DATA SHEET

SKY65135-31: 2.4-2.5 GHz WLAN Power Amplifier

Applications

- IEEE 802.11 b/g WLANs
- ISM band transmitters
- WCS fixed wireless
- Wireless access nodes

Features

- EVM < 2.8% for P_{OUT} > +27 dBm
- High gain = 31 dB
- Internal RF match with DC block and active bias circuits
- Single DC supply = +5 V
- Operating temperature = –40 °C to +85 °C
- Small, MCM (20-pin, 6 x 6 mm) package (MSL3, 260 °C per JEDEC J-STD-020)

Skyworks offers lead (Pb)-free RoHS (Restriction of Hazardous Substances) compliant packaging.

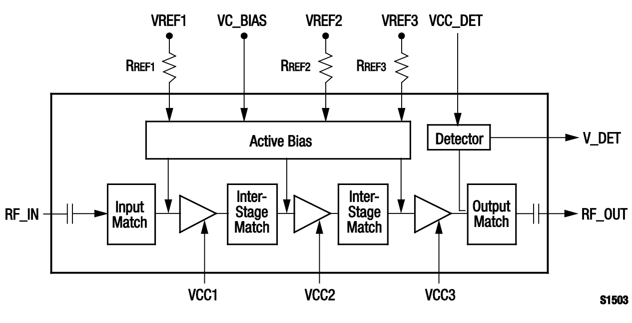


Figure 1. SKY65135-31 Block Diagram

Description

The SKY65135-31 is a Microwave Monolithic Integrated Circuit (MMIC) Power Amplifier (PA) with superior output power, linearity, and efficiency. These features make the SKY65135-31 ideal for Wireless Local Area Network (WLAN) applications. The high linearity (low EVM) and high efficiency of this device makes it ideal for use in the transmit chain of WLAN access points or modems.

The SKY65135-31 is fabricated using Skyworks high reliability Heterojunction Bipolar Transistor (HBT) InGaP process, which allows for single supply operation while maintaining high efficiency and good linearity. The device is internally matched and mounted in a 20-pin, 6 x 6 mm Multi-Chip Module (MCM) Surface-Mounted Technology (SMT) package, which allows for a highly manufacturable low cost solution.

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.

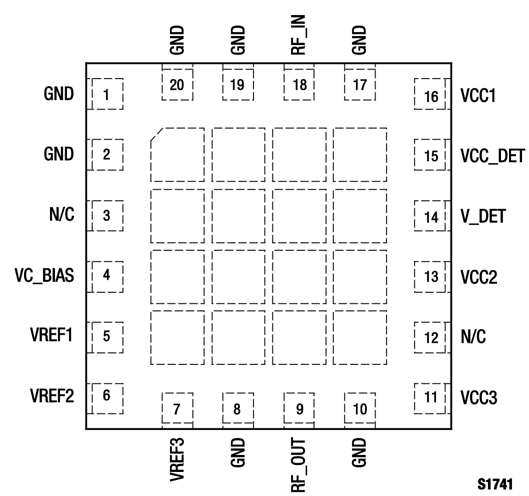


Figure 2. SKY65135-31 Pinout – 20-Pin MCM (Top View)

Table 1. SKY65135-31 Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	GND	Ground	11	VCC3	Stage 3 collector voltage
2	GND	Ground	12	N/C	No connection
3	N/C	No connection	13	VCC2	Stage 2 collector voltage
4	VC_BIAS	Bias voltage	14	V_DET	Detector output signal
5	VREF1	Bias reference voltage 1	15	VCC_DET	Detector supply voltage
6	VREF2	Bias reference voltage 2	16	VCC1	Stage 1 collector voltage
7	VREF3	Bias reference voltage 3	17	GND	Ground
8	GND	Ground	18	RF_IN	RF input
9	RF_OUT	RF output	19	GND	Ground
10	GND	Ground	20	GND	Ground

Note: The center attachment pad must have a low inductance and low thermal resistance connection to the printed circuit board ground plane.

Functional Description

The SKY65135-31 is a three-stage, HBT InGaP device optimized for high linearity and power efficiency. It contains all of the needed RF matching and DC biasing circuits. An in-module active bias circuit is included within the device for all three amplifier stages, which provides excellent gain tracking over temperature and voltage variations.

The first, second, and third output stages are independently supplied using the VCC1, VCC2, and VCC3 signals (pins 16, 13 and 11,respectively). The DC control voltage that sets the bias for all three stages is supplied by the VC_BIAS signal (pin 4). The Evaluation Board includes shunt decoupling capacitors on these pins to suppress any possible bias affect on the RF signal at low frequencies.

The bias reference voltages for stages 1, 2, and 3 are supplied using the common lines VREF1, VREF2, and VREF3 (pins 5, 6, and 7, respectively). The maximum voltage for these pins is 4 V. Resistors R1, R2, and R3 on the Evaluation Board set the correct bias to these pins when attached to a 5 V power supply.

The SKY65135-31 includes an output power detector voltage, V_DET, at pin 14. A bias voltage is required to operate the detector. The detector supply voltage is provided through the VCC_DET signal (pin 15). The maximum voltage for this pin is 4 V. Resistor R5 on the Evaluation Board sets the correct bias to this pin when attached to a 5 V power supply.

Pin 18 is the RF input and Pin 9 is the RF output. External DC blocking or RF matching is not required on the RF input and output. Grounding is through several ground pins and the package center ground.

These features make the device suitable for wideband digital applications where PA linearity and power consumption are of critical importance (e.g., WLANs). The device has been characterized with the highest specified data rates for 802.11b (11 Mbps) and 802.11g (54 Mbps). Under these stringent test conditions, the device exhibits excellent spectral purity and power efficiency.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY65135-31 are provided in Table 2. The recommended operating conditions are specified in Table 3 and electrical specifications are provided in Table 4.

Performance characteristics for the SKY65135-31 are illustrated in Figures 3 through 17.

Table 2. SKY65135-31 Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Minimum	Maximum	Units
RF output power	P_{OUT}		+28	dBm
Supply voltage (VCC, VC_BIAS) (Note 2)	V_{CC}		5.5	V
Total supply current	I_{CC}		850	mA
Reference voltage (Note 2)	V_{REF}		4	V
Detector supply voltage (VCC_DET) (Note 2)			4	V
Power dissipation	P_D		3.3	W
Case temperature	T_C	–40	+85	°C
Storage temperature	T_{STG}	–55	+125	°C
Junction temperature	T_J		+150	°C
Thermal resistance	Θ_{JC}		20	°C/W

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.

Note 2: Voltage levels measured at the pins of the package. The Evaluation Board supply voltage levels may be different. Refer to the Evaluation Board schematic diagram in this document.

***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. SKY65135-31 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
RF output power	P_{OUT}		+27		dBm
Supply voltage (Note 1)	V_{CC}, V_{C_BIAS}	4.5	5.0	5.5	V
Reference voltage (Note 1)	V_{REF}		2.5		V
Detector supply voltage (Note 1)	V_{CC_DET}		3.6		V
Operating frequency	f	2412		2462	MHz
Case temperature	T_C	–40	+25	+85	°C

Note 1: Voltage levels measured at the pins of the package. The Evaluation Board supply voltage levels may be different. Refer to the Evaluation Board schematic diagram in this document.

Table 4. SKY65135-31 Electrical Specifications (Note 1) (Note 2)
(VCC1 = VCC2 = VCC3 = VREF1 = VREF2 = VREF3 = VC_BIAS = VCC_DET = 5 V, Characteristic Impedance [Z_0] = 50 Ω,
T_C = 25 °C, Frequency = 2.442 GHz, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
IEEE 802.11g Orthogonal Frequency Division Multiplexing Input Signal, Data Rate = 54 Mbps						
Maximum transmit power				+27		dBm
Error Vector Magnitude	EVM	@ P_{OUT} = +27 dBm		2.0	2.8	%
Continuous Wave Input Signal						
Small signal gain	|S21|	P_{IN} = –25 dBm	31	32		dB
Gain flatness		2.4 GHz to 2.5 GHz		1.0	1.4	dB
Input return loss	|S11|			–10	–8	dB
Output power @ 1 dB compression	OP1dB		+31.5	+32.5		dBm
Quiescent current	I_{CCQ}	No RF input	410	465	500	mA
Operational current	I_{CC_OP}	P_{OUT} = +27 dBm			820	mA
Noise Figure	NF			5		dB
Detector voltage	V_{DET}	P_{OUT} = +27 dBm	0.75	0.80	0.95	V
2nd harmonics	2fo	CW input		–26	–22	dBm
3rd harmonics	3fo	CW input		–33	–30	dBm

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

Note 2: Voltage measured at Evaluation Board pins.

Typical Performance Characteristics

(VCC1 = VCC2 = VCC3 = VREF1 = VREF2 = VREF3 = VC_BIAS = VCC_DET = 5 V, CW, Characteristic Impedance [Z_0] = 50 Ω,
T_C = 25 °C, Frequency = 2.442 GHz, Unless Otherwise Noted)

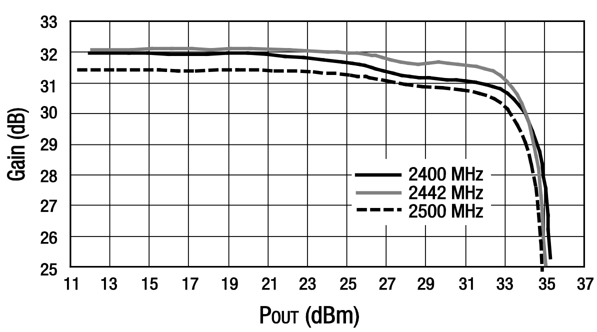


Figure 3. Gain vs Output Power Over Frequency

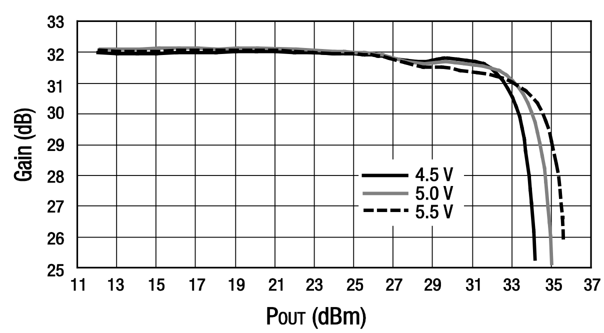


Figure 4. Gain vs Output Power Over Voltage

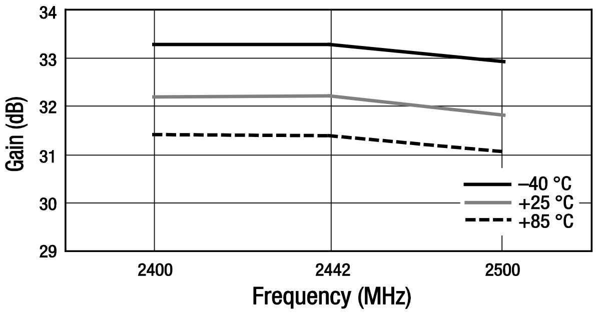


Figure 5. Small Signal Gain vs Frequency Over Temperature @ 5 V

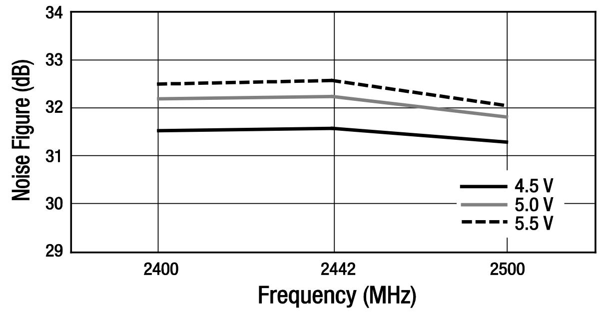


Figure 6. Small Signal Gain vs Frequency Over VCC @ 25 °C

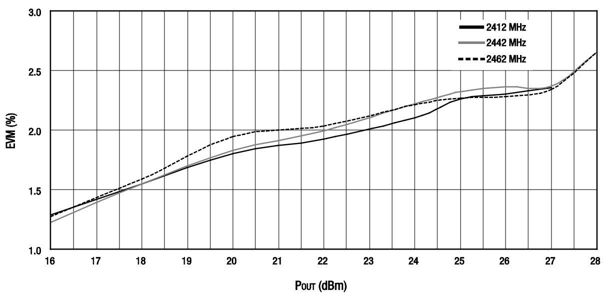


Figure 7. EVM vs Output Power Over Frequency

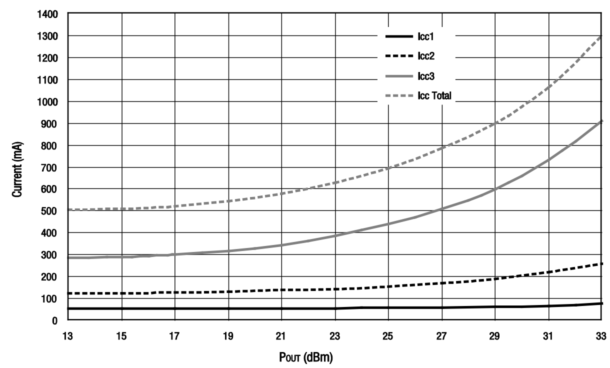


Figure 8. Current vs Output Power

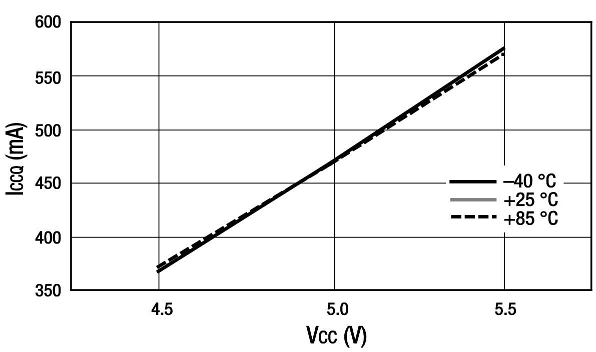


Figure 9. Quiescent Current vs VCC Over Temperature

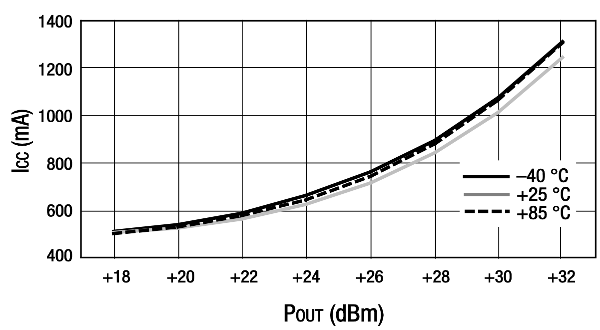


Figure 10. Current vs Output Power Over Temperature @ 5 V

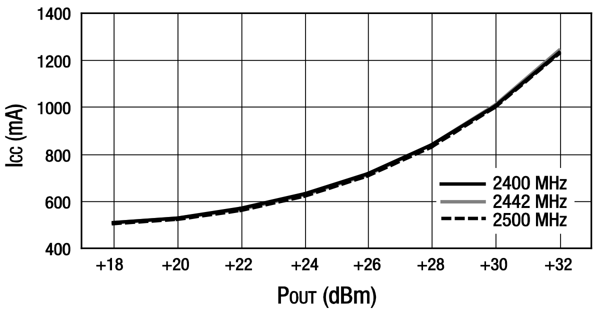


Figure 11. Supply Current vs Output Power Over Frequency

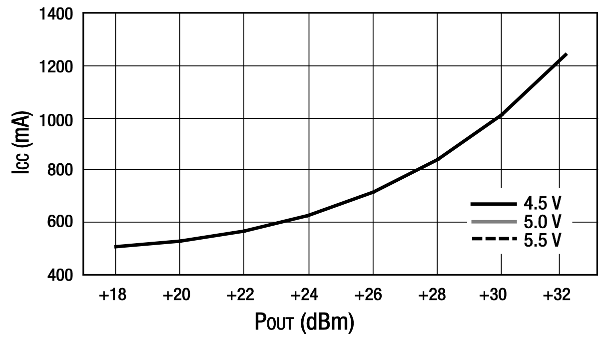


Figure 12. Supply Current vs Output Power Over Vcc

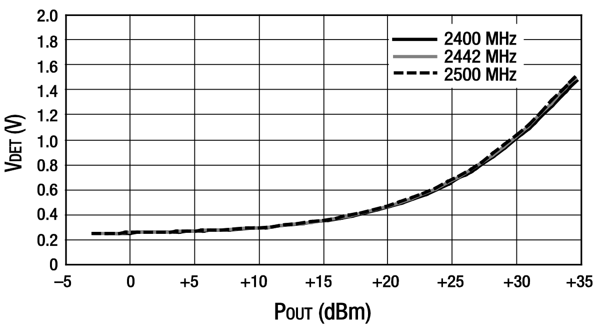


Figure 13. Detector Voltage vs Output Power Over Frequency

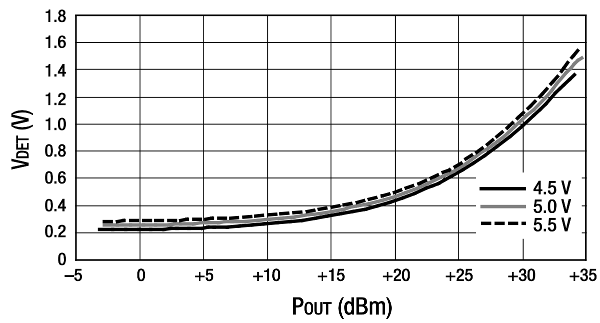


Figure 14. Detector Voltage vs Output Power Over Vcc

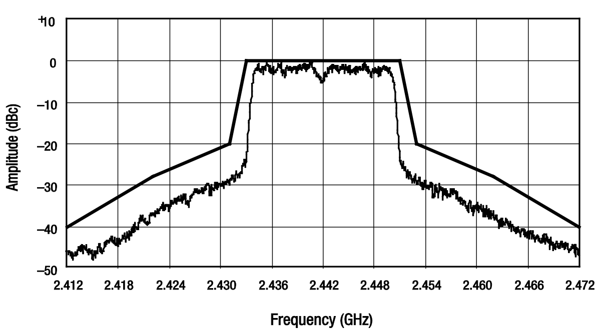


Figure 15. Spectral Response @ POUT = +30 dBm (802.11g, OFDM, 64 QAM @ 54 Mbps)

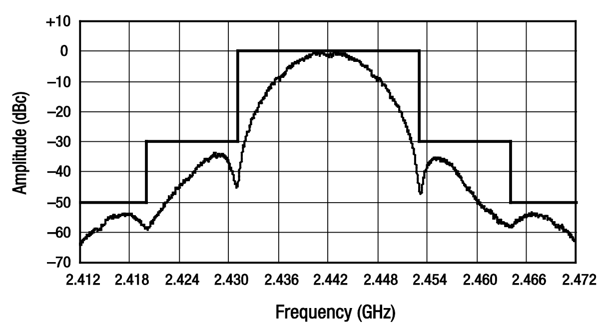


Figure 16. Spectral Response @ POUT = +31 dBm (802.11b, CCK @ 11 Mbps)

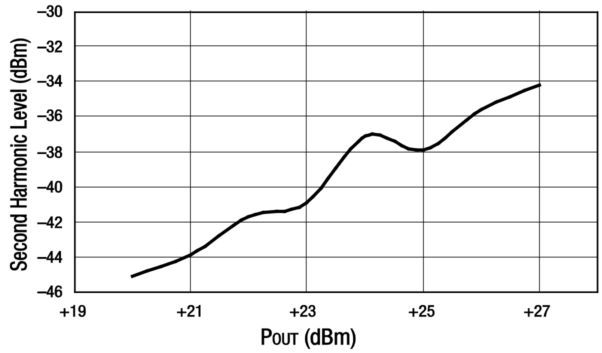


Figure 17. Second Harmonic vs Output Power (802.11b)

Evaluation Board Description

The SKY65135-31 Evaluation Board is used to test the performance of the SKY65135-31 PA. An Evaluation Board schematic diagram is provided in Figure 18. An assembly drawing for the Evaluation Board is shown in Figure 19.

An Evaluation Board layer detail drawing is shown in Figure 20. Layer detail physical characteristics are noted in Figure 21. Table 5 provides the Bill of Materials (BOM) list for Evaluation Board components.

Circuit Design Considerations

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

1. Paths to ground should be made as short as possible.
2. The ground pad of the SKY65135-31 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.
3. Bypass capacitors should be used on the DC supply lines. An RF inductor is required on the V_{CC} supply line to block RF signals from the DC supply. Refer to the schematic drawing in Figure 18 for further details.
4. The RF lines should be well separated from each other with solid ground in between traces to maximize input-to-output isolation.

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

Evaluation Board Test Procedure

Step 1: Connect a +5 V supply to the VCC1, VCC2, VCC3, VREF1, VREF2, VREF3, VC_BIAS, and VCC_DET pins. If available, enable the current limiting function of the power supply to 850 mA.

Step 2: If desired, connect a voltage meter to the V_DET pin.

Step 3: Connect a signal generator to the RF signal input port. Set it to the desired RF frequency at a power level of –15 dBm or less to the Evaluation Board. DO NOT enable the RF signal.

Step 4: Connect a spectrum analyzer to the RF signal output port.

Step 5: Enable the power supply.

Step 6: Enable the RF signal.

Step 7: Take measurements.

CAUTION: *If the input signal exceeds the rated power, the SKY65135-31 Evaluation Board can be permanently damaged.*

NOTE: *It is important to adjust the V_{CC} voltage source so that +5 V is measured at the board. The high collector currents will drop the collector voltage significantly if long leads are used. Adjust the bias voltage to compensate.*

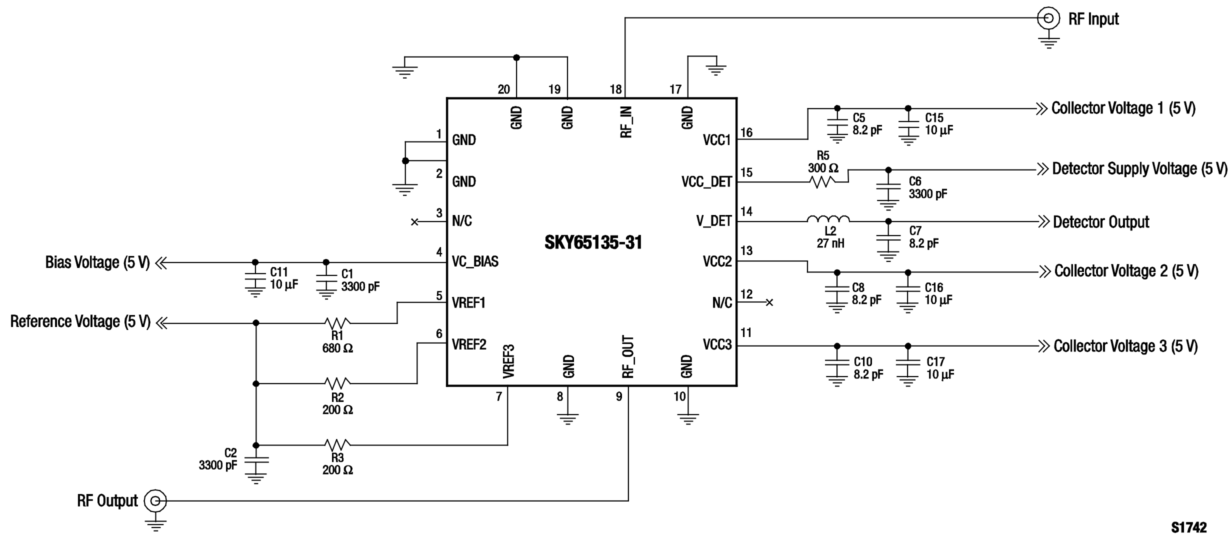


Figure 18. SKY65135-31 Evaluation Board Schematic

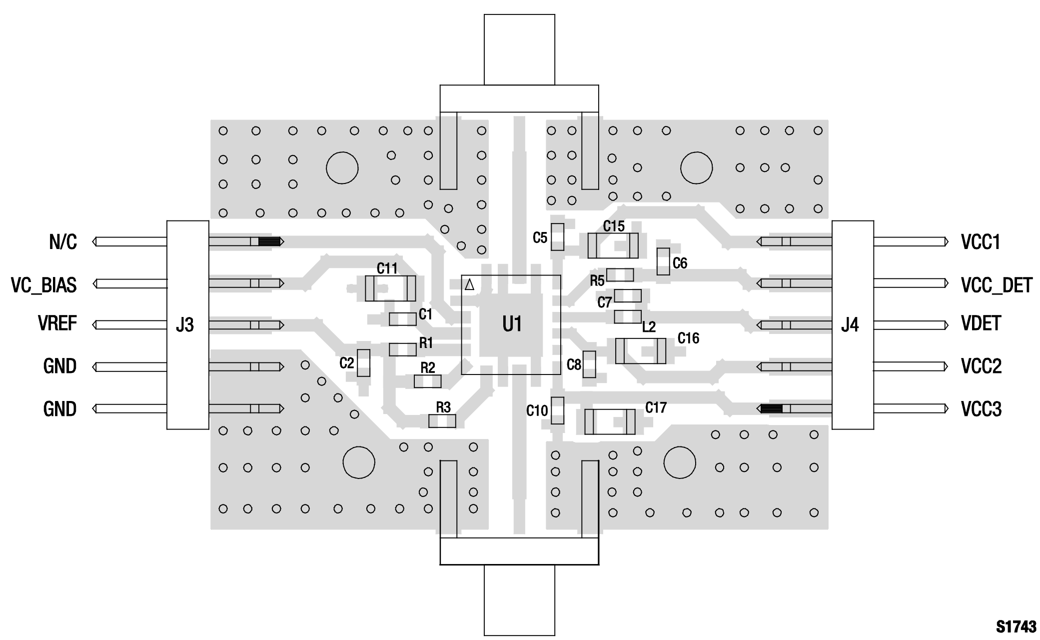
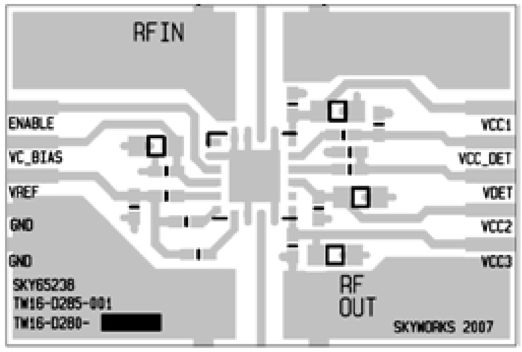
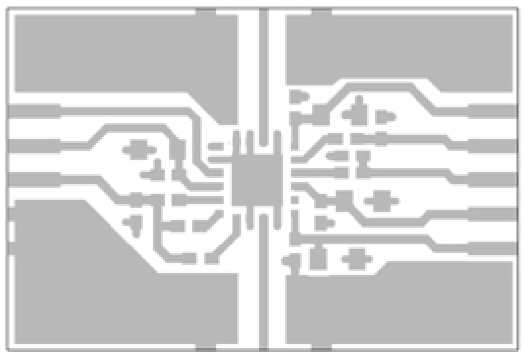


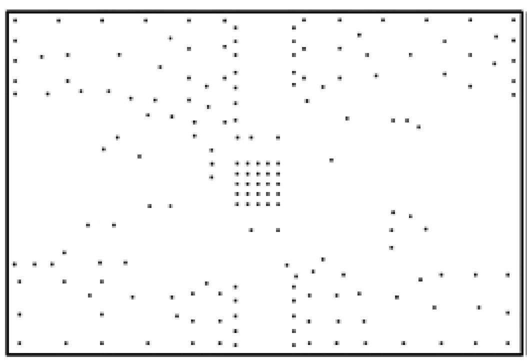
Figure 19. SKY65135-31 Evaluation Board Assembly Diagram



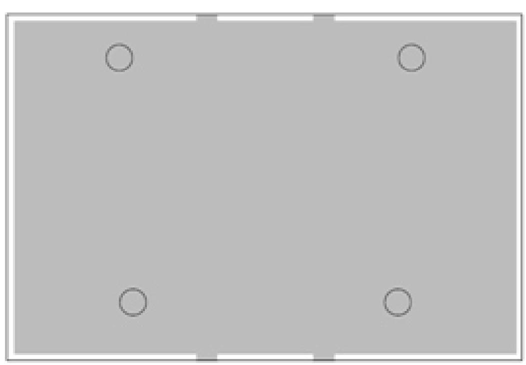
Layer 1: Silk Screen



Layer 1: Top Metal



Layer 2 and 3: Ground

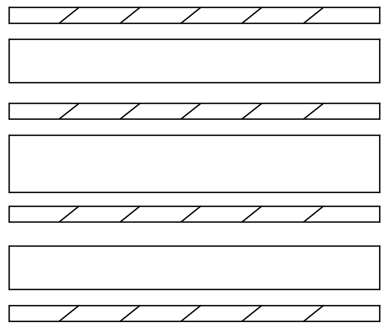


Layer 4: Backside Ground

S1508

Figure 20. SKY65135-31 Evaluation Board Layer Detail

Cross Section



Name	Thickness (mils)	Material	ε_r
L1	1.4	Cu	–
Lam1	12	Rogers 4003-12	3.38
L2 GND	1.4	Cu, 1 oz.	–
Lam2	4	FR4-4	4.35
L3 GND	1.4	Cu, 1 oz.	–
Lam3	12	FR4-12	4.35
L4	1.4	Cu, 1 oz.	–

Figure 21. Evaluation Board Layer Detail Physical Characteristics

Table 5. SKY65135-31 Evaluation Board Bill of Materials

Component	Value	Size	Product #	Manufacturer	Manufacturer's Part #	Characteristics
C1, C2, C6	3300 pF	0603	5404R28-015	Murata	GRM188R71H332KD01J	X7R, 50 V, ±10%
C5, C7, C8, C10	8.2 pF	0603	5404R98-010	Murata	GRM1885C1H8R2CZ01D	C0G, 50 V, ±0.25 pF
C11, C15, C16, C17	10 µF	0603	5404R91-005	TDK	C3216X5R0J106KT	X5R, 6 V, ±10%
L2	27 nH	0603	5332R34-030	Taiyo-Yuden	HK160827NJ-T	±5%, SRF 3400 MHz
R1	680 Ω	0603	5424R20-045	Rohm	MCR03EZHUJ680	50 V, 0.063 W, ±5%
R2, R3	200 Ω	0603	5424R20-032	Rohm	MCR03EZHUJ200	50 V, 0.063 W, ±5%
R5	300 Ω	0603	5424R20-036	Rohm	MCR03EZHUJ300	50 V, 0.063 W, ±5%

Application Circuit Notes

Center Ground. It is extremely important to sufficiently ground the bottom ground pad of the device for both thermal and stability reasons. Multiple small vias are acceptable and will work well under the device if solder migration is an issue.

GND (pins 1, 2, 8, 10, 17, 19, and 20). Attach all ground pins to the RF ground plane with the largest diameter and lowest inductance via that the layout allows. Multiple small vias are acceptable and will work well under the device if solder migration is an issue.

N/C (pins 3 and 12). These pins are open and may or may not be connected to ground.

VC_BIAS (pin 4). The bias supply voltage for stages 1 and 2, typically set to +5 V.

VREF1 (pin 5). Bias reference voltage for amplifier stage 1. This signal should be operated over the same voltage range as V_{CC} with a nominal voltage of +5 V.

VREF2 (pin 6). Bias reference voltage for amplifier stage 2. This signal should be operated over the same voltage range as V_{CC} with a nominal voltage of +5 V.

VREF3 (pin 7). Bias reference voltage for amplifier stage 3. This signal should be operated over the same voltage range as V_{CC} with a nominal voltage of +5 V.

RF_OUT (pin 9). Amplifier RF output pin (Z_0 = 50 Ω). The module includes an onboard internal DC blocking capacitor. All impedance matching is provided internal to the module.

VCC3 (pin 11). Supply voltage for the output (final) stage collector bias (typically +5 V). To bypass VCC3, capacitors C10 and C17 (see Figure 15) should be placed in the approximate location shown on the Evaluation Board, although exact placement is not critical.

VCC2 (pin 13). Supply voltage for the second stage collector bias (typically +5 V). To bypass VCC2, capacitors C8 and C16 (see Figure 15) should be placed in the approximate location shown on the Evaluation Board, although exact placement is not critical.

V_DET (pin 14). The output power detector voltage signal. The detector load and settling time constant are set external to the device. Inductor L2 and capacitor C7 (see Figure 18) are set to yield a settling time of < 0.5 µs.

VCC_DET (pin 15). The power detector supply voltage signal. Resistor R5 and capacitor C5 (see Figure 18) are used for proper bias and bypassing of this pin.

VCC1 (pin 16). Supply voltage for the first stage collector bias (typically +5 V). To bypass VCC1, capacitors C5 and C15 (see Figure 15) should be placed in the approximate location shown on the Evaluation Board, although exact placement is not critical.

RF_IN (pin 18). Amplifier RF input pin (Z_0 = 50 Ω). The module includes an onboard internal DC blocking capacitor. All impedance matching is provided internal to the module.

Package Dimensions

The PCB layout footprint for the SKY65135-31 is shown in Figure 22. Typical case markings are shown in Figure 23. Package dimensions for the 20-pin MCM are shown in Figure 24, and tape and reel dimensions are provided in Figure 25.

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 SKY65135-31 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.

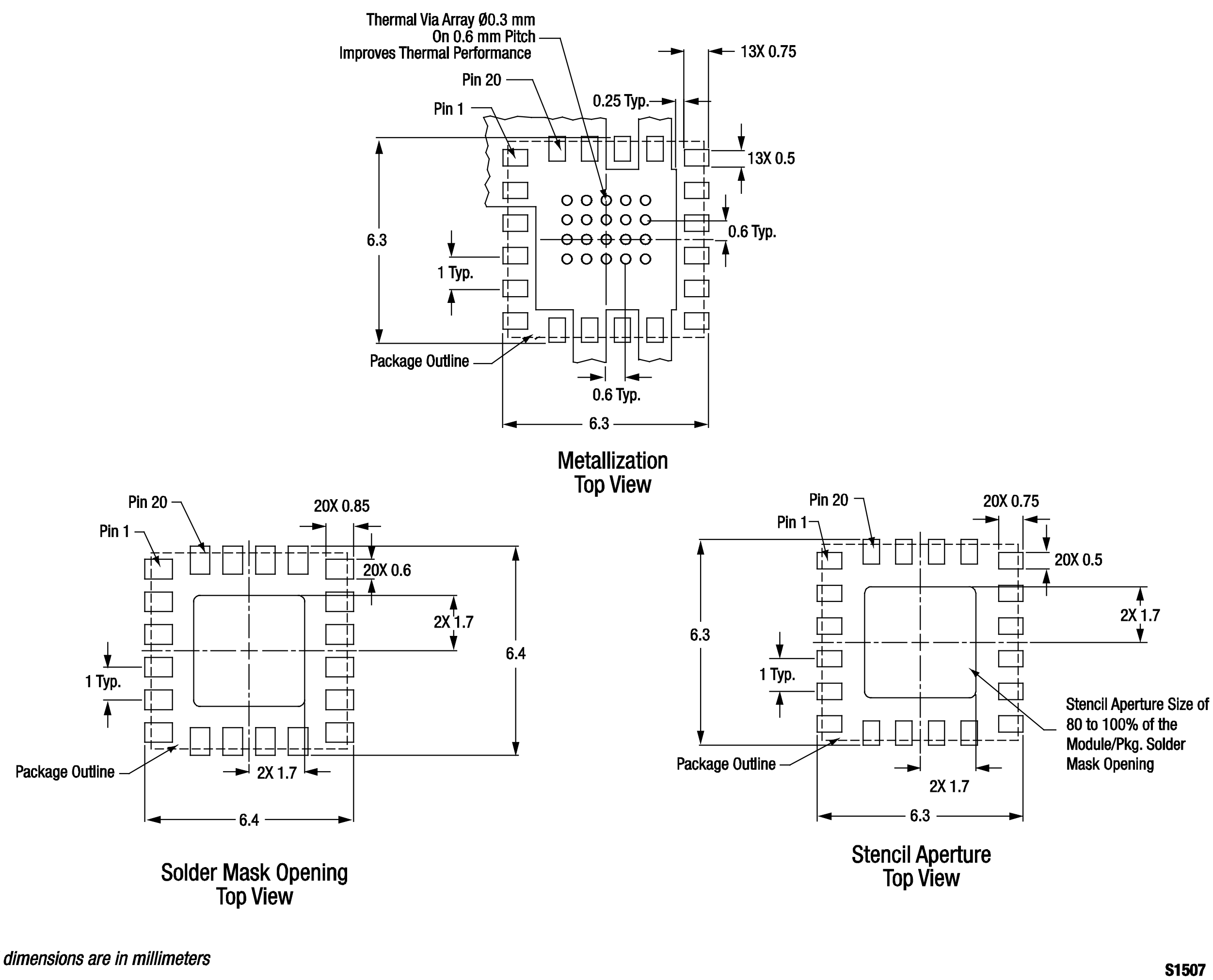


Figure 22. SKY65135-31 PCB Layout Footprint

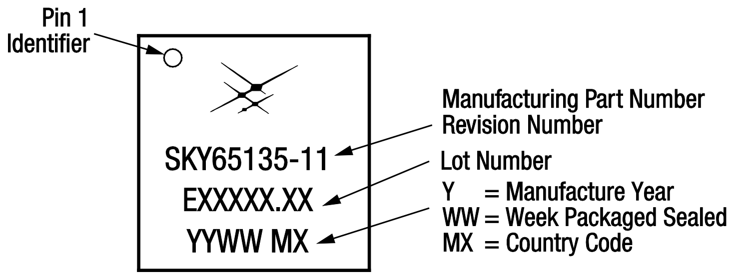


Figure 23. SKY65135-31 Typical Case Markings

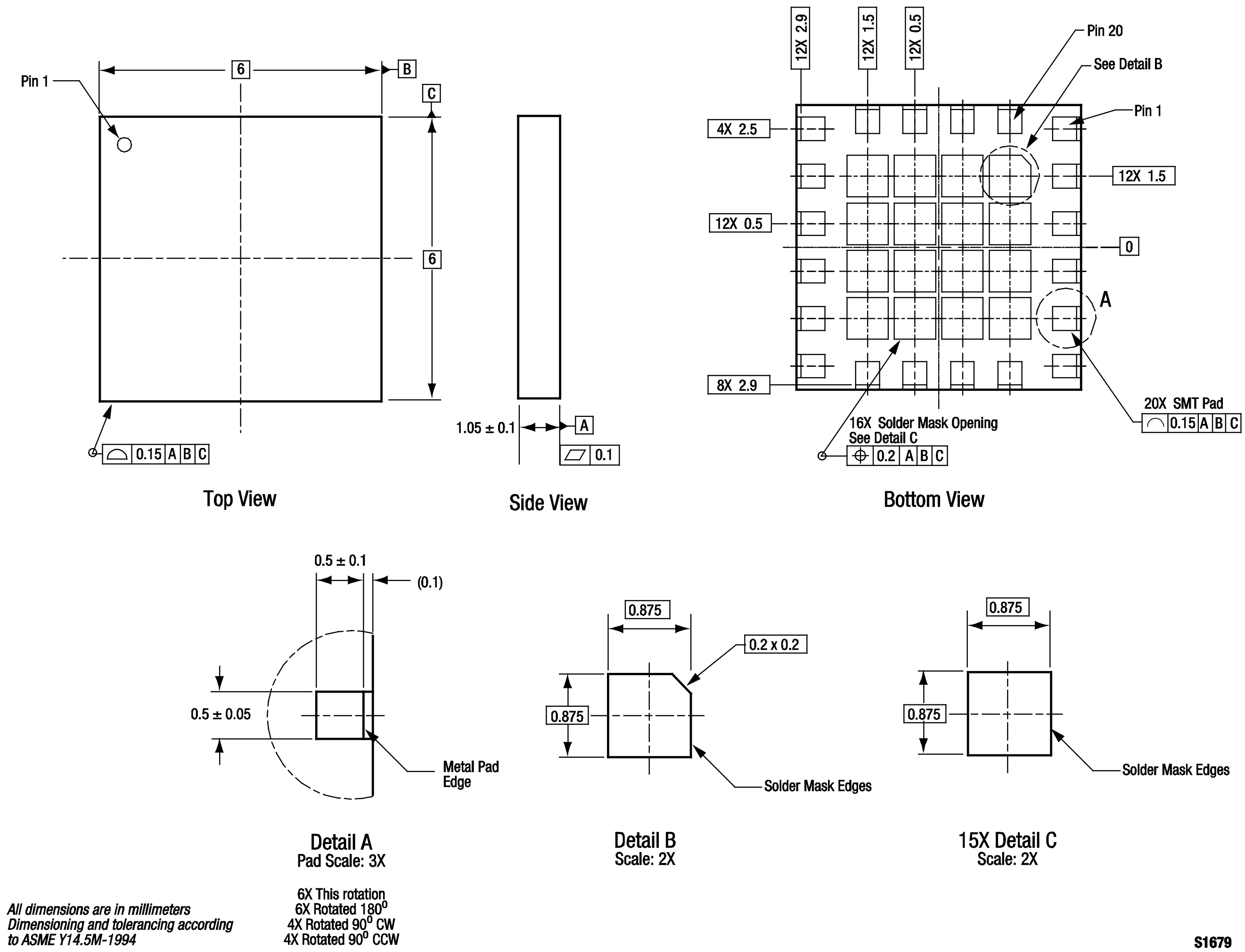


Figure 24. SKY65135-31 20-Pin MCM Package Dimensions

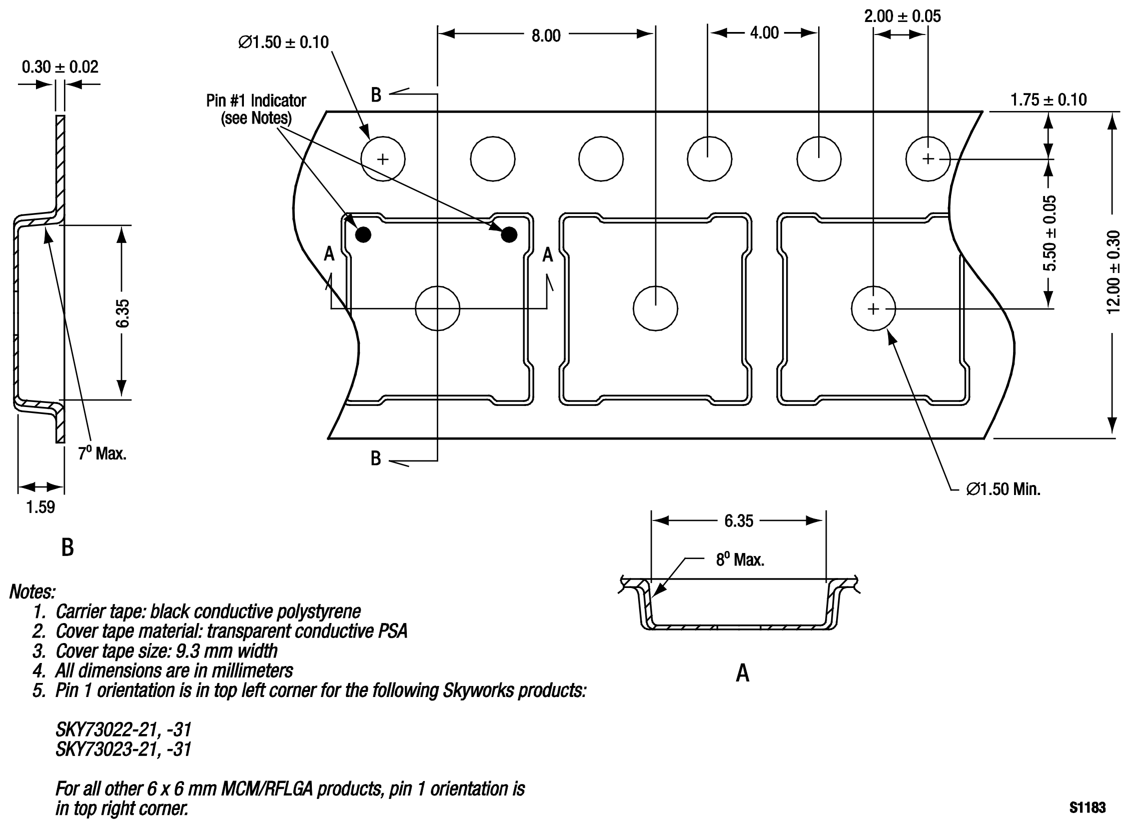


Figure 25. SKY65135-31 20-Pin MCM Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Kit Part Number
SKY65135-31 WLAN Power Amplifier	SKY65135-31	TW16-D280-031

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