DATA SHEET

SKY85321-11: 2.4 GHz, 802.11ac Front-End Module

Applications

- WiFi-enabled handsets, tablets, and mobile/portable systems
- System-in-Package (SIP) modules for embedded systems
- 802.11ac smartphones and tablets

Features

- Integrated high-performance 2.4 GHz PA, harmonic filter, LNA with bypass, and T/R switch
- Integrated positive slope power detector
- Two power modes
- Transmit gain: 28 dB
- Receive gain: 13.5 dB
- Receive bypass loss: 2.2 dB
- Output power: +20.5 dBm, MCS7, HT20
- Output power: +19 dBm, MCS9, HT40
- Nominal supply voltage: 3.7 V
- Small QFN (16-pin, 2 × 2 × 0.33 mm) package (MSL1, 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.

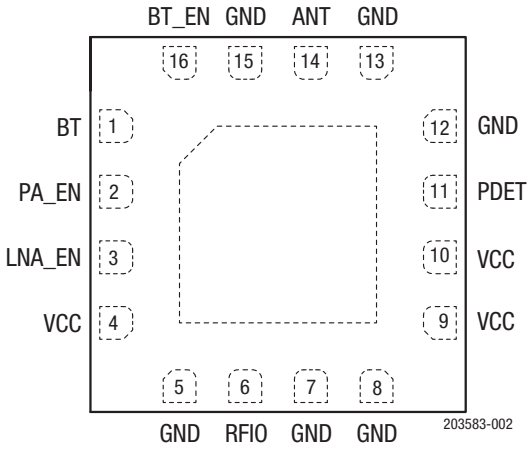


Figure 2. SKY85321-11 Pinout (Top View)

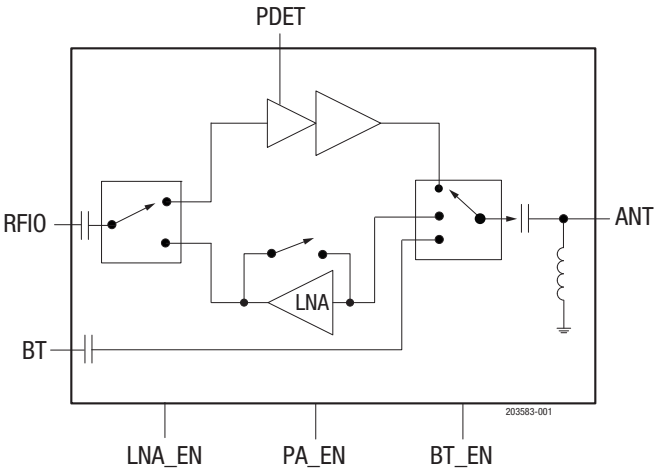


Figure 1. SKY85321-11 Block Diagram

Description

The SKY85321-11 is a complete 802.11b/g/n/ac WLAN RF front-end module (FEM). The device provides all the functionality of a fully matched power amplifier (PA), power detector, harmonic filter, low-noise amplifier (LNA), and single-pole, triple-throw (SP3T) switch.

The SKY85321-11 provides a complete 2.4 GHz WLAN RF solution from the output of the transceiver to the antenna, and from the antenna to the input of the transceiver. The LNA increases the receive sensitivity of embedded solutions to improve range or to overcome the insertion loss of cellular filters (often included for mobile applications).

The SKY85321-11 also includes a transmitter power detector with 20 dB of dynamic range, and a digital enable control for transmitter power ramp on/off control.

The device is provided in a compact, 16-pin 2 x 2 mm Quad Flat No-Lead (QFN) package. A functional block diagram is shown in Figure 1. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are described in Table 1.

Table 1. SKY85321-11 Signal Descriptions

Pin	Name	Description	Pin	Name	Description
1	BT	BT port	9	VCC	Supply voltage
2	PA_EN	Control pin	10	VCC	Supply voltage
3	LNA_EN	Control pin	11	PDET	Power detector output
4	VCC	Supply voltage	12	GND	Ground
5	GND	Ground	13	GND	Ground
6	RFIO	TX/RX port	14	ANT	Antenna pin
7	GND	Ground	15	GND	Ground
8	GND	Ground	16	BT_EN	Control pin

Technical Description

The SKY85321-11 is comprised of a high-performance 2.4 GHz PA, 2.4 GHz LNA, and SP3T switch. The device is fully matched, and requires few external components for optimal performance, which makes it ideal for small portable/mobile applications. The LNA supports an enable/disable mode for power savings when not in receive mode and a bypass function for increased receive dynamic range.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY85321-11 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 SKY85321-11 is determined by the logic provided in Table 9.

Table 2. SKY85321-11 Absolute Maximum Ratings[1]

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	V_{DD}	-0.3	+6.0	V
DC input on control pins	PA_EN, LNA_EN, BT_EN	-0.3	+3.7	V
Transmit input power, CW	P_{IN}		+5	dBm
Case operating temperature	T_A	-40	+85	°C
Storage temperature	T_{STG}	-55	+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.

***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. SKY85321-11 Recommended Operating Conditions

Parameter	Symbol	Min	Typ	Max	Units
Supply voltage relative to GND = 0 V	VCC	3.0	3.7	4.8	V
Operating temperature	T_A	-40	+25	+85	°C

Table 4. SKY85321-11 Electrical Specifications: Control Logic Characteristics[1]
(VCC = 3.7 V, TA = +25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Control voltage: High Low	 VIH VIL		 3.0 0		 3.6 0.4	 V V
Input current: High Low	 IIH IIL	All pins			 20 1	 µA µA

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

Table 5. SKY85321-11 Electrical Specifications: DC Characteristics[1]
(VCC = 3.7 V, TA = +25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Supply current, nominal mode	ICC	POUT = +20.5 dBm, MCS7		265	295	mA
Supply current, nominal mode	ICC	POUT = +19 dBm, MCS9		235	265	mA
LNA supply current	IDD_LNA			9	11	mA
LNA bypass supply/sleep current	IDD_LNA_BYP			2	5	µA

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

Table 6. SKY85321-11 Electrical Specifications: Transmit and Power Detector Characteristics[1]
(VCC = 3.7 V, TA = +25°C, All Unused Ports Terminated with 50 Ω, Nominal Mode, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Transmit Characteristics						
Frequency range	f		2400		2500	MHz
Small signal gain	S21		26	28	30	dB
Transmit flatness over 40 MHz bandwidth		ANT port pin			±0.5	dB
Transmit harmonics	2fo, 3fo, 4fo	POUT = +24.5 dBm, 802.11b, 1 Mbps			-21	dBm/MHz
Power meeting spectral mask	SM	802.11b		25		dBm
Error vector magnitude, nominal mode	EVM	POUT = +20.5 dBm, MCS7, HT20 POUT = +19 dBm, MCS9, HT40		-38 -45	-34 -37	dB dB
Error vector magnitude, 3 dB backoff mode	EVM	POUT = +17.5 dBm, MCS7, HT20 POUT = +16 dBm, MCS9, HT40		-39 -42		dB dB
Transmit input return loss	TXS11		8	10		dB
Transmit output return loss	TXS22		6	10		dB
Transmit spurious		CW PIN = 0 dBm, ANT VSWR = 6:1	All non-harmonic related outputs < -43 dBm/MHz			
Ruggedness	RUG	PIN + 5 dB, MCS7, 10:1 VSWR, 10% duty cycle	No permanent damage or performance degradation			
Power Detector Characteristics						
Output voltage	PDV_14.5 PDV_24.5	@ +14.5 dBm Detector voltage @ +24.5 dBm	340 670	365 700	390 730	mV mV
Detector 3 dB bandwidth	PDBW			2.7		MHz
Output impedance	PDZLOAD_ON PDZLOAD_OFF	PA on PA off	 1	3		kΩ MΩ

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

Table 7. SKY85321-11 Electrical Specifications: Receive Characteristics (ANT to RX Port)[1]
(V_{CC} = 3.7 V, T_A = +25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Frequency range	f		2400		2500	MHz
Receive gain, LNA mode	RX_{S21}	ANT port to receive output	12.5	13.5	14.5	dB
Receive gain, bypass mode	RX_{S21BYP}	ANT port to receive output		2.2	2.6	dB
Receive flatness over 40 MHz bandwidth		ANT port to receive output			±0.5	dB
Receive noise figure	NF	ANT port to receive output		2.1	2.4	dB
IIP3, LNA mode	IIP3	ANT port through LNA (WLAN receive)	+3	+5.5		dBm
IIP3, bypass mode	$IIP3_{BYP}$	ANT port through LNA (WLAN receive)		+30		dBm
Output return loss	S22	Return loss looking into RX pin in receive mode	-9	-11		dB
Antenna port return loss	S11	Return loss looking into ANT pin in receive mode	-12	-15		dB
RX to TX switching time	t_{RX-TX}	10 to 90%			400	ns
TX to RX switching time	t_{TX-RX}	10 to 90%			400	ns
Receive to bypass gain switching time	t_{RX}	10 to 90%			400	ns

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

Table 8. SKY85321-11 Electrical Specifications: Bluetooth Characteristics[1]
(V_{CC} = 3.7 V, T_A = +25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Frequency range	f		2400		2500	MHz
BT insertion loss	BTIL	ANT port to BT port		-0.9		dB
BT port return loss	BT_{S11}		-10	-20		dB
ANT port return loss	BT_{S22}		-10	-20		dB
Harmonics	2fo, 3fo	P_{OUT} = 14.5 dBm		-50		dBm/MHz

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

Table 9. SKY85321-11 Control Logic

Mode	PA_EN	LNA_EN	BT_EN
Sleep/RX LNA bypass mode	0	0	0
Nominal TX mode	1	0	0
RX LNA enabled mode	0	1	0
TX 3dB backoff mode	1	1	0
BT TX/RX	0	0	1

Evaluation Board Description

The SKY85321-11 Evaluation Board is used to test the performance of the SKY85321-11 FEM. A suggested application schematic diagram is shown in Figure 3. A photograph of the Evaluation Board is shown in Figure 4.

Evaluation Board Setup Procedure

1. Connect system ground to pin 16 of connector J6.
2. Apply 3.7 V to pins 9 and 12 of connector J6.
3. Test the RF paths as described by the control logic in Table 9.
4. Connect a digital multimeter to pin 1 of connector J6 to monitor the power detector voltage.
5. Monitor the ANT-to-RX performance by applying an RF signal to J3 (ANT) and measuring the response from the J1 (RFIO) connector output.
6. Monitor the transmit performance by applying an RF signal to connector J1 (RFIO) and measuring the output power on the antenna port connector J3 (ANT).

CAUTION: *Be careful not to overdrive the amplifier by applying too much RF on the device input.*

Evaluation Board Losses

The board losses from the RF connectors of the Evaluation Board to the pins of the SKY85321-11 are:

RFIO = 0.2 dB

BT = 0.2 dB

ANT = 0.2 dB

Circuit Design Considerations

The following design considerations are general in nature and must be followed regardless of final use or configuration:

- Paths to ground should be made as short as possible.
- The ground pad of the SKY85321-11 has special electrical and thermal grounding requirements. This pad is the main thermal conduit for heat dissipation.
- Since the circuit board acts as the heat sink, it must shunt as much heat as possible from the device. Therefore, design the connection to the ground pad to dissipate the maximum wattage produced by the circuit board. Multiple vias to the grounding layer are required.

NOTE: *A poor connection between the ground pad and ground increases junction temperature (TJ), which reduces the life of the device.*

- Optimum performance is guaranteed by following the application schematic, BOM, and Gerber files.
- The exposed die pad under the chip provides thermal and RF ground to the device.
- It is recommended that the maximum allowable number of vias be used to connect the PCB top metal (where the die is soldered) to all internal ground planes whenever possible, and in all cases to the bottom plane of the PCB.
- The RFIO and BT ports are AC-coupled and do not require DC blocking capacitors.
- The ANT port has an on-chip inductor to ground followed by a DC blocking capacitor between the inductor and the die. Therefore, there is no DC from the FEM present on this port. If the ANT port is connected to an external component with DC present, a 10 pF general-purpose blocking capacitor is recommended to avoid draining current from the external component.
- The C2, C14, and C11 must be placed at a minimum manufacturable distance to the FEM and on the top side of the board. L1 and C3 should be next to these components.
- Do not short pin 9 and pin10 together at the FEM landing pads or at other layers; and use L1 for separation. Distribute the Vcc connections from the top layer with no vias connections near the FEM to bring the Vcc to the top layer.
- The C3 2.2 uF decoupling capacitor should be on the primary side of the board at a minimum manufacturable distance from the FEM.

NOTE: *The Skyworks design team recommends a schematic and layout review before PCB manufacturing.*

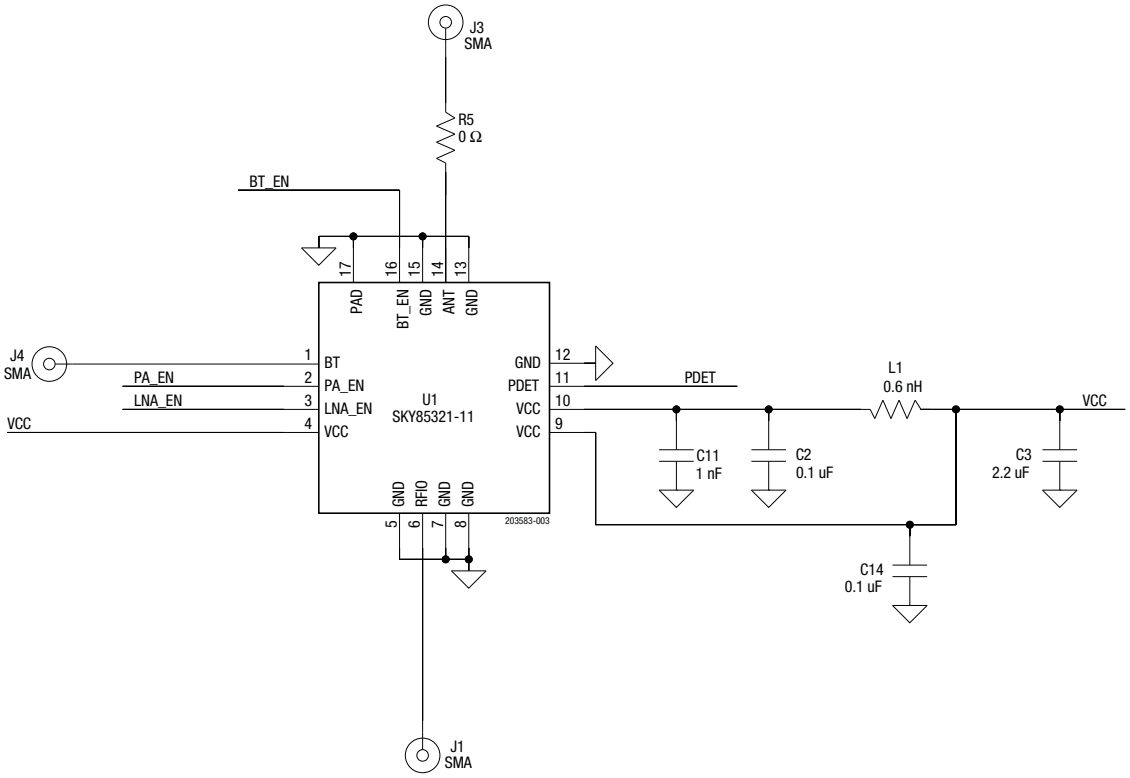


Figure 3. SKY85321-11 Application Schematic

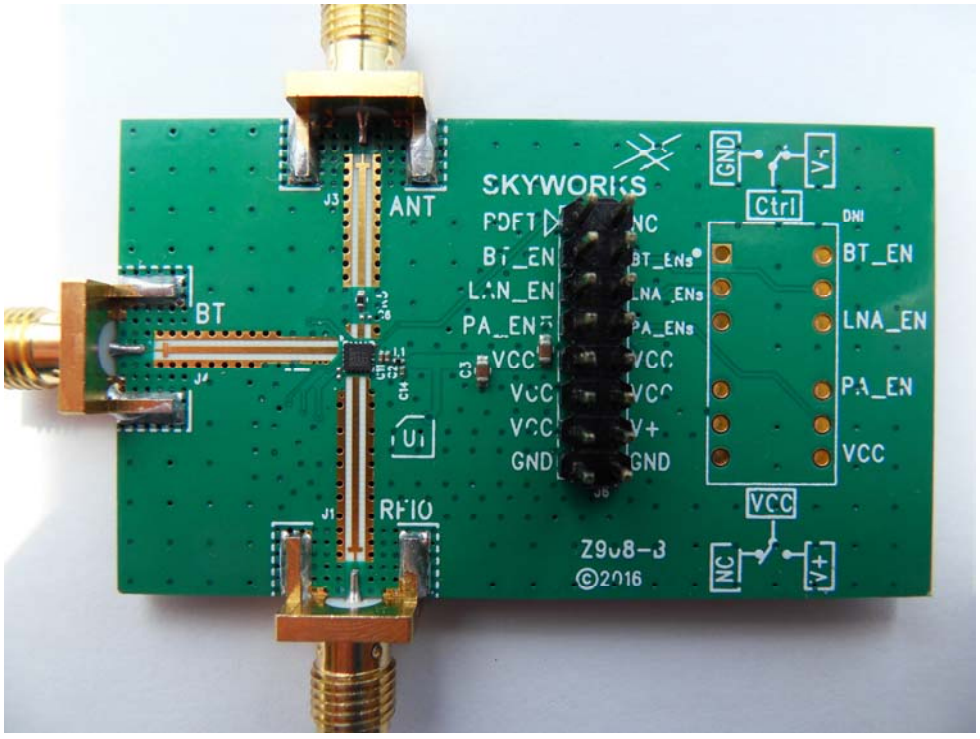


Figure 4. SKY85321-11 Evaluation Board Photograph

Package Dimensions

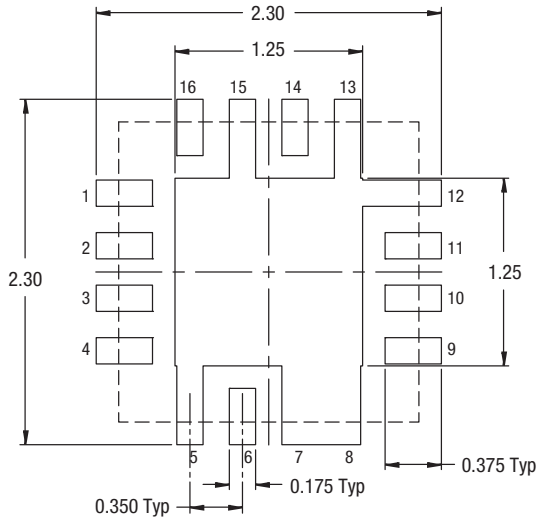
The PCB layout footprint for the SKY85321-11 is shown in Figure 5. Typical part markings are shown in Figure 6. Package dimensions are shown in Figure 7, and tape and reel dimensions are provided in Figure 8.

Package and Handling Information

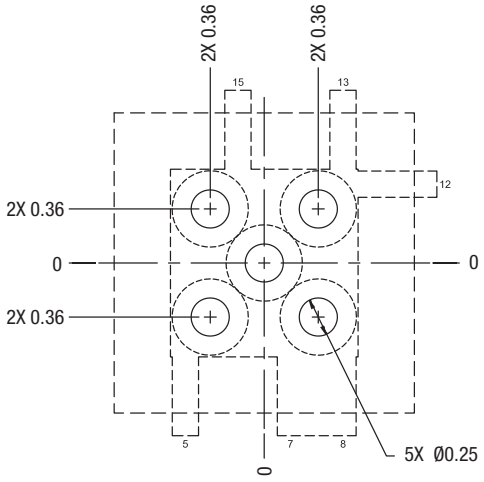
Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The SKY85321-11 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, *Solder Reflow Information*, document number 200164.

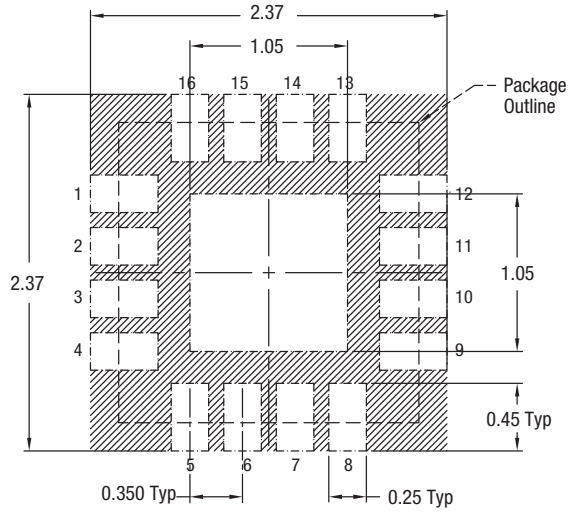
Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format.



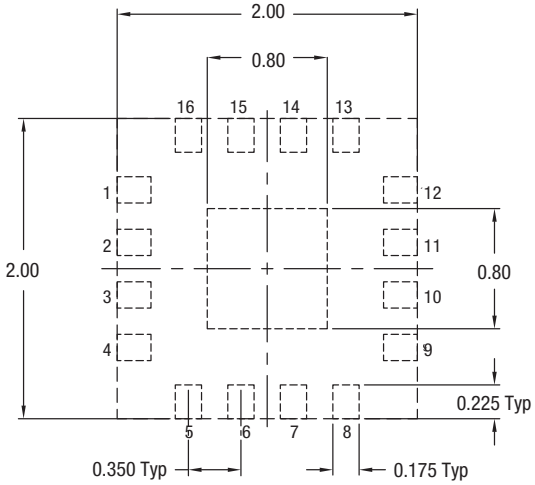
Board Metal



Via Pattern
(Note 4)



Solder Mask Pattern
(Note 6)



Stencil Pattern
(Note 5)

58% Solder Coverage
on Center Pad

Notes:

1. All dimensions are in millimeters.

2. Interpret dimensions and tolerances per ASME 14.5M--1994.

3. Unless specified, dimensions are symmetrical about center lines.

4. Via hole recommendations:
0.025 mm Cu via wall plating (minimum),
via holes to be filled with conductive paste and plated over.

5. Stencil recommendations:
0.076 mm stencil thickness, laser cut apertures,
trapezoidal walls and rounded corners offer better paste release.

6. Solder mask recommendations:
Contact board fabricator for recommended solder mask offset and tolerance.

203583-005

Figure 5. SKY85321-11 PCB Layout Footprint

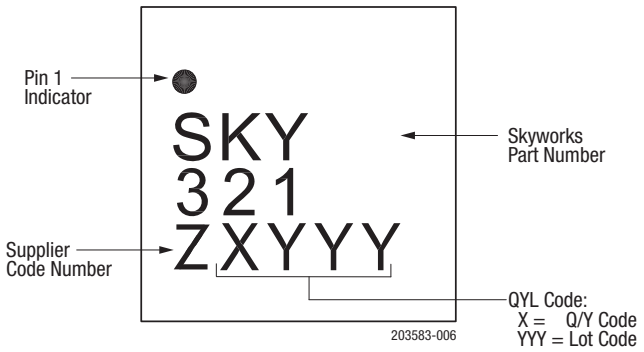


Figure 6. Typical Part Markings (Top View)

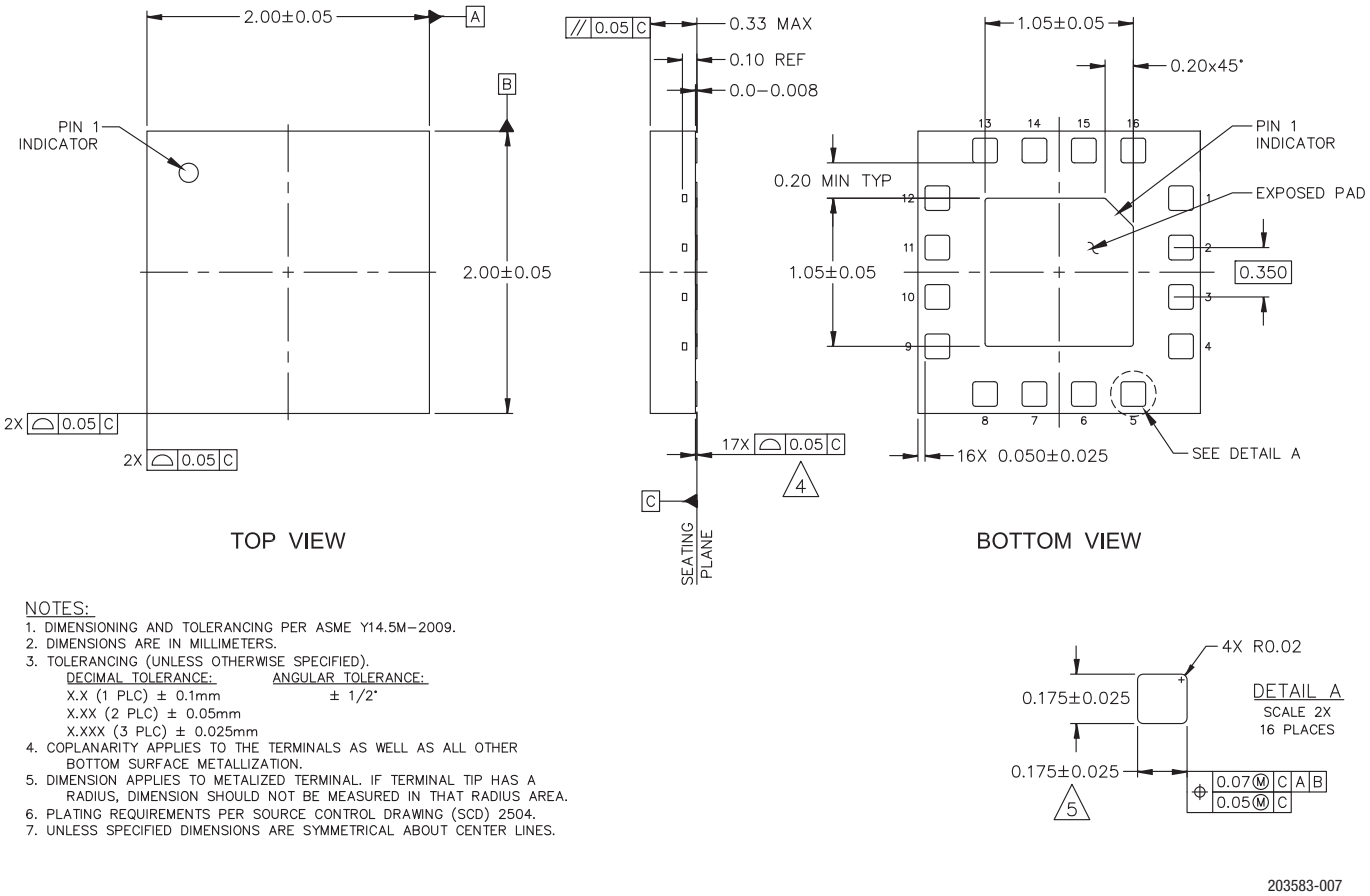
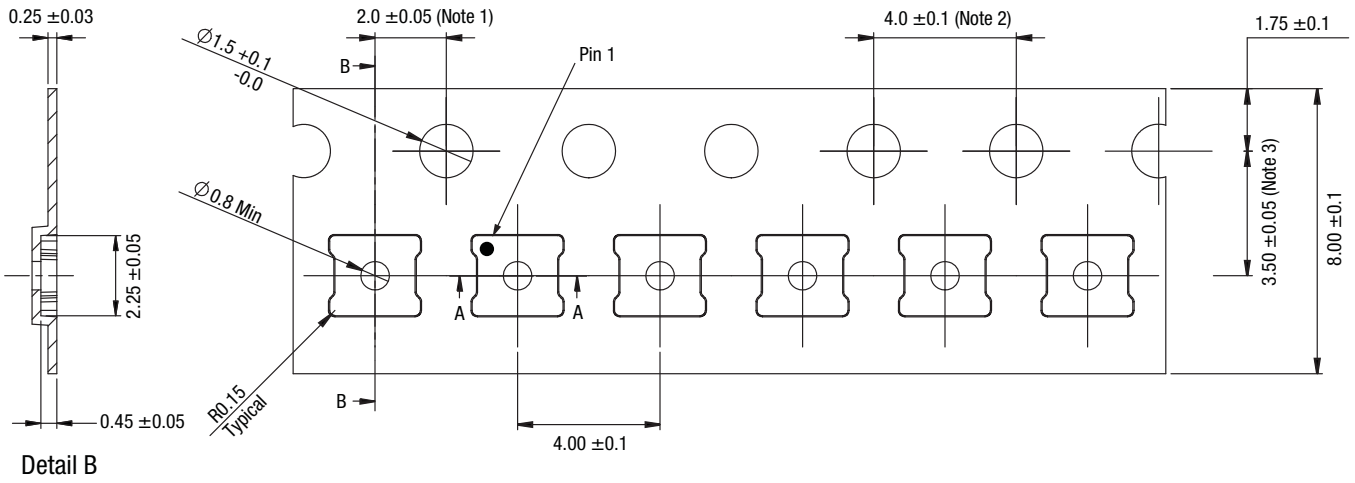
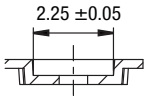


Figure 7. SKY85321-11 Package Dimensions



Notes:

1. *Measured from centerline of sprocket hole to centerline of pocket.*
2. *Cumulative tolerance of 10 sprocket holes is ±0.20 mm.*
3. *All dimensions are in millimeters.*
4. *Other material available.*



203583-008

Figure 8. SKY85321-11 Tape and Reel Dimensions

Ordering Information

Product Description	Product Part Number	Evaluation Board Part Number
SKY85321-11: 2.4 GHz, 802.11ac Front-End Module	SKY85321-11	SKY85321-11EK1