

## PRELIMINARY DATA SHEET

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

## Applications

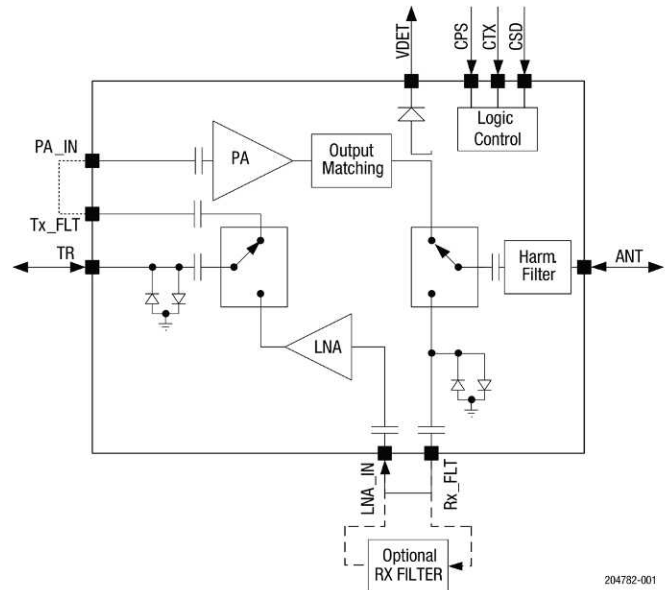
- Range extender
- Smart meters
- In-home appliances
- Smart thermostats

## 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  $\Omega$  RF interface
- Supply voltage: 3.0 V to 5.0 V
- Sleep mode current: < 1  $\mu$ A
- Small MCM (6 x 6 x 0.9 mm [nominal]) package (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. SKY66122-11 Functional Block Diagram**

## Description

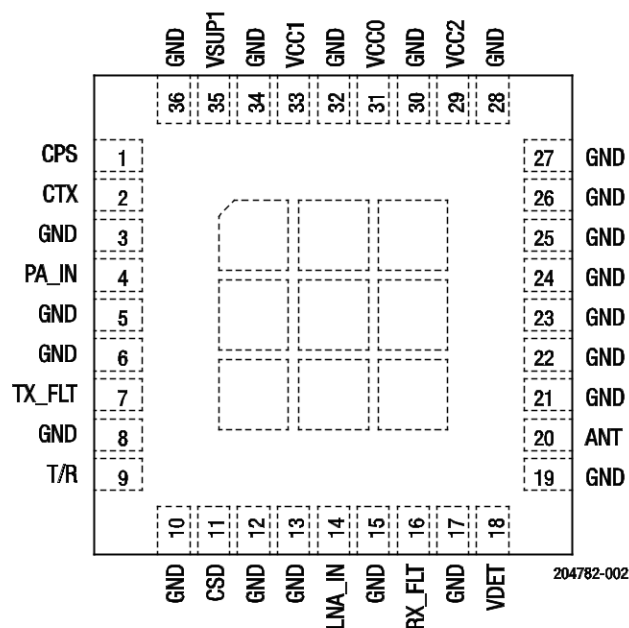
The SKY66122-11 is a high-performance, highly integrated RF front-end module (FEM) designed for high-power Industrial, Scientific, Medical (ISM) band, Wi-SUN, and other IOT applications operating in the 863 to 928 MHz frequency range.

The SKY66122-11 is designed for ease of use and maximum flexibility with fully matched, 50  $\Omega$  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.



**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	Ground	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	Power 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 recommended operating conditions are specified in Table 3 and electrical specifications are provided in Tables 4 through 8.

The state of the SKY66122-11 is determined by the logic provided in Table 9. Typical performance characteristics are shown in Figures 3 through 10.

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

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage (no RF)	V <sub>SUPPLY</sub>	-0.3	+5.5	V
Control pin (CSD, CTX) voltages		-0.3	3.6	V
Operating temperature	T <sub>A</sub>	-40	+85 <sup>2</sup>	°C
Storage temperature	T <sub>STG</sub>	-40	+125	°C
Transmit RF input power	P <sub>IN_TX_MAX</sub>		+16	dBm
Receive RF input power (ANT port)	P <sub>IN_RX_MAX</sub>		+15	dBm
Voltage standing wave ratio (ANT port)	VSWR		10:1	
Electrostatic discharge: Human Body Model (HBM), Class 1C	ESD		TBD	V

<sup>1</sup> 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.

<sup>2</sup> Tested with 30% duty cycle at P<sub>OUT</sub> = 30 dBm.

**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. SKY66122-11 Recommended Operating Conditions**

Parameter	Symbol	Min	Typ	Max	Units
Supply voltage	V <sub>CC</sub>	3.0	3.3	5.0	V
Operating temperature	T <sub>A</sub>	-40	+25	+85	°C

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

(V<sub>CC</sub> = +5.0 V, T<sub>A</sub> = +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>	I <sub>CC_TX30</sub> I <sub>CC_TX28</sub> I <sub>CC_TX23</sub>	P <sub>OUT</sub> = +30 dBm P <sub>OUT</sub> = +27.5 dBm P <sub>OUT</sub> = +23.5 dBm		640 500 325		mA mA mA
Total supply current, receive mode	I <sub>CC_RX</sub>			6.5		mA
Quiescent current	I <sub>CC_TX</sub>	No RF		55		mA
Sleep supply current	I <sub>CC_OFF</sub>	No RF		0.05	1.00	μA

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.

<sup>2</sup> I<sub>CC\_TX28</sub> and I<sub>CC\_TX23</sub> are not production tested.

**Table 5. SKY66122-11 Receive Mode Electrical Specifications<sup>1</sup>****(V<sub>CC</sub> = +3.3 V or +5.0 V, T<sub>A</sub> = +25 °C, 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	f <sub>o</sub>		863		928	MHz
Gain	RX_GAIN			16		dB
Noise figure <sup>2</sup>	NF			2.6		dB
Third order input intercept point <sup>2</sup>	IIP3			-1.5		dBm
1 dB input compression point	IP1dB			-10		dBm
Antenna port return loss	IS11I	Measured as test setup in Figure 12		10		dB
Turn-on time <sup>2</sup>	t <sub>ON</sub>	From 50% of CTX edge to 90% of final RF output power			3	us
Turn-off time <sup>2</sup>	t <sub>OFF</sub>	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			

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.<sup>2</sup> Not production tested.

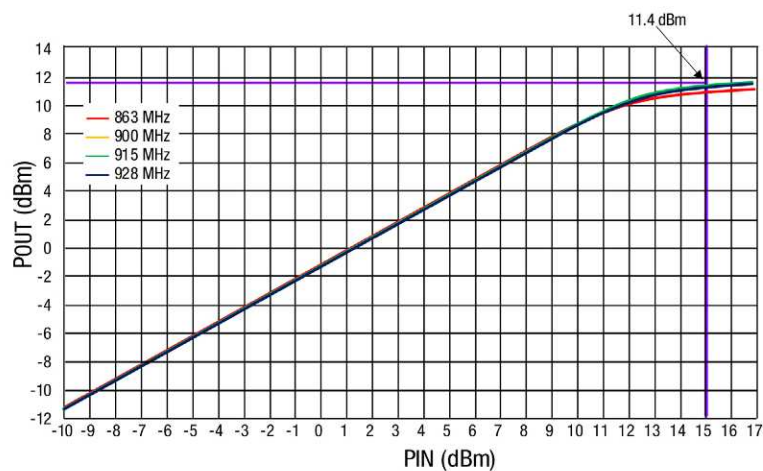


Figure 3. PIN and POUT at RX\_FLT Port

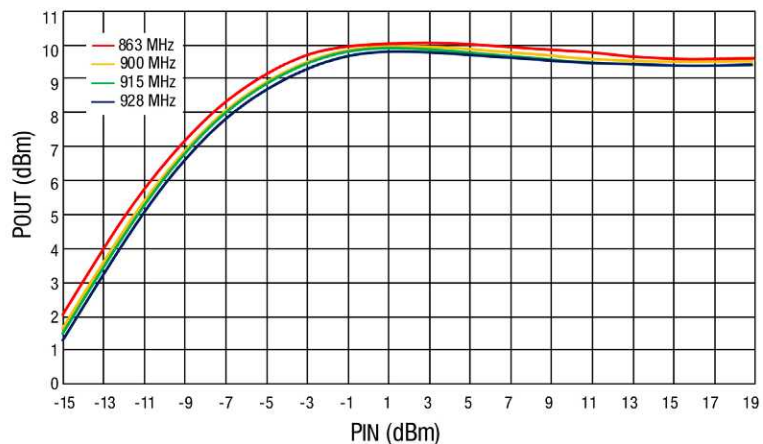
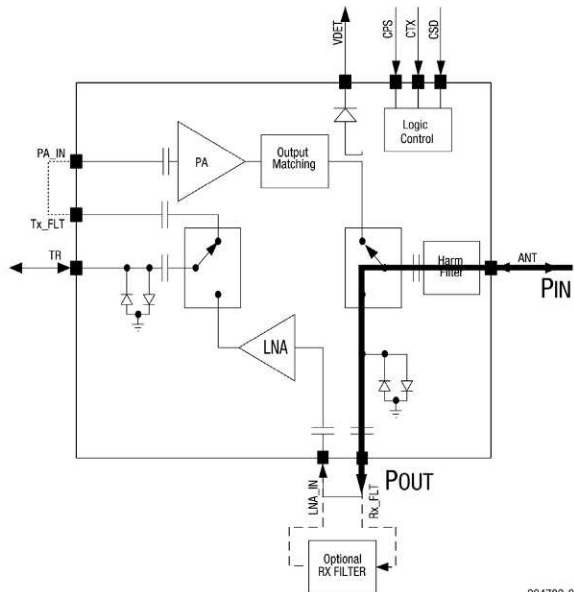
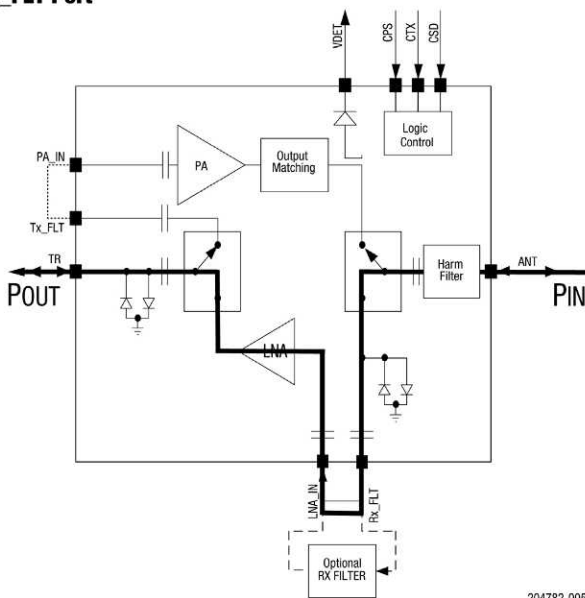


Figure 4. PIN and POUT at T/R Port in Rx Mode



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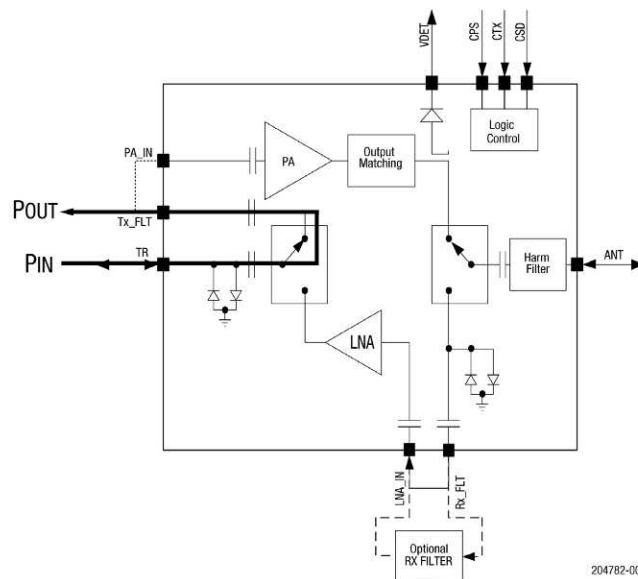
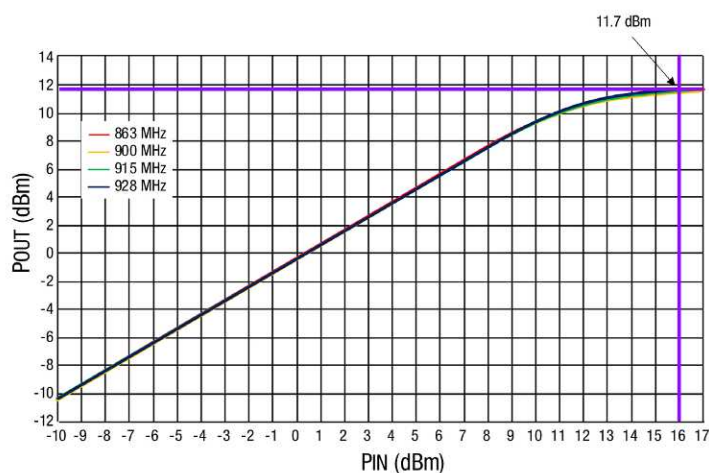


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**Table 6. SKY66122-11 Transmit Mode Electrical Specifications for 3.3 V Operation<sup>1</sup>****(V<sub>CC</sub> = +3.3 V, T<sub>A</sub> = +25 °C, P<sub>OUT</sub> = +27 dBm CW, as Measured on the Evaluation Board [De-Embedded to Device], All Unused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

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Frequency range	f <sub>o</sub>		863		928	MHz
RMS output power (ANT port) <sup>2</sup>	P <sub>OUT</sub> <sup>5</sup>	Saturated (FSK mode) Option 1 MCS0, -10 dB EVM Option 1 MCS3, -10 dB EVM Option 3 MCS6, -19 dB EVM		+27 +26 +27 +22		dBm dBm dBm dBm
Small signal gain	S <sub>21</sub>	863 to 928 MHz		30	33	dB
Output return loss	S <sub>22</sub>	Measured as test setup in Figure 12		9		dB
2 <sup>nd</sup> harmonic	2f <sub>o</sub>	Measured as test setup in Figure 12			-22	dBc
3 <sup>rd</sup> to 10 <sup>th</sup> harmonic <sup>3</sup>	3f <sub>o</sub> to 10f <sub>o</sub>				-69	dBc
Power detection range	V <sub>DET_RANGE</sub>		+10		+27	dBm
Turn-on time <sup>4</sup>	t <sub>ON</sub>	From 50% of CTX edge to 90% of final RF output power		1		us
Turn-off time <sup>4</sup>	t <sub>OFF</sub>	From 50% of CTX edge to 10% of final RF output power			1	us
Stability <sup>4</sup>	Stab	DC to 20 GHz, CW, P <sub>OUT</sub> = +27 dBm into 50 ohms, load VSWR = 6:1	All non-harmonically related outputs < -42 dBm			
Ruggedness <sup>4</sup>	RU	CW, P <sub>OUT</sub> = +27 dBm into 50 ohms load, VSWR = 10:1	No permanent damage			
Max power TX_FLT	P <sub>MAX_TX_FLT</sub>		Refer to Figure 5			

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.<sup>2</sup> Production tested at V<sub>CC</sub> = 3.3 V only.<sup>3</sup> Only the 2nd to 5th harmonics are production tested. The 6th to 10th harmonics are characterized only.<sup>4</sup> Not production tested.<sup>5</sup> P<sub>OUT</sub> maximum = 28 dBm.

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**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>****(V<sub>CC</sub> = +5.0 V, T<sub>A</sub> = +25 °C, P<sub>OUT</sub> = +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) <sup>2</sup>	P <sub>OUT</sub>	Saturated (FSK mode) Option 1 MCS0, -10 dB EVM Option 1 MCS3, -10 dB EVM Option 3 MCS6, -19 dB EVM		+30 +30 +30 +25		dBm dBm dBm dBm
Small signal gain	S <sub>21</sub>	863 to 928 MHz		33		dB
Output return loss	S <sub>22</sub>	Measured as test setup in Figure 12		9		dB
2 <sup>nd</sup> harmonic	2fo	Measured as test setup in Figure 12			-22	dBc
3 <sup>rd</sup> to 10 <sup>th</sup> harmonic <sup>3</sup>	3fo to 10fo				-72	dBc
Power detection range	V <sub>DET_RANGE</sub>		+10		+30	dBm
Turn-on time <sup>4</sup>	t <sub>ON</sub>	From 50% of CTX edge to 90% of final RF output power		1		us
Turn-off time <sup>4</sup>	t <sub>OFF</sub>	From 50% of CTX edge to 10% of final RF output power			1	us
Stability <sup>4</sup>	Stab	DC to 20 GHz, CW, P <sub>OUT</sub> = +30 dBm into 50 ohms, load VSWR = 6:1	All non-harmonically related outputs < -42 dBm			
Ruggedness <sup>4</sup>	RU	CW, P <sub>OUT</sub> = +30 dBm into 50 ohms load, VSWR = 10:1	No permanent damage			
Max power TX_FLT	P <sub>MAX_TX_FLT</sub>		Refer to Figure 5			

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.<sup>2</sup> Production tested at V<sub>CC</sub> = 5.0 V only.<sup>3</sup> Only the 2nd to 5th harmonics are production tested. The 6th to 10th harmonics are characterized only.<sup>4</sup> Not production tested.

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

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Control voltage: <sup>2</sup>						
High	V <sub>IH</sub>		1.6		3.6	V
Low	V <sub>IL</sub>		0		0.3	V
Input current: <sup>2</sup>						
High	I <sub>IH</sub>				1	μA
Low	I <sub>IL</sub>				1	μA

<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.

<sup>2</sup> Not production tested.

**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 uA of leakage current is guaranteed
5	Shutdown/sleep	0	0	1	
6	Shutdown/sleep	0	1	1	
7	Shutdown/sleep	0	1	0	

<sup>1</sup> 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, T<sub>A</sub> = +25 °C, Unless Otherwise Noted)

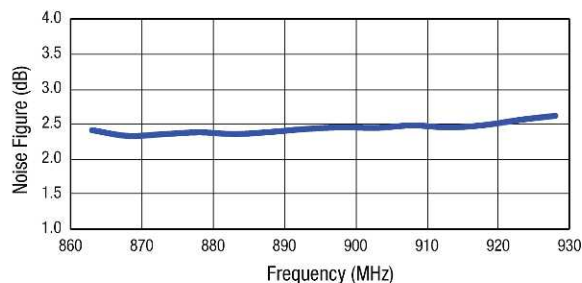


Figure 6. RX LNA Noise Figure vs Frequency

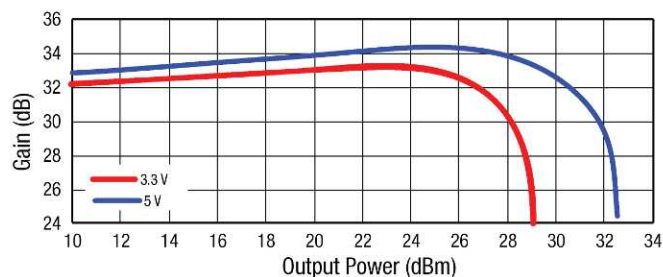


Figure 7. TX Gain vs Pout, CW

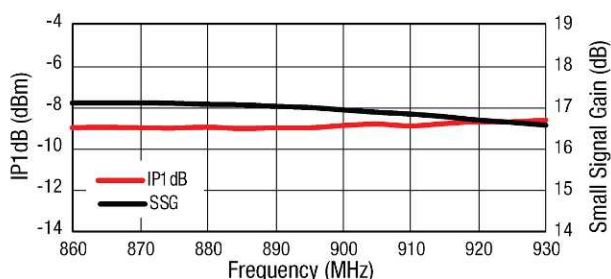


Figure 8. RX IP1dB and Small Signal Gain vs Frequency

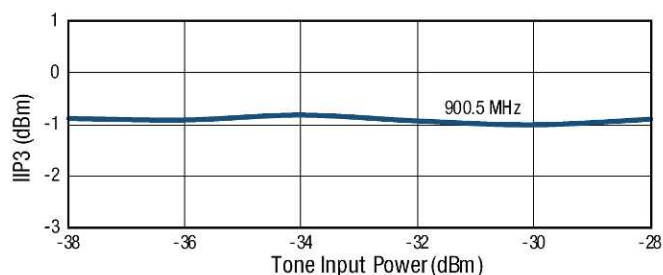


Figure 9. RX IIP3 vs Input Power

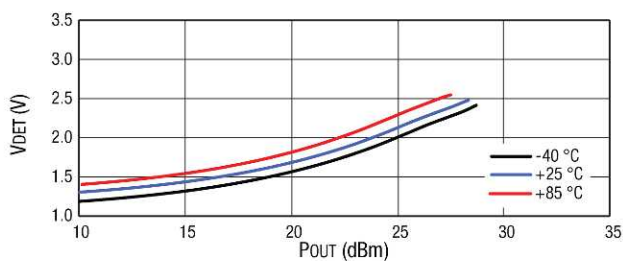


Figure 10. VDET vs Pout over Temp, VCC = 3.3 V

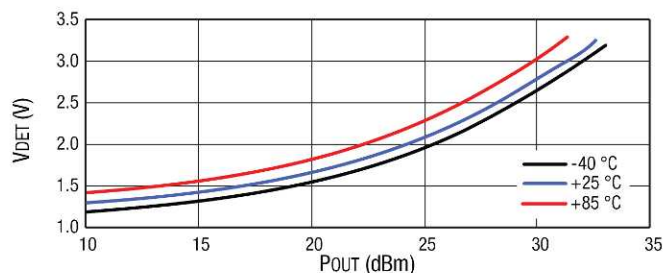


Figure 11. VDET vs Pout over Temp, VCC = 5.0 V

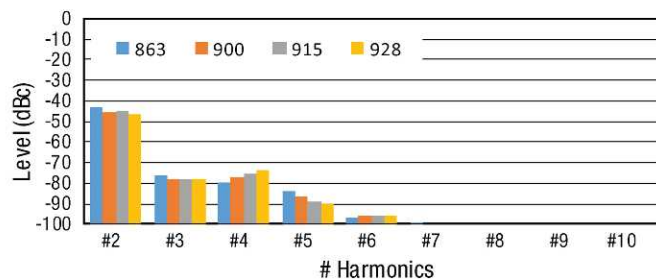


Figure 12. Harmonics @ Pout = +30 dBm, VCC = 5.0 V

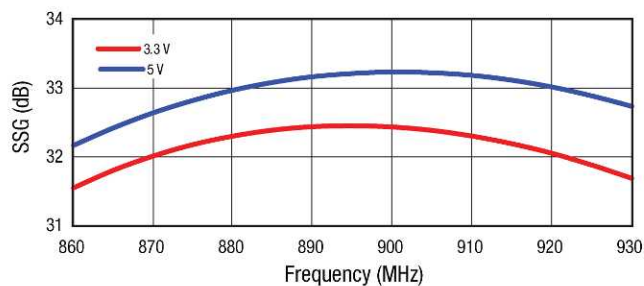


Figure 13. SSG vs Frequency

## 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.

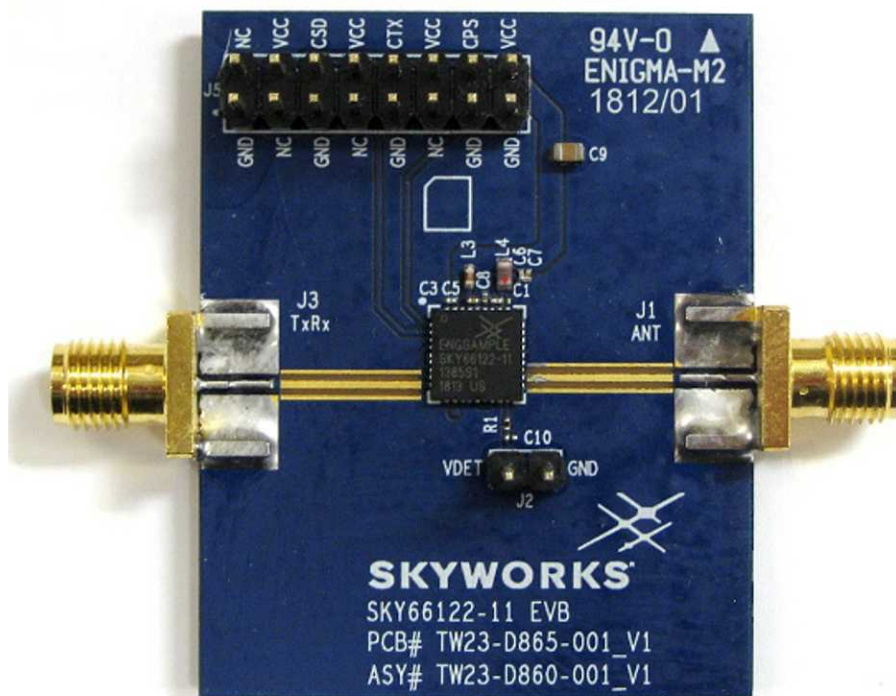
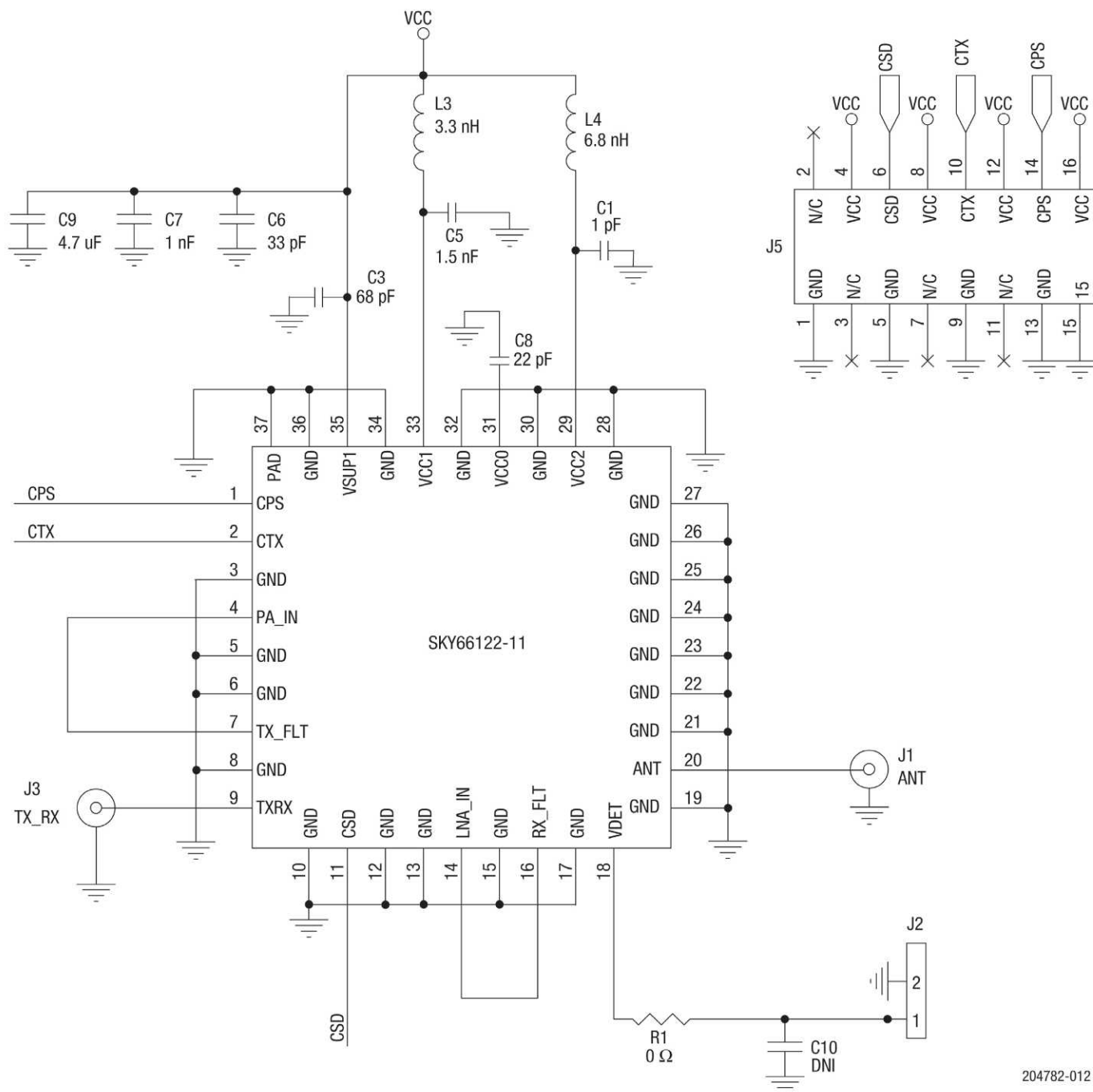
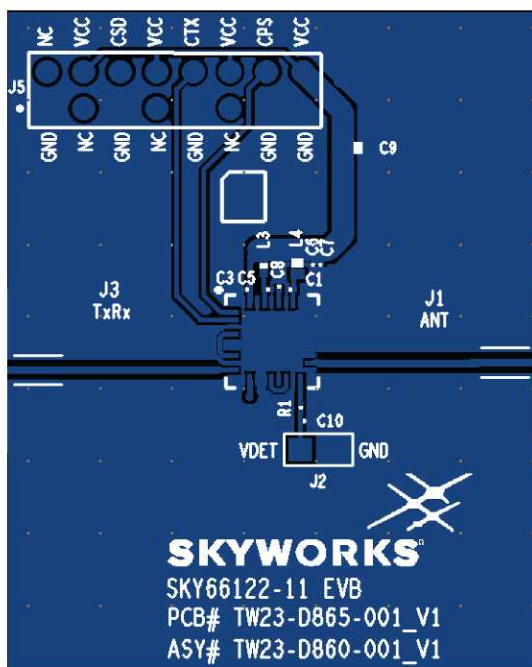


Figure 14. SKY66122-11 Evaluation Board

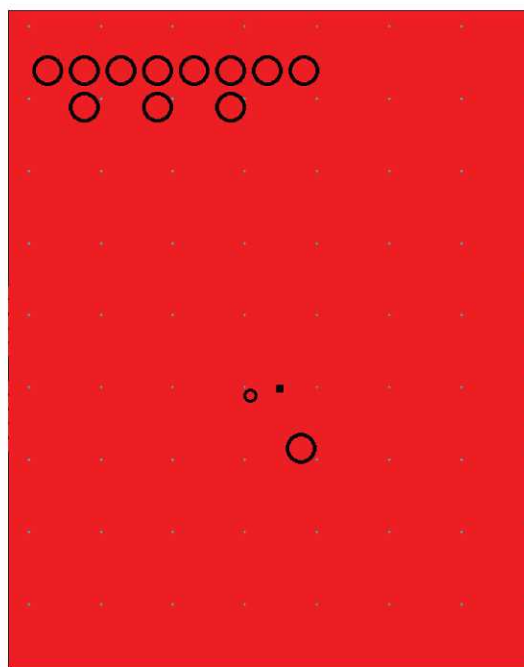


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Figure 15. SKY66122-11 Evaluation Board Schematic



Top Layer



Ground Plane

Figure 16. SKY66122-11 Evaluation Board Layer Details

Table 10. SKY66122-11 Evaluation Board Bill of Materials (BoM)

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	1pF	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 $\Omega$			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

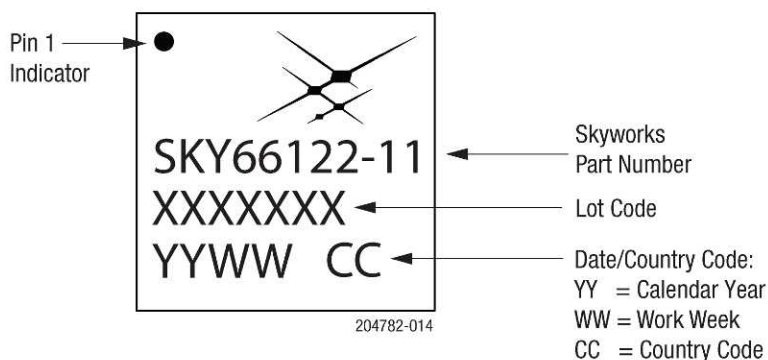
Typical part markings are shown in Figure 17. The PCB layout footprint is shown in Figure 18. Package dimensions for the SKY66122-11 are shown in Figure 19, and tape and reel dimensions are provided in Figure 20.

## Package and Handling Information

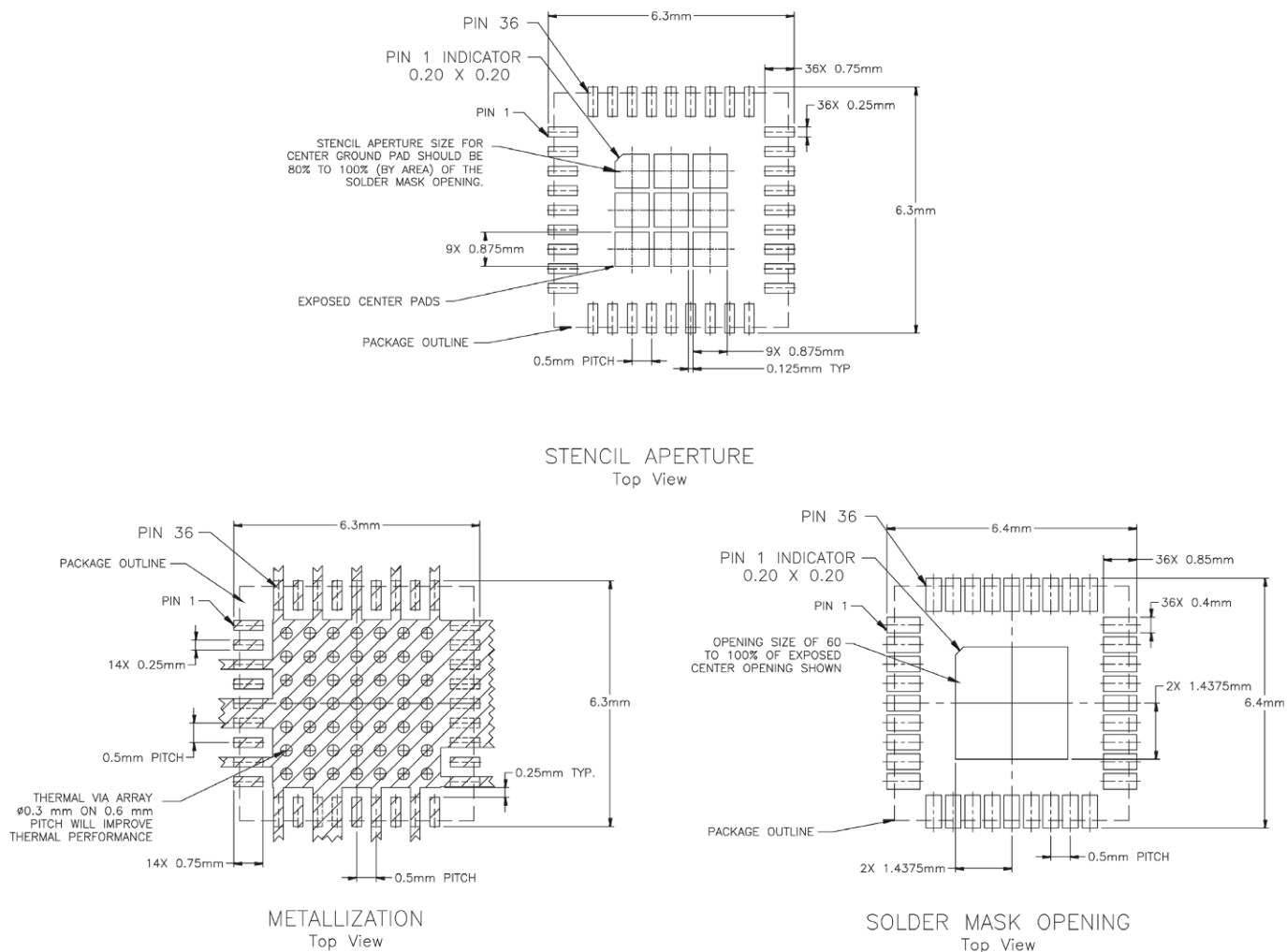
Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when 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 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.



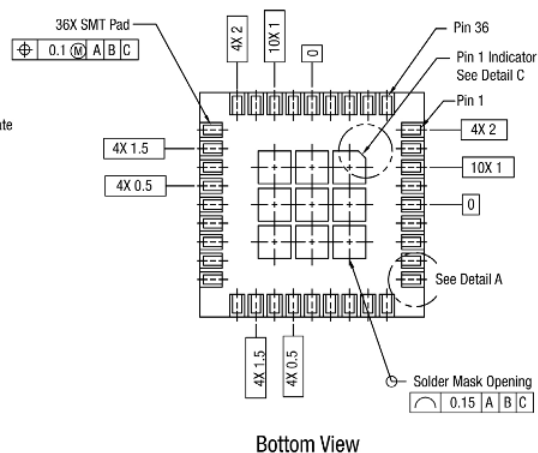
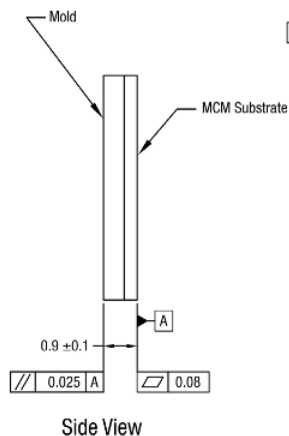
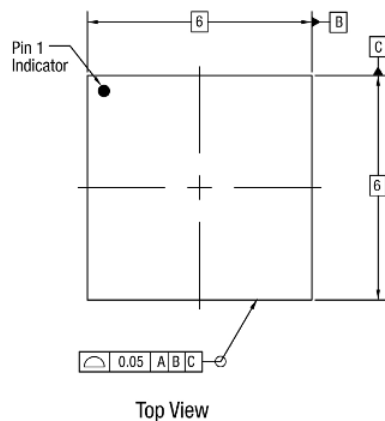
**Figure 17. SKY66122 Part Marking**



**Figure 18. SKY66122-11 PCB Layout Footprint**



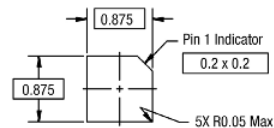
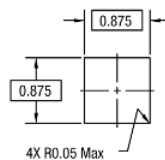
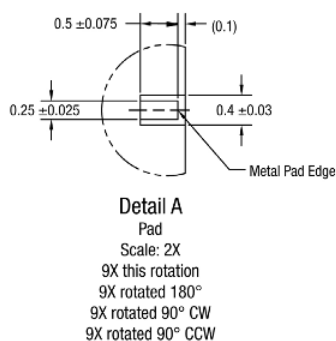
# PRELIMINARY DATA SHEET • SKY66122-11: Wi-SUN Front-End Module



## Notes:

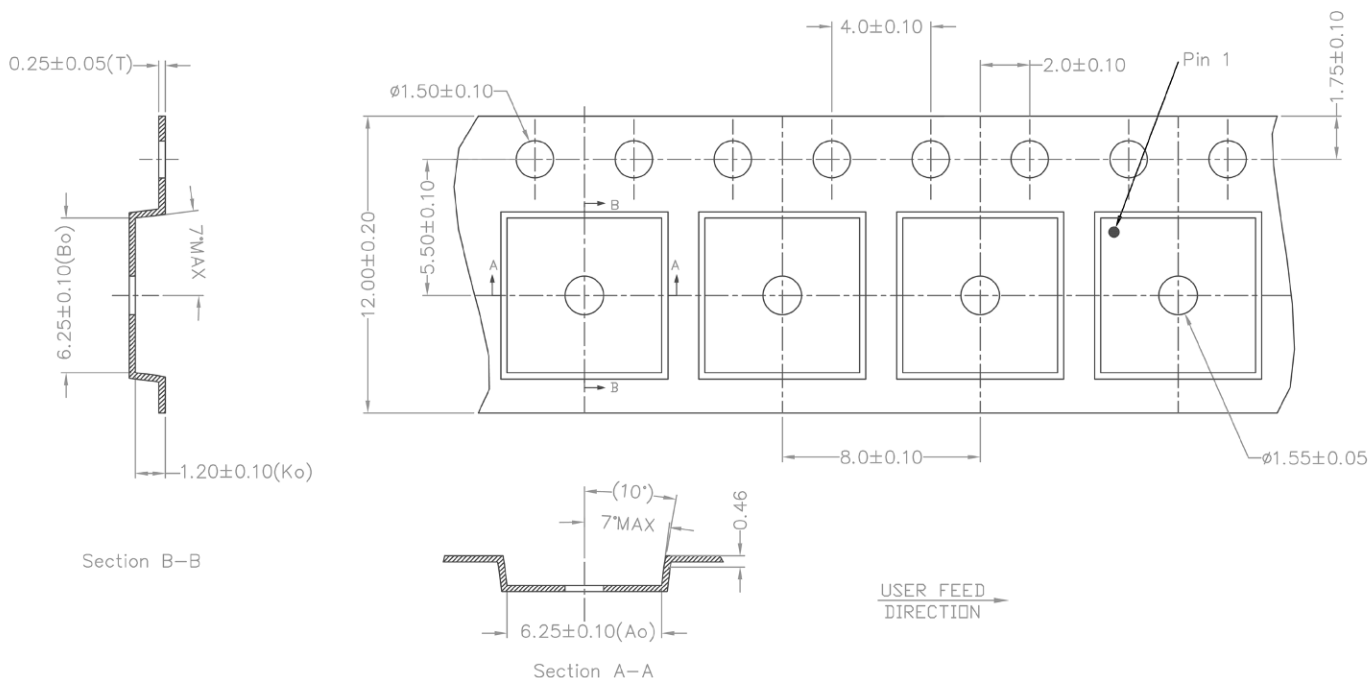
1. Dimensions and tolerances in accordance with ASME Y14.5M-1994.
2. Dimensions are in millimeters (unless otherwise specified).
3. Tolerances on:
 

Decimals	Angles
.XX = $\pm 0.05$	$\pm 30^\circ$
.XXX = $\pm 0.025$	



204782-015

**Figure 19. SKY66122-11 Package Dimensions**



NOTES:

1. CARRIER TAPE MUST MEET ALL REQUIREMENTS OF SKYWORKS GP01-D233 PROCUREMENT SPEC FOR TAPE and REEL SHIPPING.
- ② CARRIER TAPE SHALL BE BLACK CONDUCTIVE POLYCARBONATE OR POLYSTYRENE.
3. COVER TAPE SHALL BE TRANSPARENT CONDUCTIVE MATERIAL.
4. ESD-SURFACE RESISTIVITY SHALL BE  $\leq 1 \times 10^{10}$  OHMS/SQUARE PER EIA, JEDEC TNR SPECIFICATION.
5. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE :  $\pm 0.20\text{mm}$
6. Ao & Bo MEASURED ON PLANE 0.30mm ABOVE THE BOTTOM OF THE POCKET.
7. ALL DIMENSIONS ARE IN MILLIMETERS.

204782-020

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

## Ordering Information

Part Number	Product Description	Evaluation Board Part Number
SKY66122-11	863 to 928 MHz Wi-SUN Front-End Module	SKY66122-11EK1

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