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## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China





DATA SHEET

# SKY85709-11: 5 GHz 802.11ac WLAN Front-End Module

## Applications

- WiFi-enabled handsets, tablets, and mobile/portable systems
- System-in-Package (SIP) modules for embedded systems
- WLAN-enabled wireless video systems

## Features

- Integrated high-performance 5 GHz PA with harmonic filter, LNA with bypass, and SPDT
- Fully matched input and output
- Integrated, positive slope power detector
- Transmit gain: 30 dB
- Receive gain: 13.5 dB
- Output power: +19 dBm @ 2% EVM, 64 QAM 54 Mbps
- Output power: +18 dBm @ 2% EVM, MCS7 HT40
- Output power: +16 dBm @ 1.5% EVM, MCS9 HT80
- Direct connection to battery with 3.6 V nominal supply voltage
- Small, QFN (16-pin, 2.5 x 2.5 mm) package (MSL1, 260 °C per JEDEC J-STD-020)



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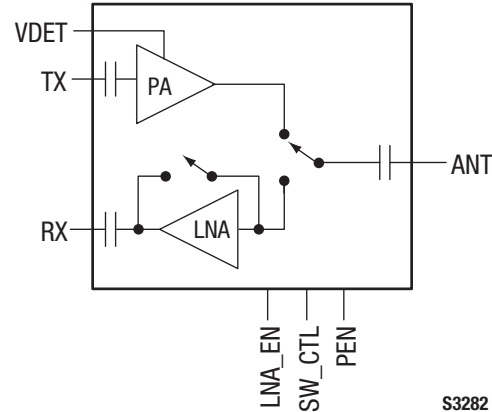


Figure 1. SKY85709-11 Block Diagram

## Description

The SKY85709-11 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 802.11n/ac applications and systems. The device operates from a single supply voltage of 3.6 V.

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 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.

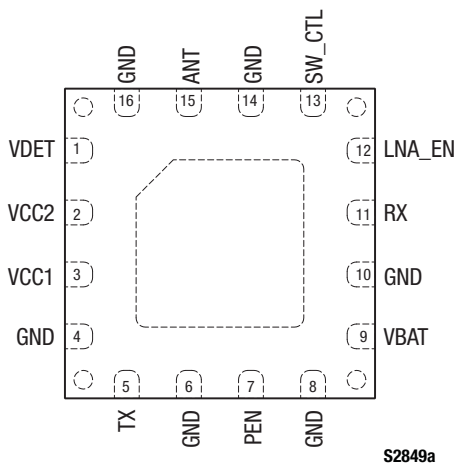


Figure 2. SKY85709-11 Pinout – 16-Pin QFN (Top View)

### Technical Description

The SKY85709-11 is comprised of a high performance 5 GHz PA, a 5 GHz LNA with bypass, and a 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 PA can be shut off using the PEN signal (pin 7).

### Electrical and Mechanical Specifications

Signal pin assignments and functional pin descriptions are described in Table 1. The absolute maximum ratings of the SKY85709-11 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 SKY85709-11 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 SKY85709-11 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.

**Table 1. SKY85709-11 Signal Descriptions**

Pin	Name	Description	Pin	Name	Description
1	VDET	Detector output voltage	9	VBAT	Logic and LNA supply
2	VCC2	Supply voltage	10	GND	Ground
3	VCC1	Supply voltage	11	RX	RF receive output
4	GND	Ground	12	LNA_EN	LNA enable
5	TX	RF transmit input	13	SW_CTL	Switch control voltage
6	GND	Ground	14	GND	Ground
7	PEN	PA enable	15	ANT	Antenna
8	GND	Ground	16	GND	Ground

**Table 2. SKY85709-11 Absolute Maximum Ratings (Note 1)**

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	V <sub>BAT</sub> , V <sub>CC</sub>	-0.3	+5.5	V
DC input on control pin	V <sub>IN</sub>	-0.3	+3.6	V
Input power (ANT terminated in 50 Ω match)	P <sub>IN</sub>		+5	dBm
Case operating temperature	T <sub>A</sub>	-40	+85	°C
Storage temperature	T <sub>ST</sub>	-40	+140	°C

**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. SKY85709-11 Recommended Operating Conditions**

Parameter	Symbol	Minimum	Typical	Maximum	Units
Supply voltage relative to GND = 0 V	V <sub>CC</sub>	3.0	3.6	4.8	V
Operating temperature	T <sub>A</sub>	-40	+25	+85	°C
Logic supply	V <sub>BAT</sub>	3.0	3.3	4.8	V

**Table 4. SKY85709-11 Electrical Specifications: DC Characteristics (Note 1)**

(V<sub>CC</sub> = V<sub>BAT</sub> = 3.6 V, P<sub>EN</sub> = 3.6 V, T<sub>A</sub> = 25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Supply current	I <sub>CC-A</sub>	P <sub>OUT</sub> = +19 dBm, 54 Mbps		260	325	mA
Quiescent current	I <sub>CC</sub>	No RF		200	260	mA
LNA supply current	I <sub>CC_LNA</sub>	LNA_EN = 3.3 V, P <sub>EN</sub> = SW_CTL = 0 V		13	18	mA
LNA bypass supply current	I <sub>CC_LNA_BYP</sub>	LNA_EN = P <sub>EN</sub> = SW_CTL = 0 V		20	25	μA

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

**Table 5. SKY85709-11 Electrical Specifications: General (1 of 2) (Note 1)**

(V<sub>CC</sub> = V<sub>BAT</sub> = 3.6 V, T<sub>A</sub> = 25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
<b>Transmit Characteristics</b>						
Frequency range	f		4900		5925	MHz
Error Vector Magnitude	EVM	5150 to 5850 MHz: P <sub>OUT</sub> = 19 dBm, 54 Mbps P <sub>OUT</sub> = 18 dBm, MCS7 HT40 P <sub>OUT</sub> = 16 dBm, MCS9 HT80		2.0 2.0 1.5	3.0 3.0 2.3	% % %
Small signal gain	S21	5150 to 5850 MHz	27	30	33	dB

**Table 5. SKY85709-11 Electrical Specifications: General (2 of 2) (Note 1)**  
**(Vcc = VBAT = 3.6 V, TA = 25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)**

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
<b>Transmit Characteristics (continued)</b>						
Gain flatness		Over any 80 MHz bandwidth		±0.25		dB
		Full band		±1		dB
Harmonics: Second Third	2fo 3fo	P <sub>OUT</sub> = +19 dBm, 6 Mbps, 802.11a			-30 -40	dBm/MHz dBm/MHz
Delay and rise/fall time	t <sub>DR</sub> , t <sub>DF</sub>	50% of V <sub>PA_EN</sub> edge and 90/10% of final output power level			400	ns
Input return loss	S11	@ TX port		-14	-9	dB
Output return loss	S22	@ ANT port		-15	-10	dB
Stability	Stab	VCC = VBAT = 4.2 V, CW, P <sub>OUT</sub> = +21 dBm, 0.1 GHz to 20 GHz, load VSWR = 6:1	All non-harmonically related outputs < -43 dBm/MHz			
Ruggedness		VCC = VBAT = 4.2 V, P <sub>IN</sub> = -4 dBm 6Mbps, 0.1 GHz to 20 GHz, load VSWR = 10:1	No permanent damage or performance degradation			
<b>Receive Characteristics</b>						
Frequency range	f		4900		5925	MHz
Small signal gain	S21	LNA enabled	+11	+13.5	+16	dB
		Bypass mode	-7	-5	-3	dB
Noise figure	NF			2.7		dB
3 <sup>rd</sup> Order Input Intercept Point	IIP3	LNA enabled		+3		dBm
		Bypass mode		+19		dBm
2 <sup>nd</sup> Order Input Intercept Point	IIP2	@ 2600 MHz		+50		dBm
Input return loss	S11	LNA enabled		-13	-10	dB
		Bypass mode		-13	-10	dB
Output return loss	S22	LNA enabled		-7	-3.5	dB
		Bypass mode		-15	-12	dB
Enable time	t <sub>EN</sub>	10% to 90% of receive RF power, from time that LNA_EN is at 50%			500	ns
Switch isolation	ISOL <sub>SW</sub>		17			dB
<b>Power Detector Characteristics</b>						
Frequency range	f		4900		5925	MHz
Power detector range, CW	PDR	Measured @ ANT pin	+4		+25	dBm
Output impedance	PDZ <sub>LOAD</sub>			2.2		kΩ
Output voltage	PDV <sub>NO_RF</sub>	P <sub>OUT</sub> = no RF, measured in to 1 MΩ, 5500 MHz		0.2		V
	PDV <sub>P19</sub>	P <sub>OUT</sub> = +19 dBm, CW, measured in to 1 MΩ, 5500 MHz		0.85		V
Detector bandwidth	PD <sub>BW</sub>			4		MHz

**Table 6. SKY85709-11 Electrical Specifications: Control Logic Characteristics**  
(V<sub>CC</sub> = V<sub>BAT</sub> = 3.6 V, T<sub>A</sub> = 25 °C, All Unused Ports Terminated with 50 Ω, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Control voltage:						
High	V <sub>IH</sub>		1.6		3.6	V
Low	V <sub>IL</sub>		0		0.4	V
Input current:						
High	I <sub>IH</sub>				10	μA
Low	I <sub>IL</sub>				10	μA

**Table 7. SKY85709-11 Control Logic**

Mode	PEN (Pin 7)	SW_CTL (Pin 13)	LNA_EN (Pin 12)
WLAN transmit	1	1	0
WLAN receive	0	0	1
WLAN receive bypass mode	0	0	0

Note: "1" = 3.3 V, "0" = 0 V. Any other state than described in this Table places the switch into an undefined state. An undefined state will not damage the device.

## Evaluation Board Description

The SKY85709-11 Evaluation Board is used to test the performance of the SKY85709-11 FEM. A suggested application schematic diagram is shown in Figure 3. A photograph of the Evaluation Board is shown in Figure 4.

## Evaluation Board Test Procedures

1. Connect the system ground to pin 1 of connector J1.
2. Apply 3.6 V to pin 4 of connector J1 and to pin 2 of connector J2.
3. Select a path to test according to the modes shown in Table 7.
4. Connect a multimeter or oscilloscope to pin 2 of connector J1 to monitor the power detector voltage.
5. Apply an RF signal to connector J3 (ANT) to monitor the RX to ANT performance. Measure the response from the output of connector J4 (RX).
6. Apply an RF signal to connector J5 (TX) to monitor the TX to ANT performance. Monitor the output power on connector J3 (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 ports are AC-coupled and do not require DC blocking capacitors.
- Capacitors C1 and C9 (100 pF) should be on the primary side of the Evaluation Board at a minimum manufacturable distance from the FEM.
- The ground pad of the SKY85709-11 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 conduct as much heat as possible from the device. Therefore, design the connection to the ground pad to dissipate the maximum heat produced by the FEM. Multiple vias to the grounding layer are required.

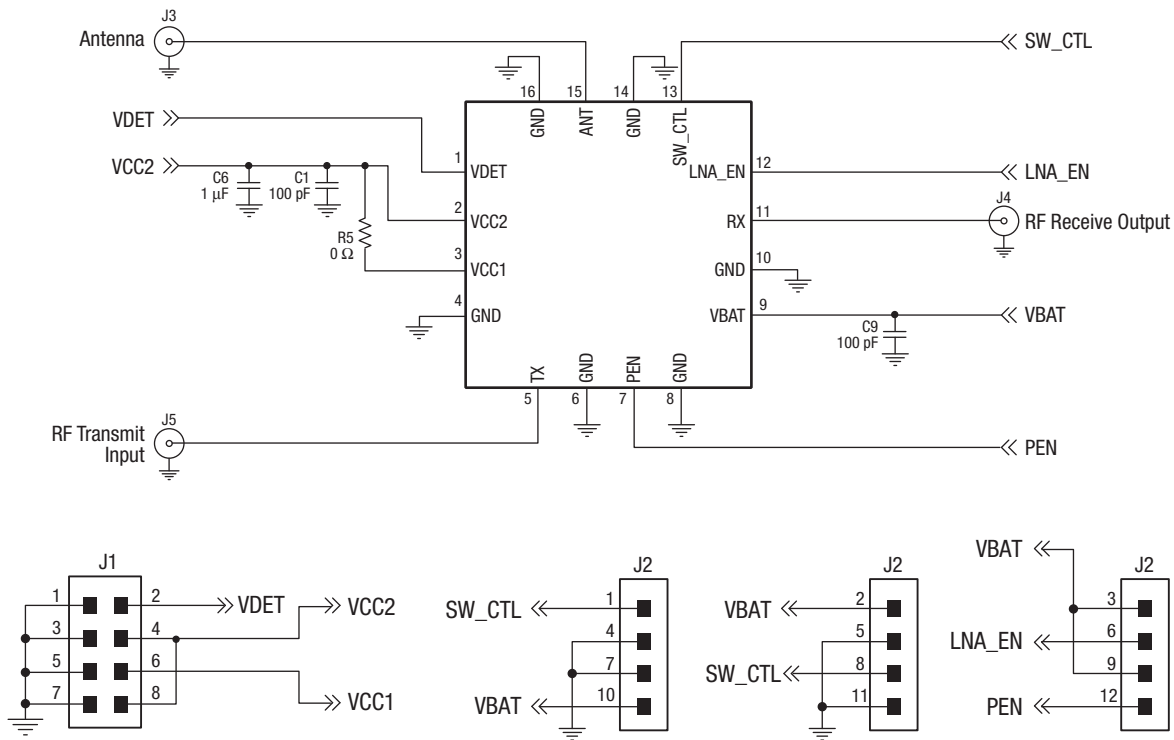
## Evaluation Board Losses

The board losses from the RF connectors of the Evaluation Board to the pins of the SKY85709-11 are:

$$\text{ANT} = \text{TXT} = \text{RX} = 0.20 \text{ dB}$$

## Package Dimensions

The PCB layout footprint for the SKY85709-11 is shown in Figure 5. Typical case 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.



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Figure 3. SKY85709-11 Application Schematic

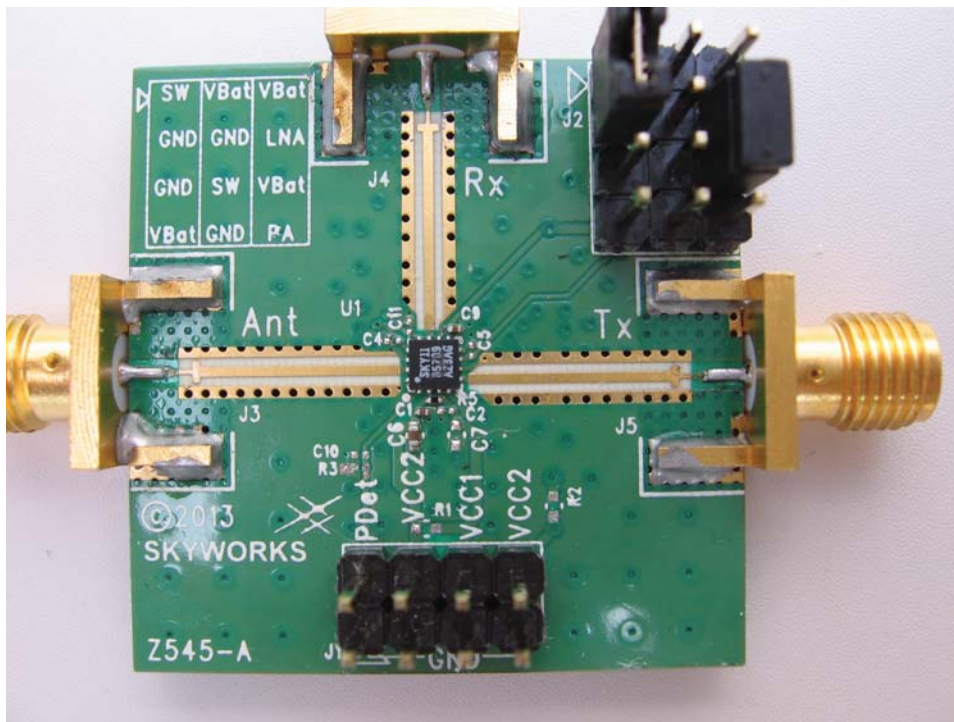
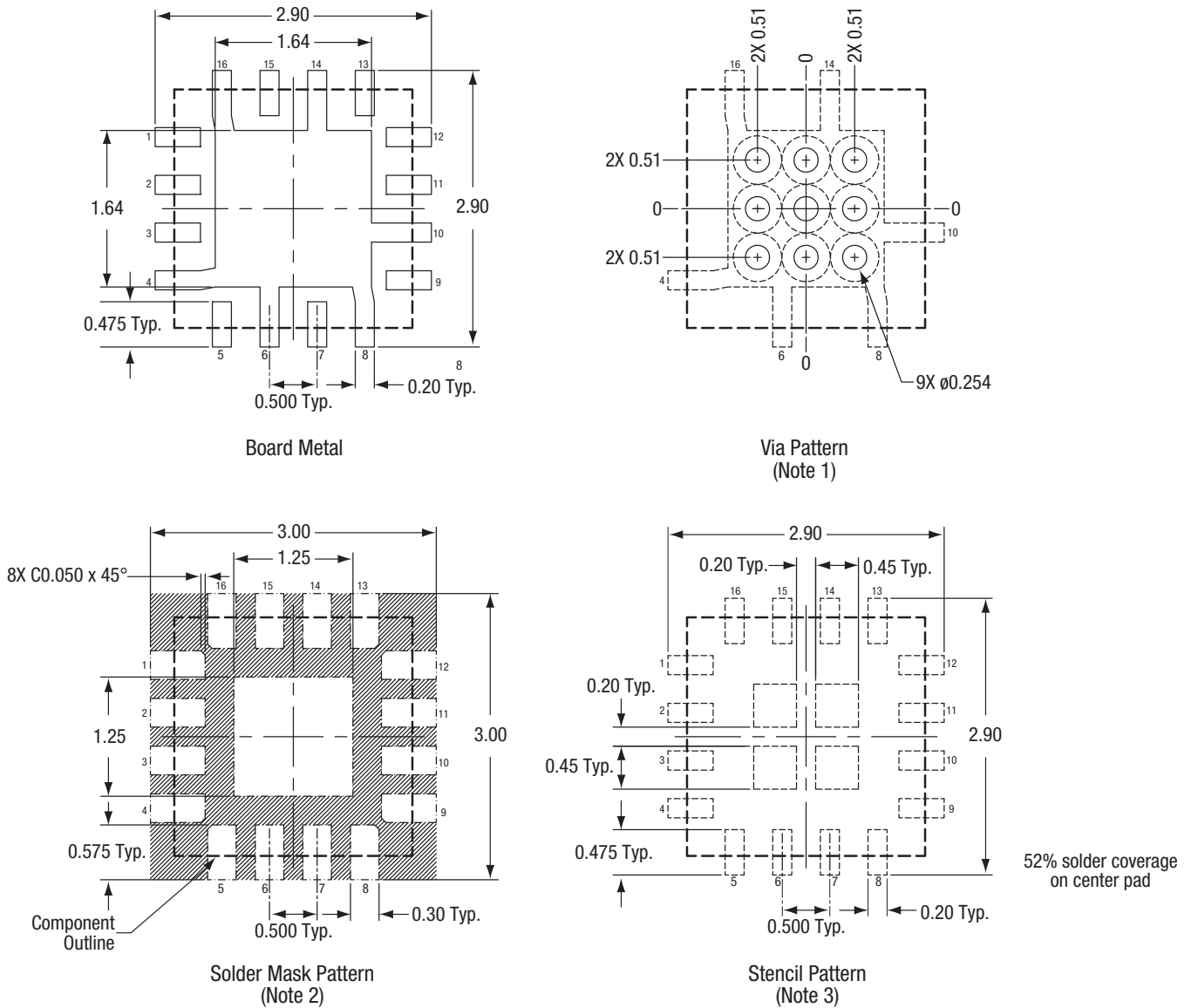


Figure 4. SKY85709-11 Evaluation Board



NOTES:

1. Via hole recommendations:  
0.025 mm Cu via wall plating (minimum),  
via hole to be filled with conductive paste  
and plated over.
2. Soldermask recommendations:  
Contact board fabricator for recommended  
soldermask offset and tolerance.
3. Stencil recommendations:  
0.10 mm stencil thickness, laser cut apertures,  
trapezoidal walls and rounded corners offer  
better paste release.

Dimension and tolerancing according to ASME Y14.5M-1994.  
Unless specified, dimensions are symmetrical about center lines.  
All dimensions are in millimeters.

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Figure 5. SKY85709-11 PCB Layout Footprint



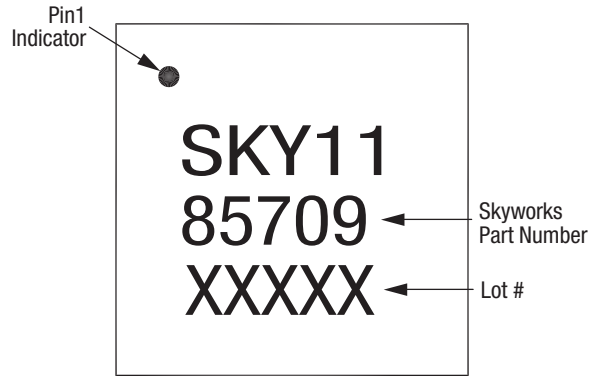
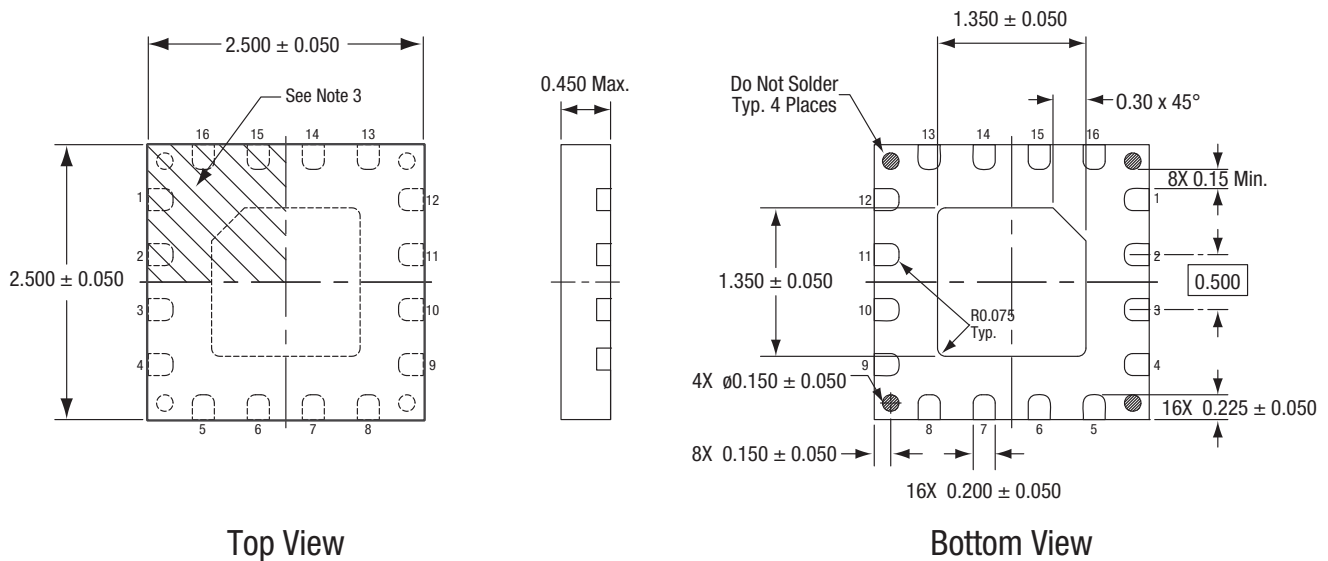


Figure 6. Typical Case Markings (Top View)



Top View

Bottom View

NOTES:

1. All measurements are in millimeters.
2. Dimensioning and tolerancing according to ASME Y14.5M-1994.  
Unless otherwise specified the following values apply:  
Decimal Tolerance:      Angular Tolerance:  
X.X (1 place) ± 0.1 mm      ±1°  
X.XX (2 places) ± 0.05 mm  
X.XXX (3 places) ± 0.025 mm
3. Terminal #1 identification mark located within marked area.
4. Unless specified, dimensions are symmetrical about center lines.

S2620

Figure 7. SKY85709-11 16-Pin QFN Package Dimensions



## Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY85709-11: 5 GHz Front-End Module	SKY85709-11	SKY85709-EVB

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