PRELIMINARY DATA SHEET

SKY85717-21: 5 GHz, 802.11ac Front-End Module

Applications

- 802.11ac set-top boxes, networking, and personal computer systems
- PC cards, PCMCIA cards, mini-cards, and half mini-cards
- WLAN enabled wireless video systems

Features

- Integrated high performance 5 GHz PA, LNA with bypass, and SPDT
- Fully-matched input and output
- Integrated, positive slope power detector
- Transmit loopback mode
- Transmit gain: 28 dB
- Receive gain: 12 dB
- Output power: +19.5 dBm, MCS7, HT40
- Output power: +18.5 dBm @ 1.8% EVM, MCS9, HT80
- High linearity and high efficiency modes
- Direct connection to battery with 5 V nominal supply voltage
- Small, QFN (16-pin, 2.5 x 2.5 x 0.4 mm) package (MSL1, 260 °C per JEDEC J-STD-020)

Skyworks Pb-free products are compliant with all applicable legislation. For additional information, refer to *Skyworks Definition of Lead (Pb)-Free*, document number SQ04-0073.

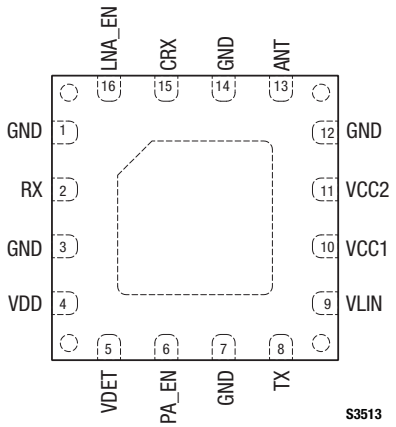


Figure 2. SKY85717-21 Pinout – 16-Pin QFN (Top View)

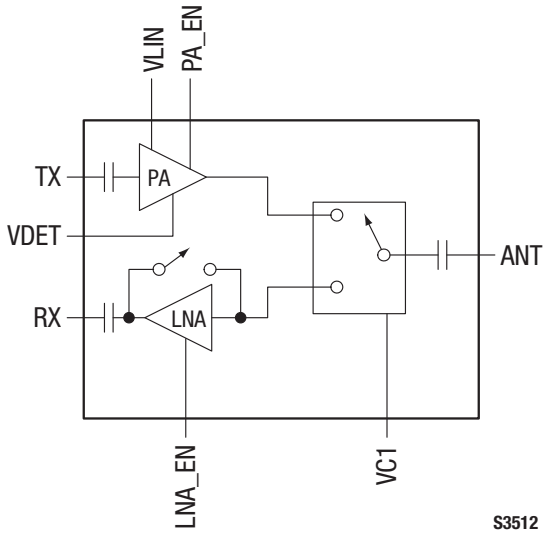


Figure 1. SKY85717-21 Block Diagram

Description

The SKY85717-21 is a highly-integrated, 5 GHz front-end module (FEM) incorporating a 5 GHz single-pole, double-throw (SPDT) transmit/receive (T/R) switch, a 5 GHz low-noise amplifier (LNA) with bypass, and a 5 GHz power amplifier (PA) intended for mobile/portable 802.11ac applications and systems.

An enable/disable function is included that allows power savings during off mode. An integrated power detector with 20 dB of dynamic range is included to provide closed-loop power control within the system.

The device is provided in a compact, 16-pin 2.5 x 2.5 x 0.4 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 provided in Table 1.

Technical Description

The SKY85717-21 is comprised of a high performance 5 GHz PA, 5 GHz LNA, and broadband SPDT switch. The device is fully-matched, and requires few external components for optimal performance, which makes it ideal for small portable/mobile applications. The FEM provides up to +28 dB of gain over the frequency band. The LNA supports an enable/disable mode for power savings when not in receive mode and a bypass function for increased receive dynamic range. The PA can be shut off using the PA_EN signal (pin 6).

Electrical and Mechanical Specifications

Signal pin assignments and functional pin descriptions are described in Table 1. The absolute maximum ratings of the SKY85717-21 are provided in Table 2. The recommended operating conditions are specified in Table 3 and electrical specifications are provided in Tables 4, 5, and 6.

The state of the SKY85717-21 is determined by the logic provided in Table 7.

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 SKY85717-21 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.

Table 1. SKY85717-21 Signal Descriptions

Pin	Name	Description	Pin	Name	Description
1	GND	Ground	9	VLIN	Transmit linearity mode control
2	RX	RF receive output	10	VCC1	Supply voltage
3	GND	Ground	11	VCC2	Supply voltage
4	VDD	LNA supply voltage and transmit bias	12	GND	Ground
5	VDET	Detector output voltage	13	ANT	Antenna
6	PA_EN	PA enable	14	GND	Ground
7	GND	Ground	15	CRX	Switch control voltage
8	TX	RF transmit input	16	LNA_EN	LNA enable

Note: N/C = No connect. Keep pin floating.

Table 2. SKY85717-21 Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage (non-operating, no RF)	V_{CC} V_{DD}	–1 –1	+6 +6	V V
DC input on control pin (PA_EN, LNA_EN, CRX, VLIN)	V_{IN}	–0.3	+6.0	V
Input power (ANT terminated in 50 Ω match)	P_{IN}		+5	dBm
Case operating temperature	T_A	–40	+85	°C
Storage temperature	T_{ST}	–40	+140	°C
Electrostatic discharge: Human Body Model (HBM), Class 1C	ESD		1000	V

Note 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.

***CAUTION**: 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. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions should be used at all times.*

Table 3. SKY85717-21 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply voltage relative to GND = 0 V	V_{CC}, V_{DD}	3.9	5.0	5.5	V
Operating temperature	T_A	–40	+25	+85	°C

Table 4. SKY85717-21 Electrical Specifications: DC Characteristics (Note 1)
(V_{CC} = 5.0 V, PA_EN = 3.3 V, T_A = 25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Supply current, high linearity mode	I_{CC-A}	P_{OUT} = +20.5 dBm, VLIN = 3.3 V		230	260	mA
Supply current, high efficiency mode	I_{CC-A}	P_{OUT} = +20.5 dBm, VLIN = 0 V		220	240	mA
Supply current	I_{CC-OFF}	No RF applied, PA_EN = CRX = LNA_EN = 0 V		20		µA
Quiescent current, high efficiency mode	I_{CQ}	No RF		170		mA
LNA supply current	I_{CC_LNA}	LNA_EN = 3.3 V, CRX = 3.3 V		11		mA
LNA bypass supply current	$I_{CC\_LNA\_BYP}$	LNA_EN = 0 V, CRX = 3.3 V		200		µA

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

Table 5. SKY85717-21 Electrical Specifications: General (Note 1)
(V_{CC} = 5.0 V, PA_EN = 3.3 V, LNA_EN = CRX = 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		4900		5850	MHz
Error Vector Magnitude, high linearity mode	EVM	5150 to 5850 MHz, VLIN = 3.3 V: P_{OUT} = +19.5 dBm, MCS7, HT40 P_{OUT} = +18.5 dBm, MCS9, HT80		 1.8	 3.0 2.0	 % %
Error Vector Magnitude, high efficiency mode	EVM	5150 to 5850 MHz, VLIN = 0 V: P_{OUT} = +19.5 dBm, MCS7, HT40 P_{OUT} = +18.5 dBm, MCS9, HT80		 1.8	 3.0 2.0	 % %
Output power	P_{OUT}	MCS0, mask compliance	+22	+24		dBm
Small signal gain	S21	5150 to 5850 MHz		28		dB
Harmonics (2nd and 3rd)	2fo, 3fo	P_{OUT} = +20 dBm, 6 Mbps, 802.11a			–45	dBm/MHz
Delay and rise/fall time	t_{DR}, t_{DF}	50% of V_{PA_EN} edge and 90/10% of final output power level			400	ns
Input return loss	S11	@ TX port		–12		dB
Stability	Stab	802.11n, MCS0, HT40, P_{OUT} = +20 dBm, 0.1 GHz to 20 GHz, load VSWR = 6:1	All non-harmonically related outputs < –43 dBm/MHz			
Ruggedness		CW, P_{IN} = 0 dBm, 0.1 GHz to 20 GHz, load VSWR = 10:1	No permanent damage or performance degradation			
Receive Characteristics						
Frequency range	f		4900		5850	MHz
Small signal gain	S21	LNA enabled Bypass mode		+12 –8		dB dB
Noise figure	NF			2.5		dB
3rd Order Input Intercept Point	IIP3	LNA enabled Bypass mode		+5 +20		dBm dBm
Input return loss	S11	LNA enabled Bypass mode		–8 –8		dB dB
Output return loss	S22			–8		dB
Enable time	t_{EN}	10% to 90% of receive RF power, from time that LNA_EN is at 50%			400	ns
Power Detector Characteristics						
Frequency range	f		4900		5850	MHz
Power detector range, CW	PDR	Measured @ ANT pin	0		+23	dBm
Output impedance	PDZ_{LOAD}			2.2		kΩ
Output voltage	PDV_{NO_RF} PDV_{P21}	P_{OUT} = no RF, measured into 1 MΩ P_{OUT} = +21 dBm, CW, measured into 1 MΩ		0.2 0.9		V V
Detector bandwidth	PD_{BW}			3.6		MHz

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

Table 6. SKY85717-21 Electrical Specifications: Control Logic Characteristics (Note 1)
(V_{CC} = 5.0 V, PA_EN = 3.3 V, LNA_EN = CRX = 0 V, T_A = 25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Control voltage: High Low	 V_{IH} V_{IL}		 1.6 0		 3.6 0.4	 V V
Input current, high	I_{IH}			120		µA
Input current, low	I_{IL}				1	µA

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

Table 7. SKY85717-21 Control Logic

Mode	CRX (Pin 15)	LNA_EN (Pin 16) (Note 1)	PA_EN (Pin 6) (Note 2)	VLIN (Pin 9)
WLAN receive	1	1	0	0
WLAN receive bypass mode	1	0	0	0
WLAN transmit, high linearity mode	0	0	1	1
WLAN transmit, high efficiency mode	0	0	1	0
WLAN off	0	0	0	0

Note 1: LNA is on while LNA_EN is high. LNA is off and in bypass mode when LNA_EN is low.

Note 2: PA_EN controls PA enable and transmit/receive switch logic.

Evaluation Board Description

The SKY85717-21 Evaluation Board is used to test the performance of the SKY85717-21 FEM. A suggested application schematic diagram is shown in Figure 3. A photograph of the Evaluation Board is shown in Figure 4. A Bill of Materials (BOM) for the Evaluation Board is provided in Table 8.

Evaluation Board Test Procedures

1. Connect the system ground to connector J4, pin 2, of the Evaluation Board.
2. Apply 5 V to connector J4, pins 1 and 3.
3. Select a path to test according to the modes shown in Table 7.
4. Connect a multimeter or oscilloscope to connector J5, pin 12, to monitor the power detector voltage.
5. Apply an RF signal to connector J1 (ANT) to monitor the RX to ANT performance. Measure the response from the output of connector J2 (RX).
6. Apply an RF signal to connector J3 (TX) to monitor the ANT to TX performance. Monitor the output power on connector J1 (ANT). Care should be taken not to overdrive the amplifier by applying too much RF on the input to the device (–20 dBm provides a suitable starting input power for the device).

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 RX and ANT ports are AC-coupled and do not require DC blocking capacitors. There are ESD diodes to ground and a DC blocking capacitor between the TX port (pin 8) and the die. Therefore, there is no DC present on this port.
- If the TX port is connected to an external component with >3 VDC present on it, a 10 pF (component C8) general purpose blocking capacitor is recommended.
- Capacitors C6 (1 µF) and C7 (100 pF) should be on the primary side of the Evaluation Board at a minimum manufacturable distance from the FEM.
- Capacitor C20 (0.3 pF) needs to be as close as possible at manufacturable distance from the ANT pin of the IC, followed by L1 (1.0 nH) and C19 (0.3 pF), also at manufacturable distance from C20 and L1, respectively.
- The ground pad of the SKY85717-21 has special electrical and thermal grounding requirements. This pad is the main thermal conduit for heat dissipation. Because 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.
- Evaluation Board trace losses are:

  RX = TX = 0.32 dB and ANT = 0.35 dB.

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

Package Dimensions

The PCB layout footprint for the SKY85717-21 is shown in Figure 5. Typical part markings are shown in Figure 6. Package dimensions for the 16-pin QFN are shown in Figure 7, and tape and reel dimensions are provided in Figure 8.

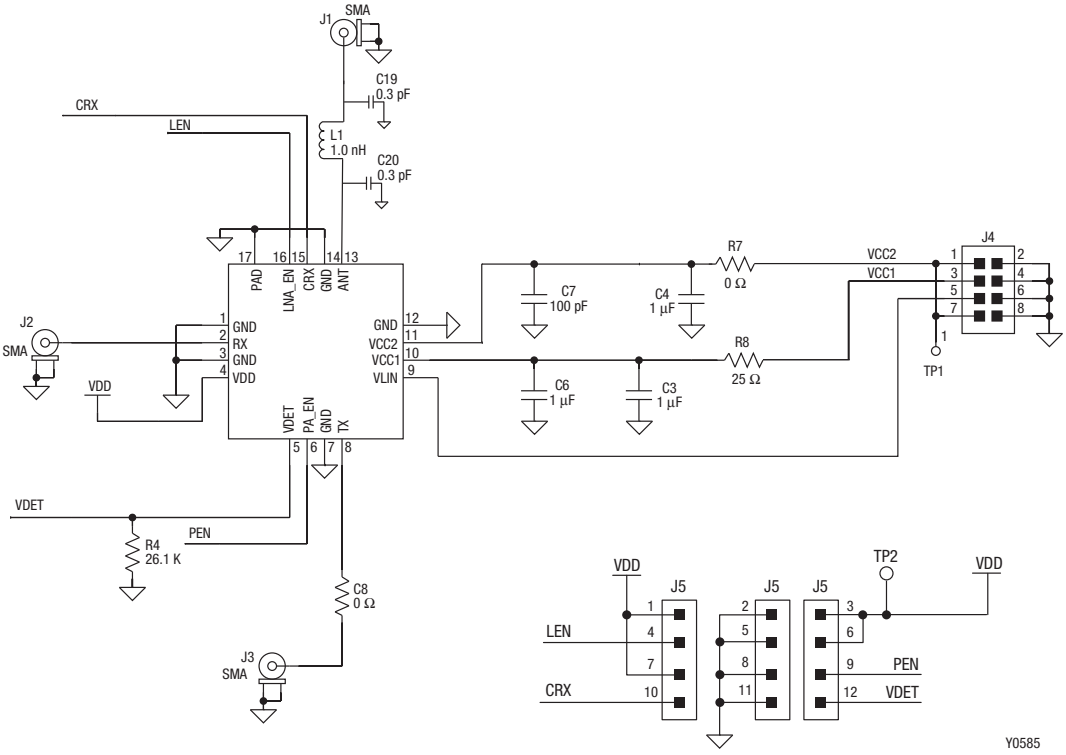


Figure 3. SKY85717-21 Application Schematic

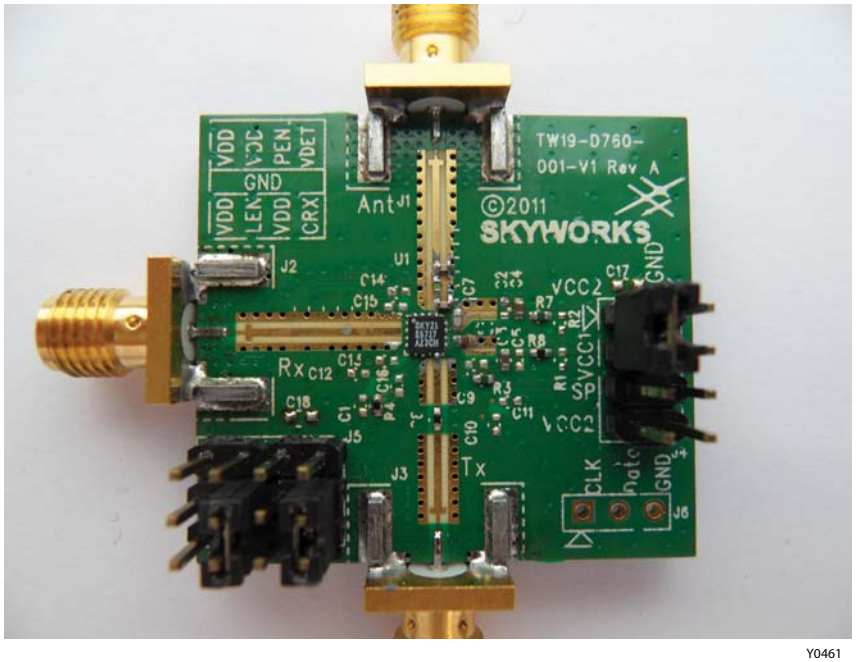
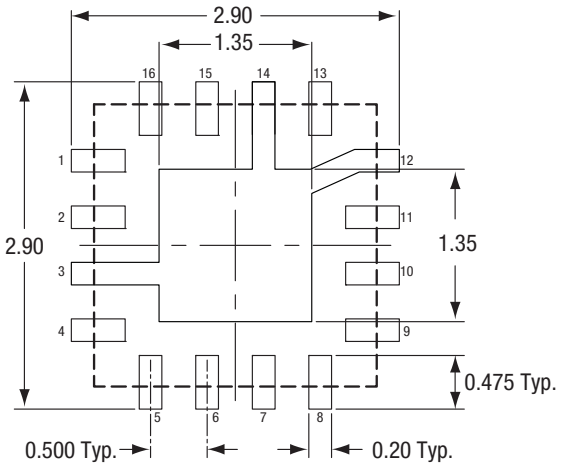


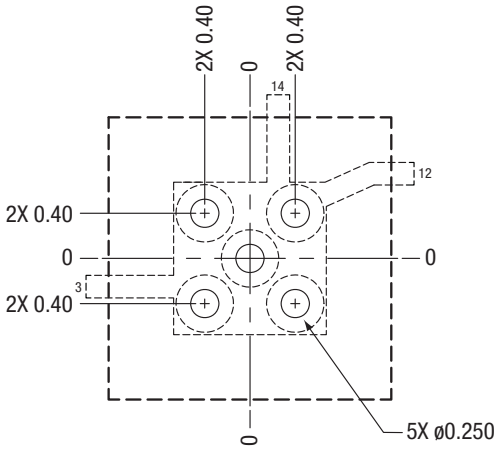
Figure 4. SKY85717-21 Evaluation Board Assembly

Table 8. SKY85717-21 Evaluation Board Bill of Materials (BOM)

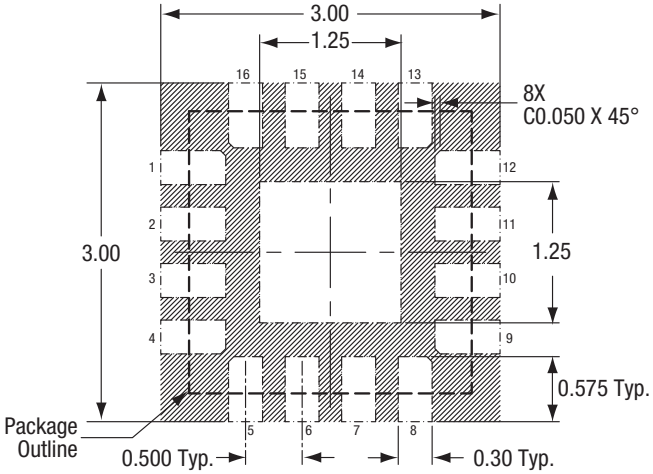
Reference	Value	Manufacturer	Mfr Part Number	Package	Description
R7	0 Ω	Panasonic	ERJ2GEJ0R0	0402	Thick film chip resistor
L1	1.0 nH	Murata	LQG15HN1N0S02D	0402	High frequency multilayer
R8	24.9 Ω	Panasonic	ERJ2RKF24R9	0402	Thick film chip resistor
R4	26.1K	Panasonic	ERJ2RKF2612	0402	Thick film chip resistor
C7	100 pF	Murata	GRM1555C1H101JZ01	0402	Multilayer ceramic
C19, C20	0.3 pF	Murata	GJM1555C1HR30WB01	0402	RF, High Q, low loss
C8, R3	0 Ω	Panasonic	ERJ2GE0R00	0402	Thick film chip resistor
C3, C4, C6	1 uF	TDK Corporation	C1005X5R1A105K	0402	Multilayer ceramic



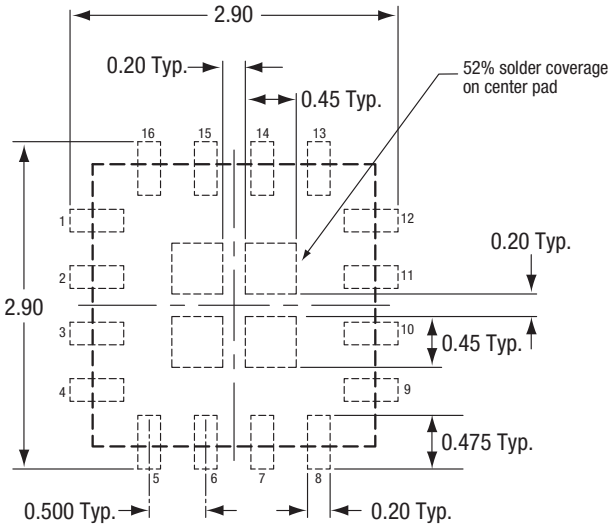
Board Metal



Via Pattern
(Note 4)



Solder Mask Pattern
(Note 6)



Stencil Pattern
(Note 5)

Notes:

1. *All dimensions are in millimeters*
2. *Dimensioning and tolerancing according to ASME Y14.5M-1994*
3. *Unless specified, dimensions are symmetrical about center lines.*
4. *Via hole recommendations: 0.025 mm Cu via wall plating (minimum), soldermask on the far side should tent or plug via holes.*
5. *Stencil recommendations: 0.10 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.*

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Figure 5. SKY85717-21 PCB Layout Footprint

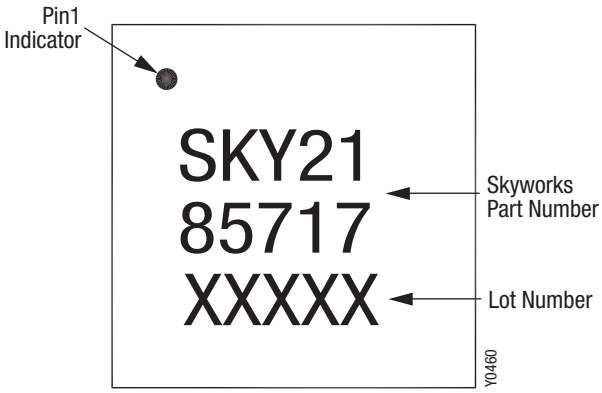
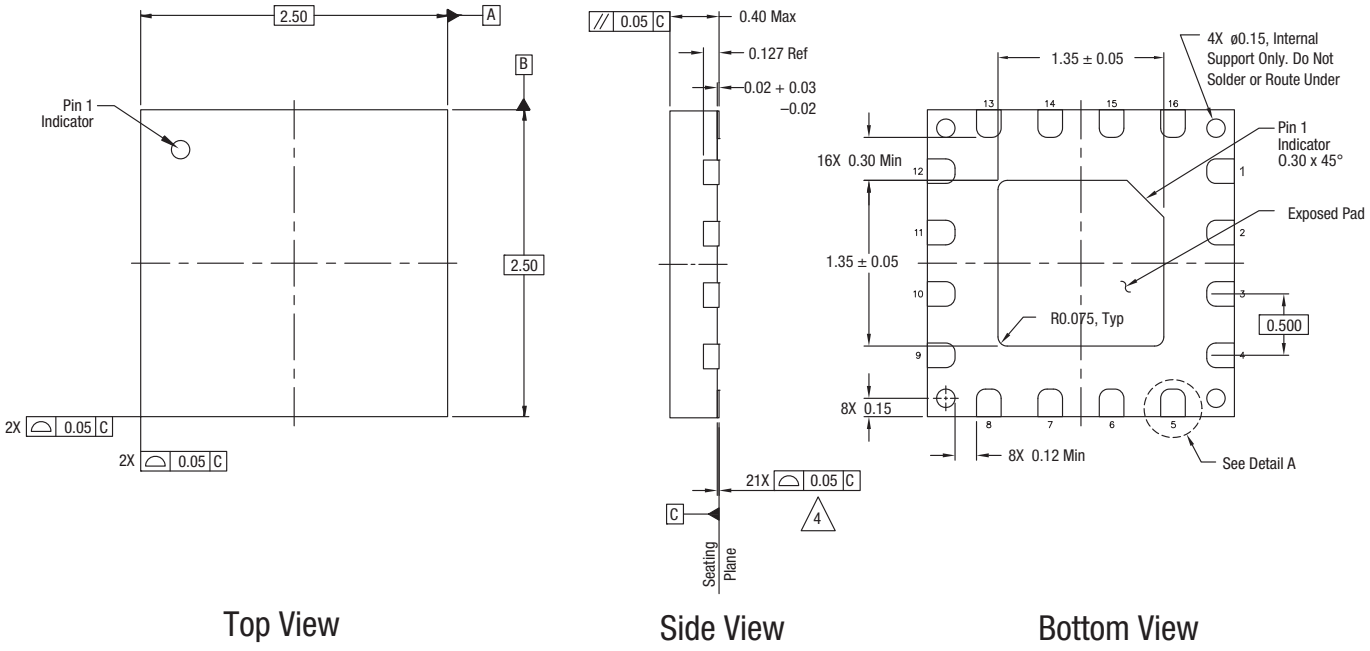


Figure 6. Typical Part Markings (Top View)



Notes:

1. *All measurements are in millimeters.*
2. *Dimensions and tolerances according to ASME Y14.5M-1994.*
3. *Unless otherwise specified the following values apply:*
   Decimal Tolerance: *Angular Tolerance:*
   X.X (1 place) ± 0.1 mm ± 0.5°
   X.XX (2 places) ± 0.05 mm
   X.XXX (3 places) ± 0.025 mm
4. *Coplanarity applies to the terminals as well as all other bottom surface metallization.*
5. *Dimension applies to metallized terminal. If terminal tip has a radius, dimension should not be measured in that radius area.*
6. *Unless specified, dimensions are symmetrical about center lines.*

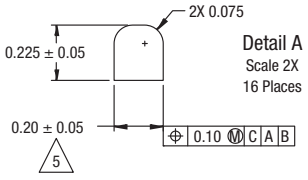


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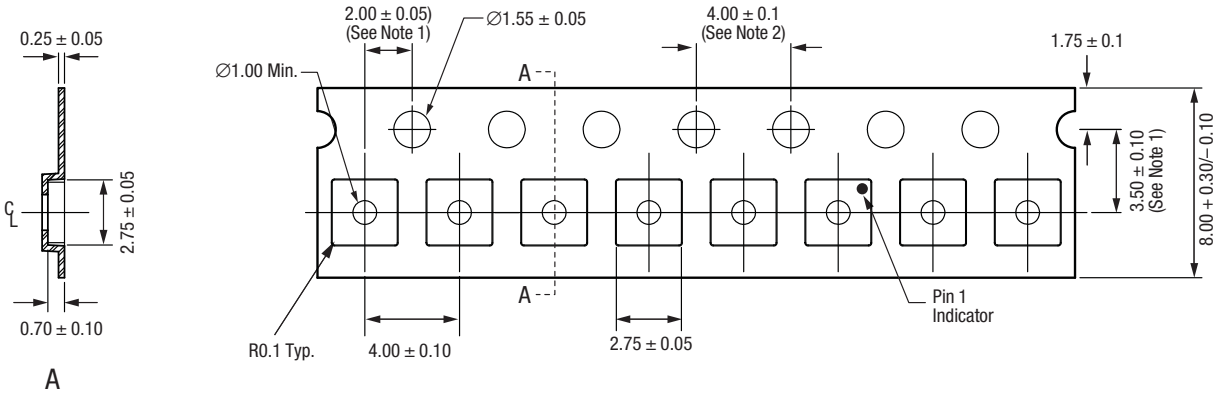
Figure 7. SKY85717-21 16-Pin QFN Package Dimensions



Notes:
1. *Measured from centerline of sprocket hole to centerline of pocket.*
2. *Cumulative tolerance of 10 sprocket holes: ±0.02 mm.*
3. *All measurements are in millimeters.*

S2678a

Figure 8. SKY85717-21 Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY85717-21: 5 GHz, 802.11ac Front-End Module	SKY85717-21	SKY85717-21-EVB