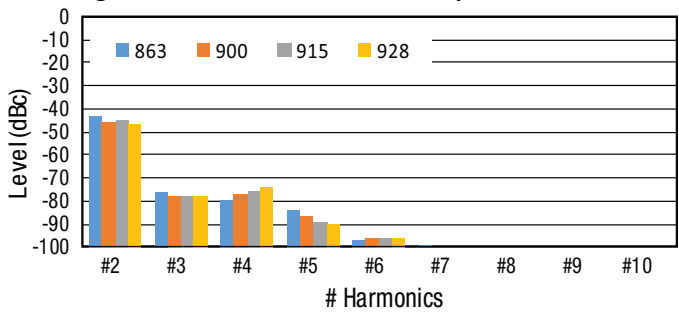


Figure 12. Harmonics @ POUT = +30 dBm, VCC = 5.0 V

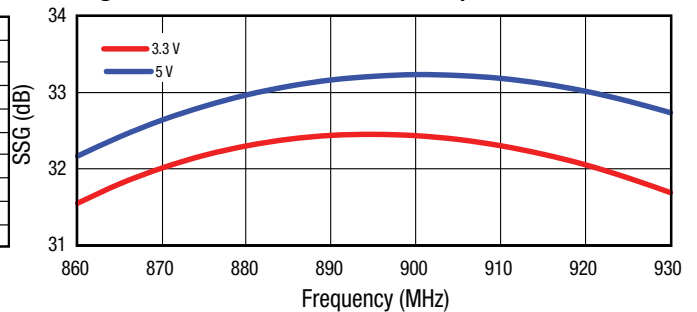


Figure 13. SSG vs Frequency

## Evaluation Board Description

The SKY66122-11 Evaluation Board is used to test the performance of the SKY66122-11 front-end module. The Evaluation Board is shown in Figure 14. An Evaluation Board schematic diagram is provided in Figure 15. Layer detail information is provided in Figure 16. The Evaluation Board Bill of Materials is listed in Table 10.

## PCB Recommendations

Top layer: Plan to add the footprint for a shield case over the RF section.

Bottom layer: Lay out as much as possible for minimum traces on the bottom. Having a solid ground plane under the shield case will complete the shielding.

Avoid using thermal relief pads for ground connections of components and the shield case. Always place vias close to each shunt connection.

Spread ground vias equally in a manner that stitches the grounds together.

Metal Layer 1 = RF traces (microstripes or coplanar) + control lines. Core thickness between top RF layer and ground plane is critical.

Metal Layer 2 = Solid ground plane. No trace routings. Metal Layer 3 = Control lines + VCC traces (no VCC plane)

Metal Layer 4 = Solid ground plane under the shield case area.

Pour copper on each layer connected to the ground plane. Use VCC traces in a star distribution pattern.



Figure 14. SKY66122-11 Evaluation Board

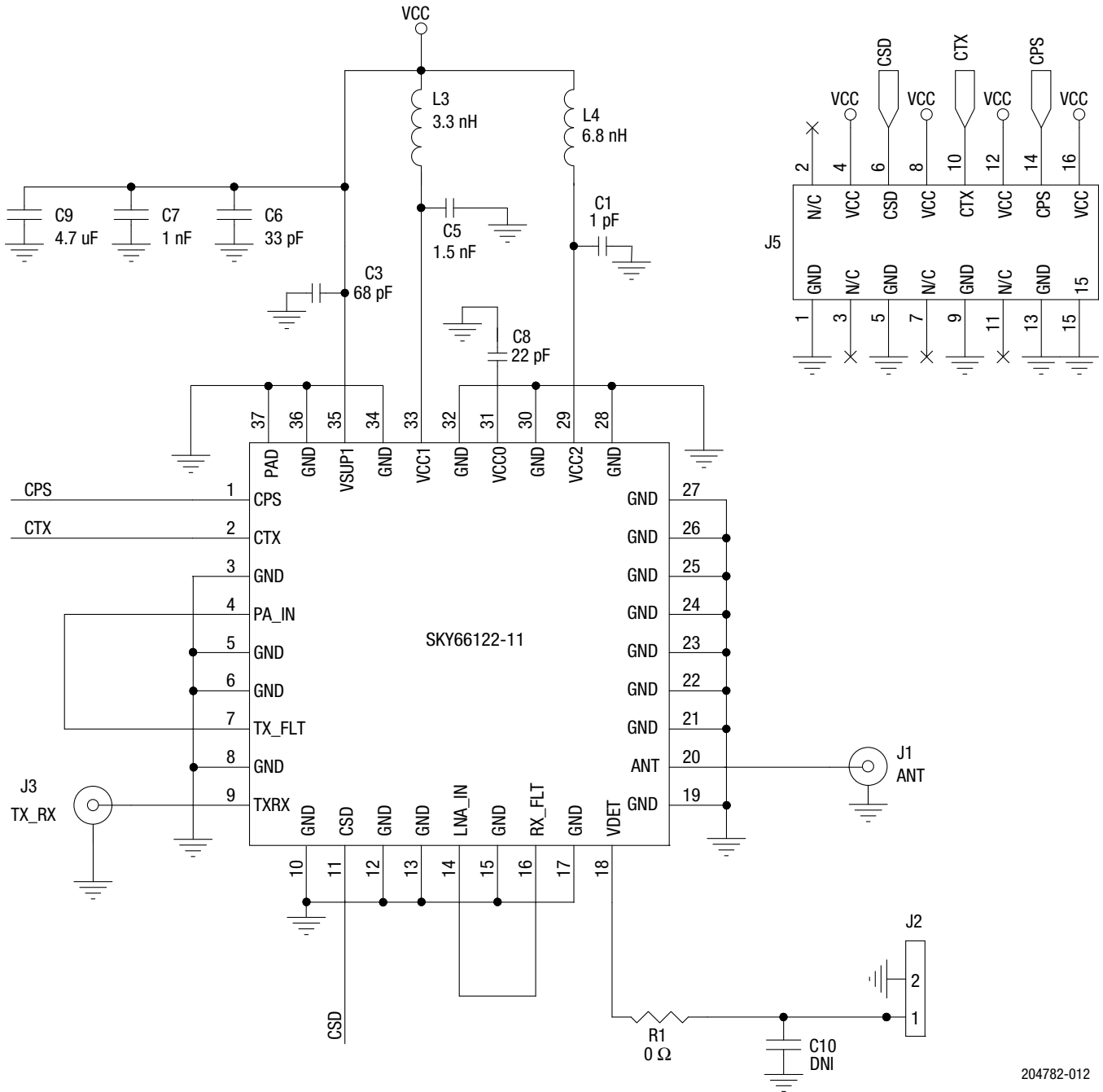
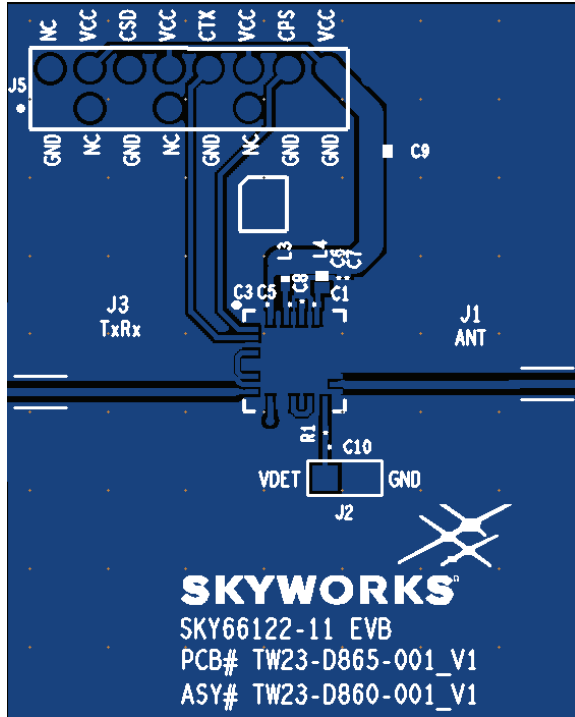
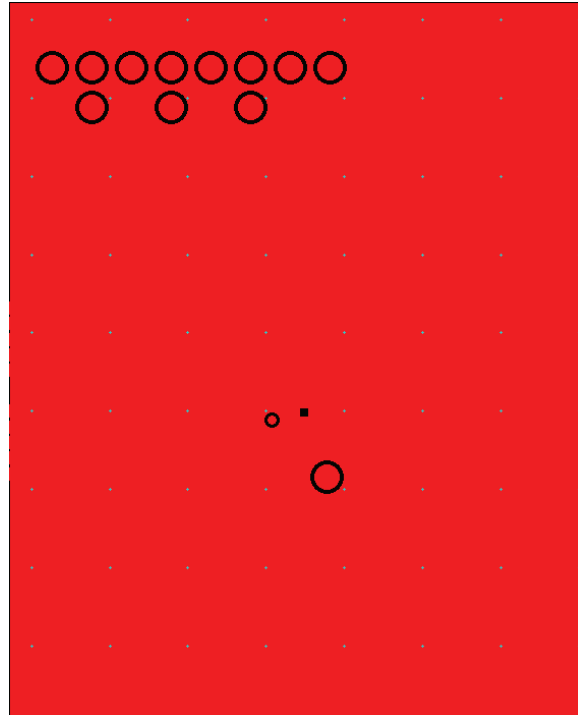


Figure 15. SKY66122-11 Evaluation Board Schematic



Top Layer



Ground Plane

Figure 16. SKY66122-11 Evaluation Board Layer Details

Table 10. SKY66122-11 Evaluation Board Bill of Materials

| Component | Value            | Manufacturer            | Mfr Part Number   | Size       | Description   |
|-----------|------------------|-------------------------|-------------------|------------|---|
| C5        | 1.5 nF           | Murata                  | GRM033R71C152JA01 | 0201       | Multilayer ceramic                                    |
| C7        | 1 nF             | Murata                  | GRM033R71C102JD01 | 0201       | Multilayer ceramic                                    |
| C1        | 1 pF             | Murata                  | GRM0335C1E1R0BD01 | 0201       | Multilayer ceramic                                    |
| L3        | 3.3 nH           | Coilcraft               | 0402CS-3N3XJL     | 0402       |   |
| C9        | 4.7 uF           | Murata                  | GRM188R60J475KE19 | 0603       | Multilayer ceramic                                    |
| L4        | 6.8 nH           | Coilcraft               | 0603CS-6N8XJL     | 0603       |   |
| J2        | 1 x 2            | Samtec                  |                   |            | Header pin  |
| J5        | 8 x 2            | Samtec                  |                   |            | Header pin  |
| C8        | 22 pF            | Murata                  | GRM0335C1E220JD01 | 0201       | Multilayer ceramic                                    |
| C6        | 33 pF            | Murata                  | GRM0335C1E330JD01 | 0201       | Multilayer ceramic                                    |
| C3        | 68 pF            | Murata                  | GRM0335C1E680JD01 | 0201       | Multilayer ceramic                                    |
| C10       | DNI              |                         |                   |            |   |
| R1        | 0 Ω              |                         |                   | 0201       | Any supplier  |
| U1        | SKY66122-11      | Skyworks Solutions Inc. | SKY66122-11       | MCM600X600 |   |
| PCB1      | TW23-D865-001_V1 | Skyworks Solutions Inc. | TW23-D865-001_V1  |            | PCB   |
| J1, J3    | SMA              | Johnson Components      | 142-0701-851      | End launch | SMA end launch straight jack receptacle - tab contact |

### Package Dimensions

Typical part markings are shown in Figure 17. The PCB layout footprint is shown in Figure 18. Package dimensions for the SKY66122-11 are shown in Figure 19, and tape and reel dimensions are provided in Figure 20.

### 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 SKY66122-11 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 & 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.

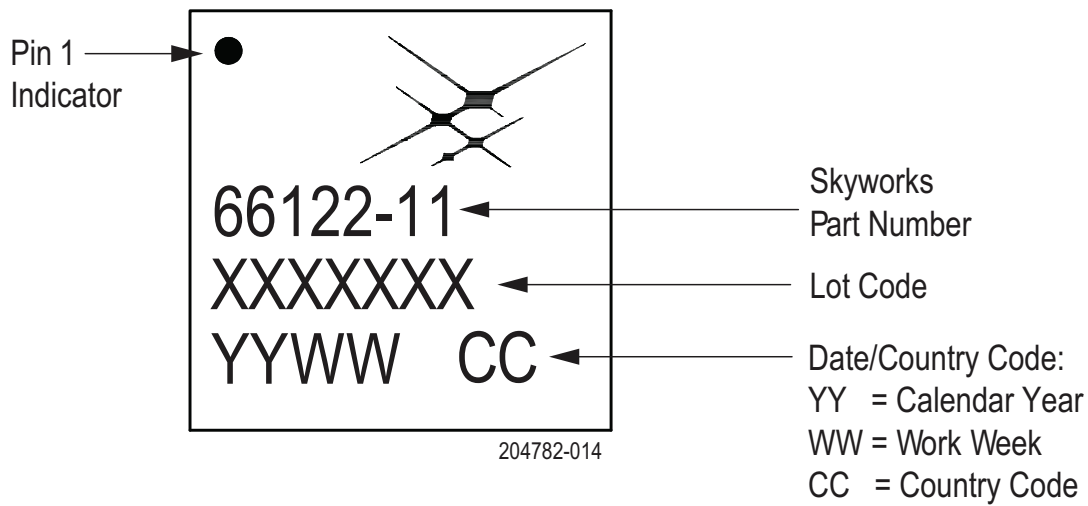
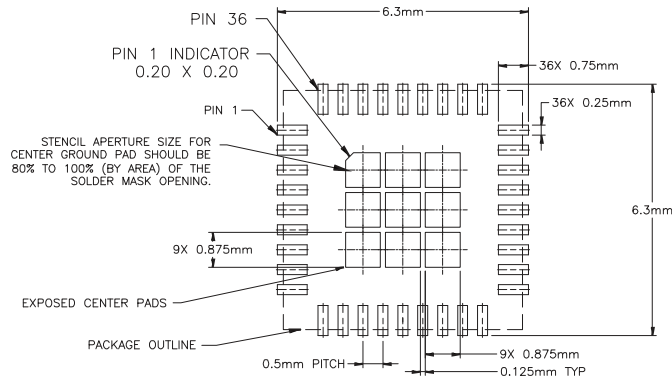
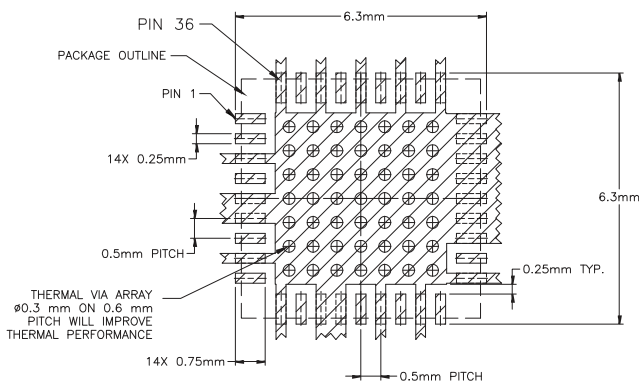


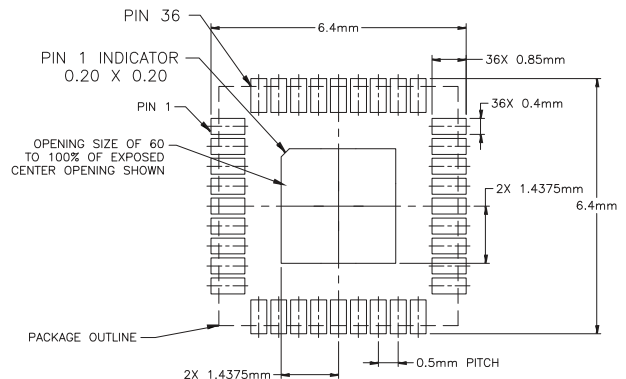
Figure 17. SKY66122-11 Typical Part Marking



STENCIL APERTURE  
Top View



METALLIZATION  
Top View

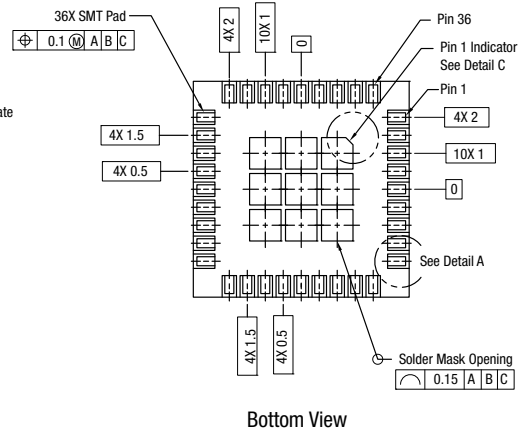
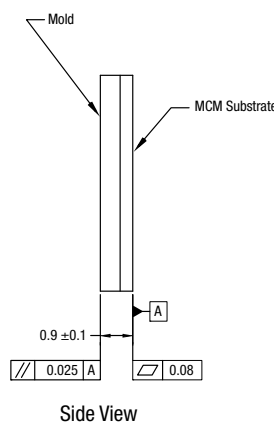
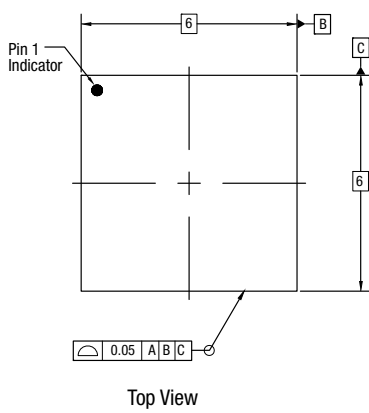


SOLDER MASK OPENING  
Top View

NOTE: THERMAL VIAS SHOULD BE RESIN FILLED AND CAPPED IN ACCORDANCE WITH IPC-4761 TYPE VII VIAS. 30-35UM Cu THICKNESS IS RECOMMENDED.

204782-016

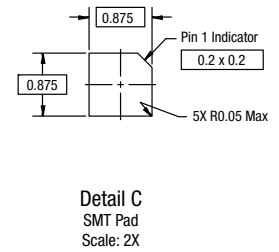
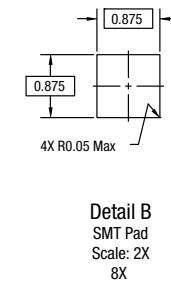
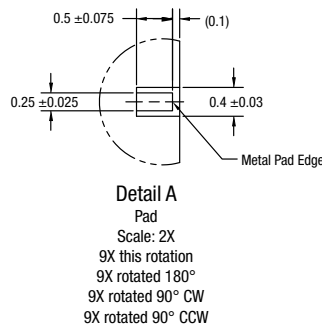
Figure 18. SKY66122-11 PCB Layout Footprint



Notes:

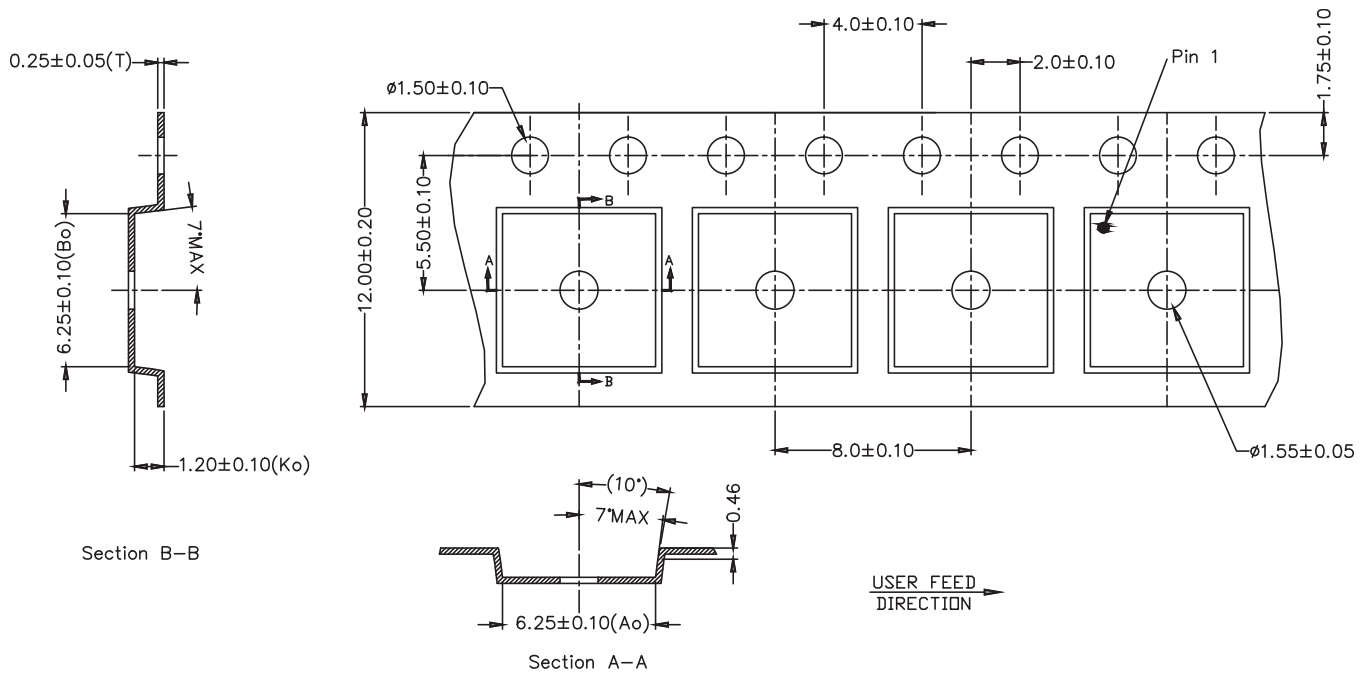
1. Dimensions and tolerances in accordance with ASME Y14.5M-1994.
2. Dimensions are in millimeters (unless otherwise specified).
3. Tolerances on:
 

|              |        |
|--------------|--------|
| Decimals     | Angles |
| .XX = ±.05   | ±.30°  |
| .XXX = ±.025 |        |



204782-015

Figure 19. SKY66122-11 Package Dimensions



**NOTES:**

10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE :  $\pm 0.20\text{mm}$   
 Ao & Bo MEASURED ON PLANE 0.30mm ABOVE THE BOTTOM OF THE POCKET.  
 ALL DIMENSIONS ARE IN MILLIMETERS.

204782-020

**Figure 20. SKY66122-11 Tape and Reel Dimensions**



## Ordering Information

| Part Number | Part Description   | Evaluation Board Part Number |
|-------------|--|------------------------------|
| SKY66122-11 | 863 to 928 MHz Front-End Module for Wi-SUN® Applications | SKY66122-11EK1               |

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