DATA SHEET

SKY66112-11: 2.4 GHz ZigBee®/Thread/Bluetooth® Smart Front-End Module

Applications

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

Features

- Integrated PA with up to +21 dBm output power
- Integrated LNA (2 dB noise figure typical) and bypass path
- Integrated antenna diversity switching for all modes
- 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
- No external bias resistor is required
- Small MCM (22-pin, 3.5 mm x 3.0 mm x 1.0 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.

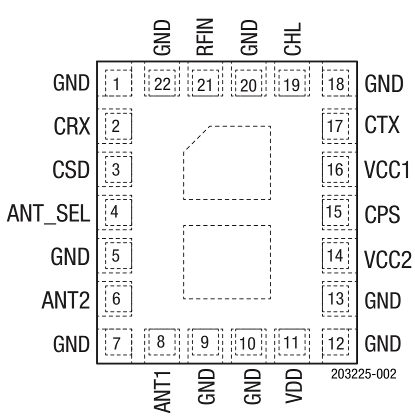


Figure 2. SKY66112-11 Pinout (Top View)

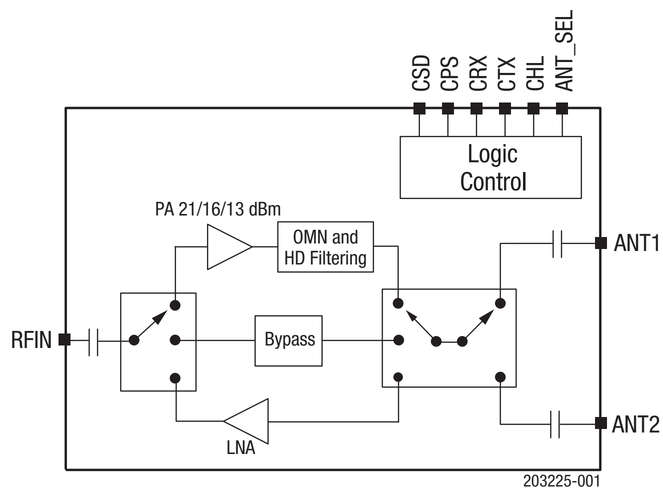


Figure 1. SKY66112-11 Block Diagram

Description

The SKY66112-11 is a high-performance, fully integrated RF front-end module (FEM) designed for ZigBee, Thread, and Bluetooth Smart applications.

The SKY66112-11 is designed for ease of use and maximum flexibility. The device provides an integrated inter-stage matching and harmonic filter, 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 1.8 V to 3.6 V that allows the SKY66112-11 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 SKY66112-11 is provided in a small, 22-pin, 3.5 mm x 3.0 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. SKY66112-11 Signal Descriptions[1]

Pin	Name	Description	Pin	Name	Description
1	GND	Ground	12	GND	Ground
2	CRX	Connect to GPIO signal for mode control (see Table 6)	13	GND	Ground
3	CSD	Connect to GPIO signal for mode control (see Table 6)	14	VCC2	PA output stage supply
4	ANT_SEL	Connect to GPIO signal to control antenna switch (see Table 7)	15	CPS	Connect to GPIO signal for mode control (see Table 6)
5	GND	Ground	16	VCC1	PA first stage and LNA supply
6	ANT2	Connect to 50 Ω antenna	17	CTX	Connect to GPIO signal for mode control (see Table 6)
7	GND	Ground	18	GND	Ground
8	ANT1	Connect to 50 Ω antenna	19	CHL	Connect to GPIO signal for mode control (see Table 6)
9	GND	Ground	20	GND	Ground
10	GND	Ground	21	RFIN	RF input power (transmit/receive port)
11	VDD	Digital logic and RF switch supply	22	GND	Ground

[1] The paddle should be connected to ground.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY66112-11 are provided in Table 2. The recommended operating conditions are specified in Table 3, and electrical specifications are provided in Tables 4 and 5.

The state of the SKY66112-11 is determined by the logic provided in Table 6. Table 7 shows the antenna select logic.

Table 2. SKY66112-11 Absolute Maximum Ratings[1]

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	V_{CC1} V_{CC2} V_{DD}	–0.3 –0.3 –0.3	+3.6 +3.6 +3.6	V V V
Control pin voltages	V_{CTL}	–0.3	+3.6	V
Transmit output power at ANT1 or ANT2 port into 50 Ω load	$P_{OUT\_TX\_MAX}$		+22.5	dBm
Transmit input power at RFIN port	$P_{IN\_TX\_MAX}$		+5.0	dBm
Receive input power at ANT1 or ANT2 ports[2]	$P_{IN\_RX\_MAX}$		+15	dBm
Bypass input power at ANT1 or ANT2 ports[2]	$P_{IN\_BYP\_MAX}$		+20	dBm
Operating temperature	T_A	–40	+85	°C
Storage temperature	T_{STG}	–40	+125	°C
Electrostatic discharge: Human Body Model (HBM)	ESD		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	Minimum	Typical	Maximum	Units
Supply voltage on VCC1 pin	V_{CC1}	1.7	1.8	3.3	V
Supply voltage on VCC2 pin	V_{CC2}	0.6	3.0	3.3	V
Supply voltage on VDD pin	V_{DD}	1.8[1]	3.0	3.3	V
Operating temperature	T_A	–40	+25	+85	°C

[1] Performance at VDD = 1.8 V will be slightly degraded compared to VDD = 2.5 V and above.

Table 4. SKY66112-11 Electrical Specifications[1]
(V_{CC1} = 1.8 V, V_{CC2} = 3.0 V, V_{DD} = 3.0 V, T_A = +25 °C, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
DC Characteristics						
Total supply current	I_{CC_TX}	P_{OUT} = +21 dBm[2] P_{OUT} = +20 dBm[2] P_{OUT} = +16 dBm[3] P_{OUT} = +13 dBm[4]		115 90 60 45		mA mA mA mA
Total supply current	I_{CC_RX}			3.5	6	mA
Total supply current	I_{CC_BYP}			5		µA
Sleep supply current	I_{CC_OFF}	No RF			1	µA
Quiescent current	I_{CCQ_TX}	High-power mode[2] Low-power mode[3] Low-power mode[4]		12 8 8		mA mA mA
Logic Characteristics						
Control voltage: High Low	 V_{IH} V_{IL}		 1.6 0		 V_{DD} 0.3	 V V
Control current: High Low	 I_{IH} I_{IL}				 1.0 1.0	 µA µA
Dual Antenna Switch Characteristics						
Isolation between ANT1 and ANT2 ports	ISO_{ANTSW}			–20		dB
ANT1 to ANT2 switching time	t_{ANT1_ANT2}			400		ns

[1] Performance is guaranteed only under the conditions listed in this table.
[2] V_{CC1} = 1.8 V, V_{CC2} = 3.0 V
[3] V_{CC1} = 1.8 V, V_{CC2} = 1.8 V
[4] V_{CC1} = 1.8 V, V_{CC2} = 1.2 V

Table 5. SKY66112-11 Electrical Specifications[1]
(V_{CC1} = 1.8 V, V_{CC2} = 3.0 V, V_{DD} = 3.0 V, T_A = +25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Transmit Characteristics						
Frequency range	f		2400		2483	MHz
Output power at ANT1 or ANT2 port	P_{OUT}	V_{CC1} = 1.8 V, V_{CC2} = 3.0 V, P_{IN} = –1 dBm V_{CC1} = 1.8 V, V_{CC2} = 3.0 V, P_{IN} = –2 dBm V_{CC1} = 1.8 V, V_{CC2} = 1.8 V, P_{IN} = –3 dBm V_{CC1} = 1.8 V, V_{CC2} = 1.2 V, P_{IN} = –3 dBm		+21 +20 +16 +13		dBm dBm dBm dBm
Saturated gain, high power mode	G_{SAT}			22		dB
Saturated output power variation	ΔP_{OUT}	Across all ZigBee channels			1	dBp-p
2nd and 3rd harmonics[2]	2fo, 3fo	P_{OUT} = +20.0 dBm, IEEE 802.15.4 source			–42	dBm/MHz
Input return loss	S11			–12		dB
Turn-on time[2]	t_{RISE}	From 50% of CTX edge to 90% of final RF output power		800		ns
Turn-off time[2]	t_{FALL}	From 50% of CTX edge to 10% of final RF output power		800		ns
Stability[2]	STAB	CW, Pin = 0 dBm, 0.1 GHz to 20 GHz, load VSWR = 6:1	All non-harmonically related outputs < –42 dBm/MHz			
Ruggedness[2]	RUG	CW, Pin = 0 dBm, load VSWR = 10:1	No permanent damage			
Receive Characteristics						
Frequency range	f		2400		2483	MHz
Receive gain	RX_{GAIN}			11		dB
Receive noise figure	NF			2		dB
Third order input intercept point	IIP3			0		dBm
1 dB input compression point	IP1dB		–14	–8		dBm
Input return loss	S11	ANT1 or ANT2 ports		–10		dB
Output return loss	S22			–12		dB
Turn-on time[2]	t_{RISE}	From 50% of CRX edge to 90% of final RF output power		800		ns
Turn-off time[2]	t_{FALL}	From 50% of CRX edge to 10% of final RF output power		800		ns
Bypass Characteristics						
Frequency range	f		2400		2483	MHz
Bypass gain	BYP_{GAIN}			–2		dB
Input return loss	S11			–15		dB
Output return loss	S22			–20		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. SKY66112-11 Mode Control Logic[1]
(V_{CC1} = 1.8 V, V_{CC2} = 3.0 V, V_{DD} = 3.0 V, T_A = +25 °C)

Mode	Description	CSD (Pin 3)	CPS (Pin 15)	CRX (Pin 2)	CTX (Pin 17)	CHL (Pin 19)
0	All off (sleep mode)[1]	0	X	X	X	X
1	Receive LNA mode	1	0	1	0	X
2	Transmit high-power mode	1	0	X	1	1
3	Transmit low-power mode	1	0	X	1	0
4	Receive bypass mode	1	1	1	0	X
5	Transmit bypass mode	1	1	X	1	X
6	All off (sleep mode)	1	X	0	0	X

[1] All controls must be at V_{DD} or 0 V to achieve the specified sleep current.

Table 7. SKY66112-11 Antenna Select Logic
(V_{CC1} = 1.8 V, V_{CC2} = 3.0 V, V_{DD} = 3.0 V, T_A = +25 °C)

Description	ANT_SEL (Pin 4)
ANT1 port enabled	0
ANT2 port enabled	1

CHL Control Pin

The CHL pin controls the bias of the PA. For high V_{CC2} (for example, 3.0 V), high-power mode (CHL = 1) offers superior TX gain at minimal cost in Icc. For $V_{CC2} \leq 2.0$ V, low-power mode (CHL = 0) offers significant Icc savings.

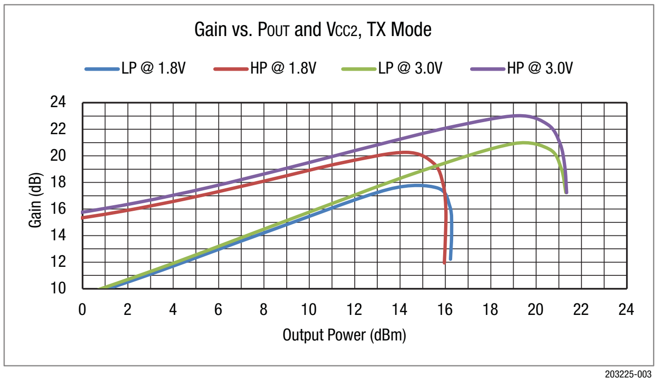


Figure 3. Effect of CHL on Gain
(V_{CC1} = 1.8 V, V_{DD} = 3.0 V, f = 2440 MHz)

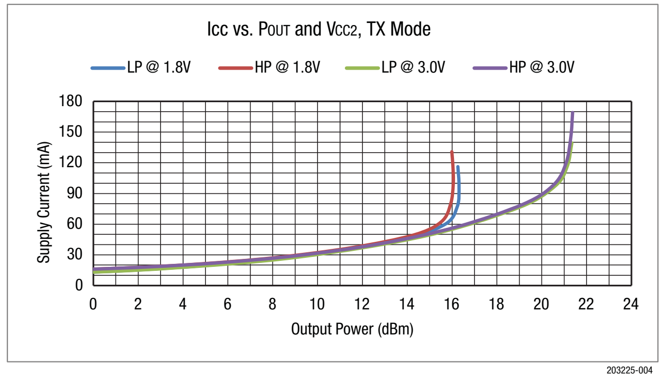


Figure 4. Effect of CHL on Supply Current
(V_{CC1} = 1.8 V, V_{DD} = 3.0 V, f = 2440 MHz)

Effect of VDD

V_{DD} supplies the digital logic and the RF switches. It has a nominal level of 3.0 V and typically draws 5 to 20 µA in TX, RX, and bypass modes. Lowering V_{DD} to 1.8 V reduces TX gain by ~0.25 dB and RX gain by ~0.4 dB, but improves RX P1dB by ~0.25 dB.

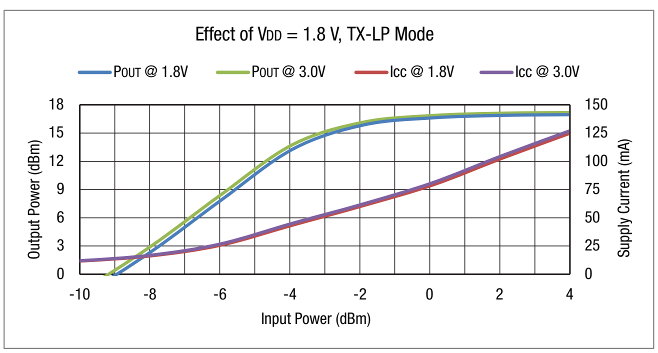


Figure 5. Effect of Lowering V_{DD}
(V_{CC1} = V_{CC2} = 1.8 V, TX-LP mode, f = 2440 MHz)

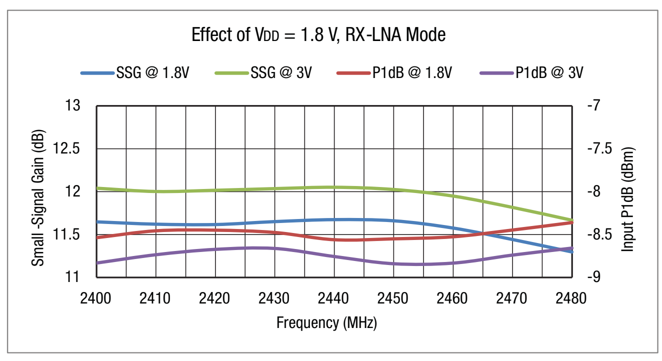


Figure 6. Effect of Lowering V_{DD}
(V_{CC1} = V_{CC2} = 1.8 V, P_{IN} = -25 dBm, RX-LNA Mode)

Effect of VCC1

VCC1 supplies the LNA and the first stage of the PA. It has a nominal level of 1.8 V and typically draws 10 to 20 mA in TX mode and 3.5 mA in RX mode. Raising Vcc1 to 3.0 V increases RX and TX small-signal gain by ~0.3 dB and RX P1dB by ~1 dB. However, it also increases TX Icc by 1 to 30 mA depending on input power. To avoid high TX Icc, it is recommended to keep PIN at or below -2 dBm.

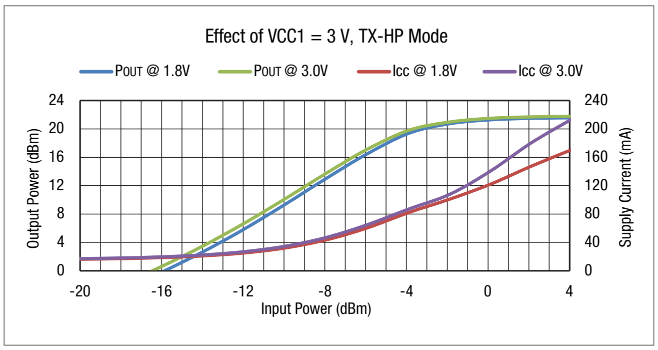


Figure 7. Effect of Raising VCC1 (VCC2 = VDD = 3.0 V, f = 2440 MHz, TX-HP Mode)

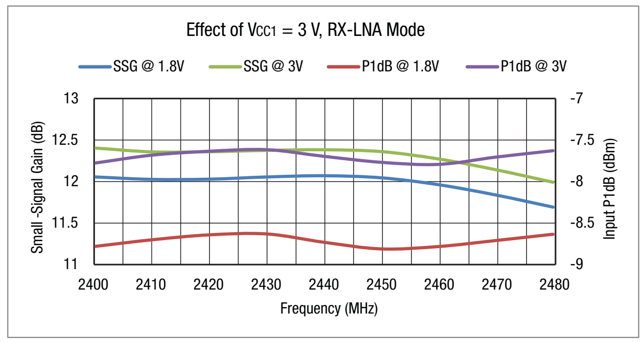


Figure 8. Effect of Raising VCC1 (VCC2 = VDD = 3.0 V, PIN = -25 dBm, RX-LNA Mode)

Effect of VCC2

Vcc2 supplies the output stage of the PA. The level of Vcc2 directly controls the saturated TX output power and this supply draws the majority of the current in TX mode.

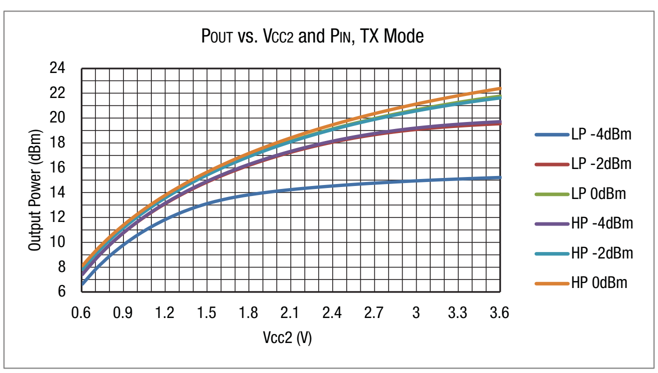


Figure 9. POUT vs. VCC2 and PIN (VCC1 = 1.8 V, VDD = 3.0 V, f = 2440 MHz)

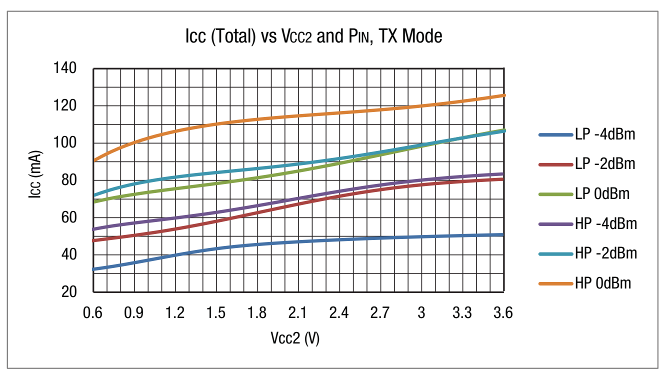
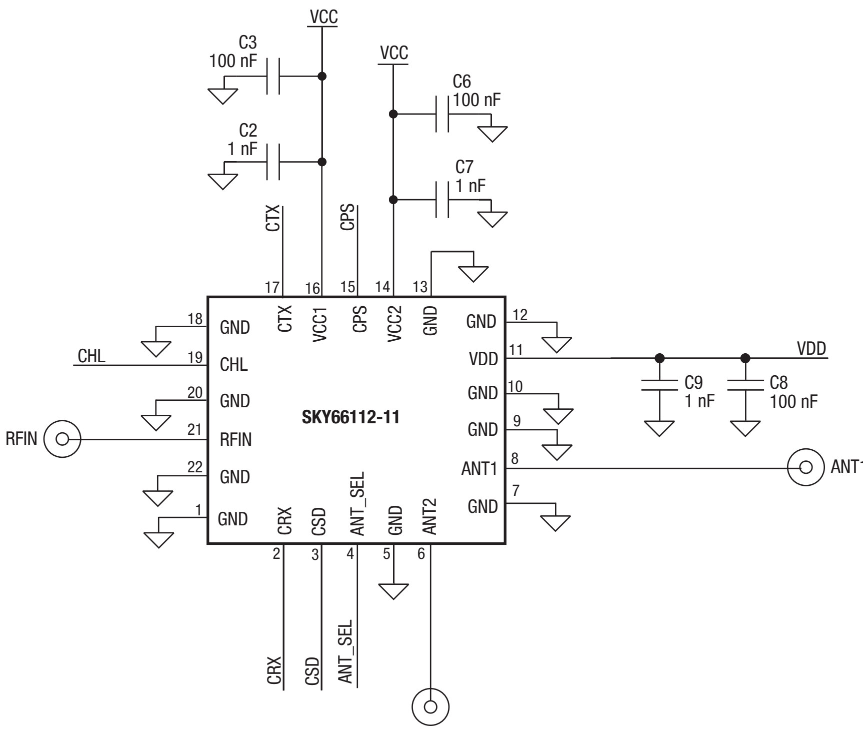


Figure 10. ICC vs. VCC2 and PIN (VCC1 = 1.8 V, VDD = 3.0 V, f = 2440 MHz)

Application Schematic Description

A reference design schematic is provided in Figure 11. An evaluation board schematic diagram is shown in Figure 12.



Note: The paddle should be connected to ground.

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Figure 11. SKY66112-11 Reference Design Schematic

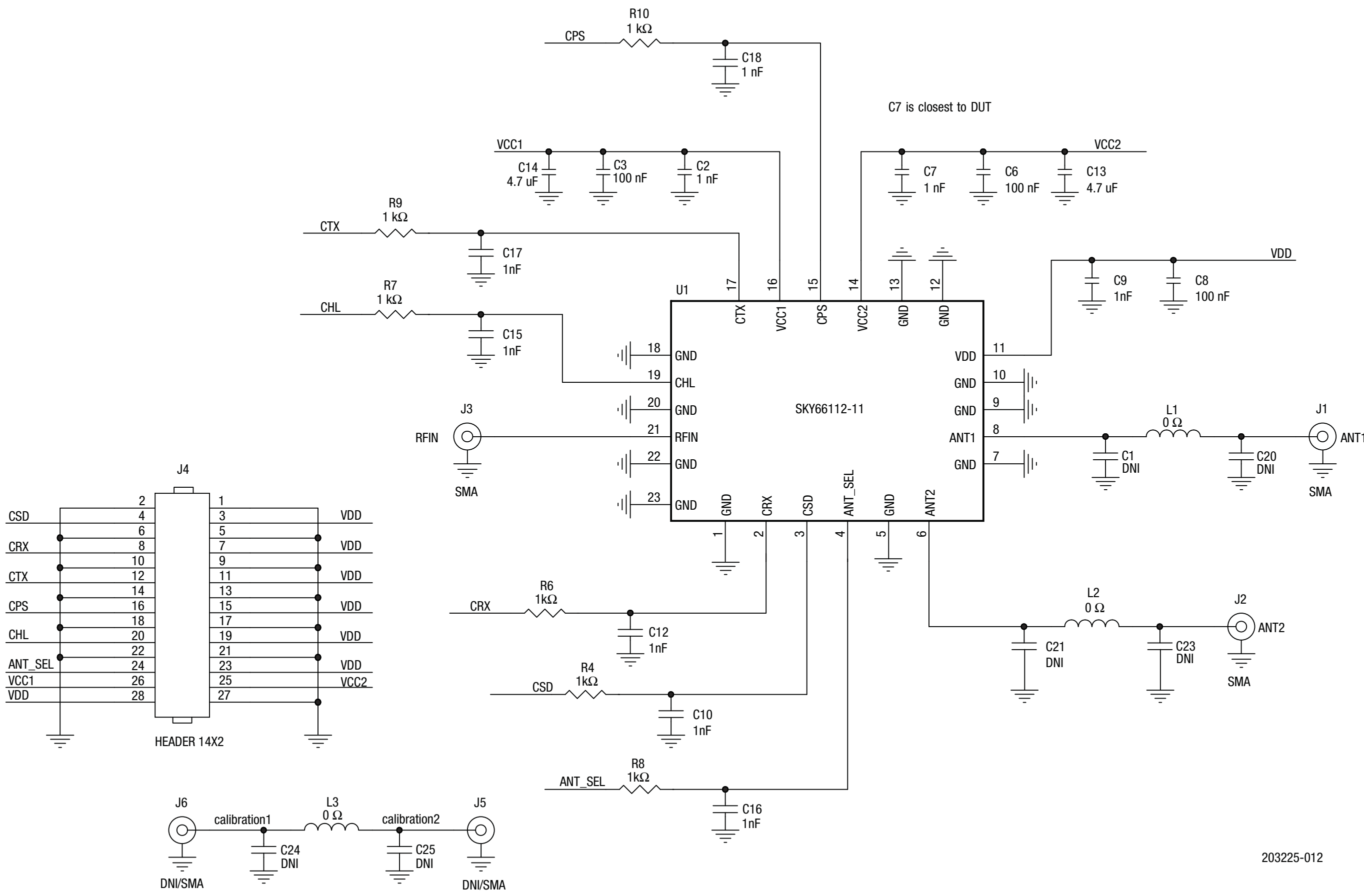


Figure 12. SKY66112-11 Evaluation Board Schematic Diagram

Package Dimensions

The typical part marking is shown in Figure 13. The PCB layout footprint for the SKY66112-11 is provided in Figure 14. Package dimensions are shown in Figure 15, and tape and reel dimensions are provided in Figure 16.

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 SKY66112-11 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.

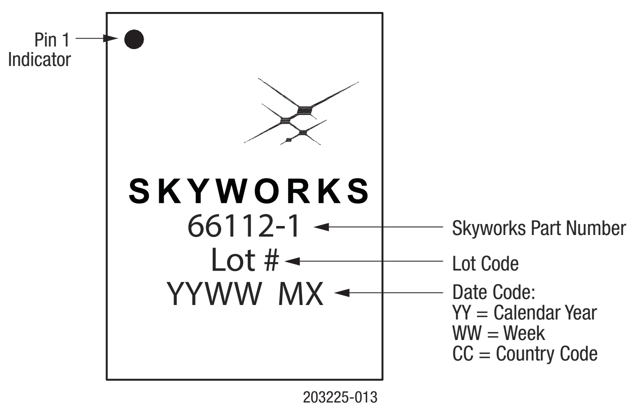
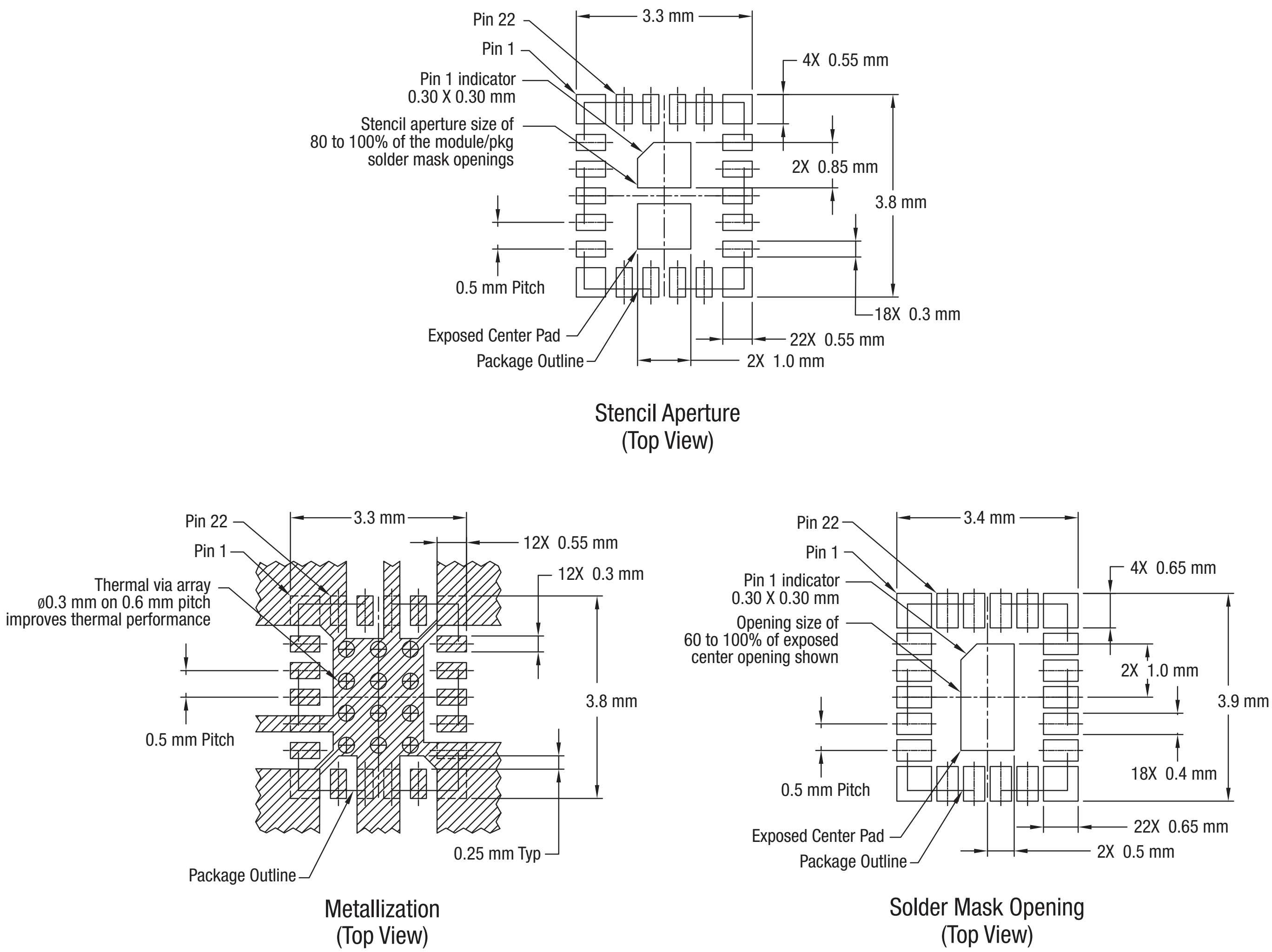


Figure 13. SKY66112-11 Typical Part Marking (Top View)



Notes:

1. *All measurements are in millimeters.*
2. *Thermal vias should be resin filled and capped in accordance with IPC-4761 type VII vias. Recommended Cu thickness is 30 to 35 μm.*

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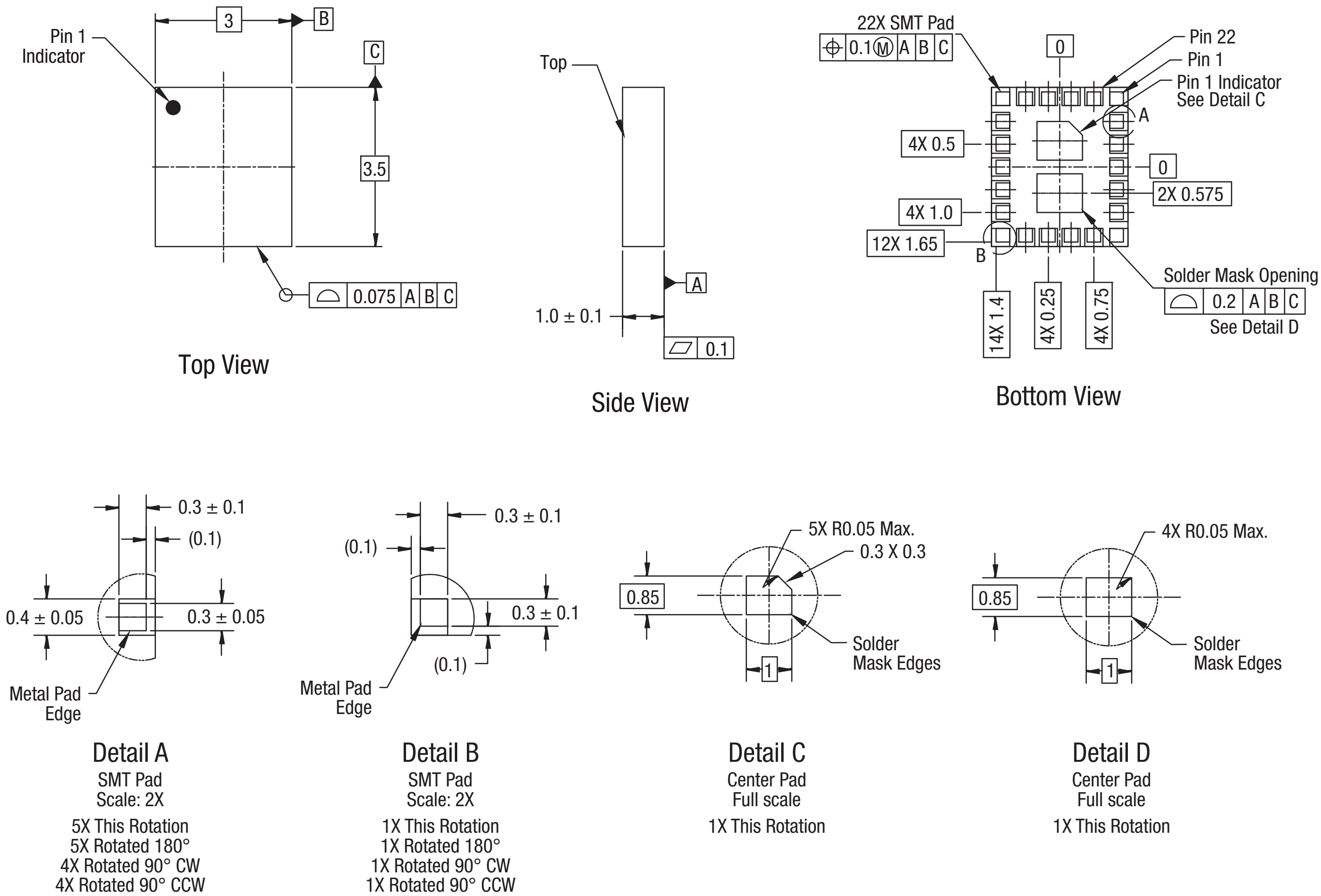
Figure 14. SKY66112-11 PCB Layout Footprint



Notes:

1. *Dimensions and tolerances according to ASME Y14.5M-1994.*
2. *All measurements are in millimeters.*

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Figure 15. SKY66112-11 Package Dimensions

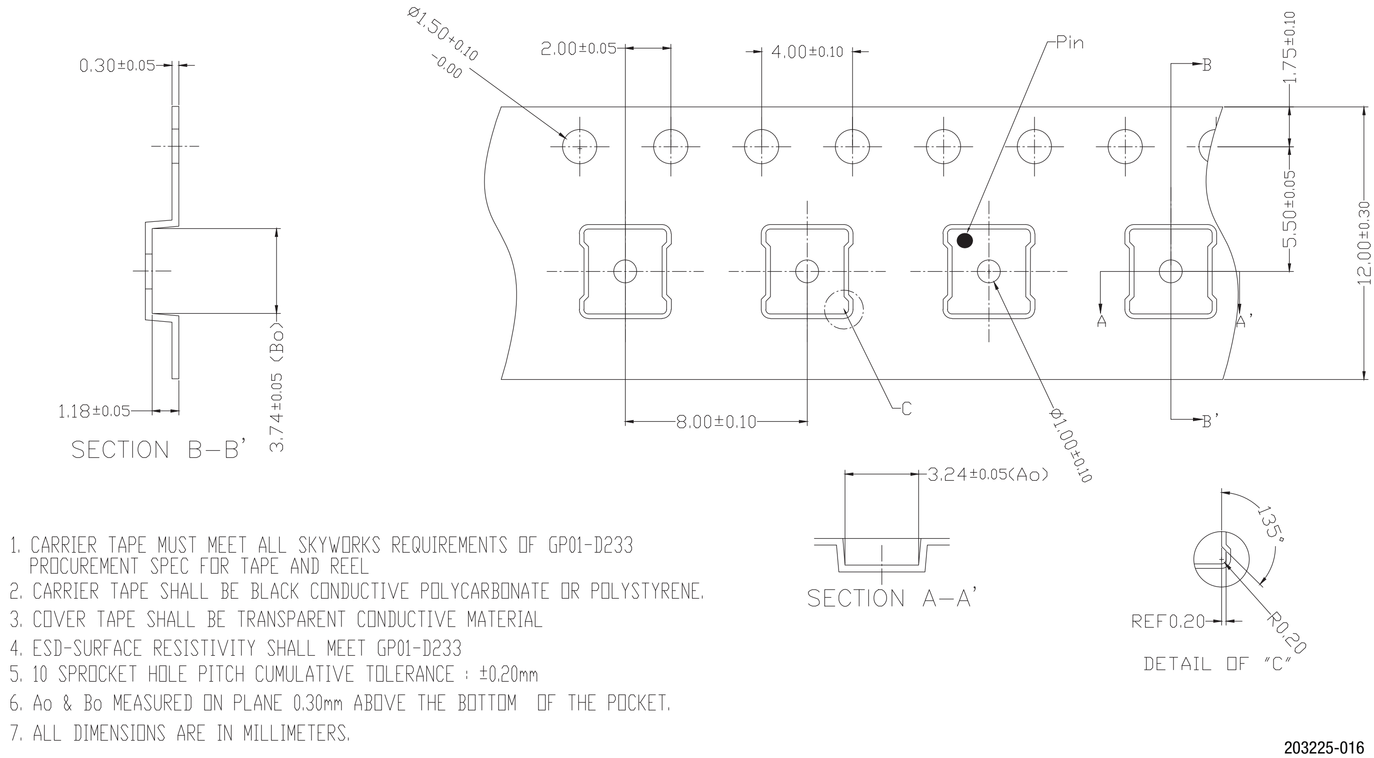

Figure 16. SKY66112-11 Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY66112-11: 2.4 GHz Zigbee/Thread/Bluetooth Smart FEM	SKY66112-11	SKY66112-11EK1

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