PRELIMINARY DATA SHEET

SKY65152: 2.4–2.5 GHz WLAN Power Amplifier

Applications

- IEEE802.11 b/g WLAN
- ISM band transmitter
- WCS fixed wireless
- Wireless access nodes

Features

- EVM < 3% for P_{OUT} > 27 dBm
- High gain: 31 dB
- Internal RF match with DC block and active bias circuits
- Internal ON/OFF control circuit
- Single DC supply: 5 V
- Operating temperature -40 °C to +85 °C
- Available on tape and reel
- Available lead (Pb)-free and RoHs-compliant
- MCM (20-pin, 6 x 6 mm) lead (Pb)-free package (MSL-3 @ 260 °C per JEDEC J-STD-020)

Description

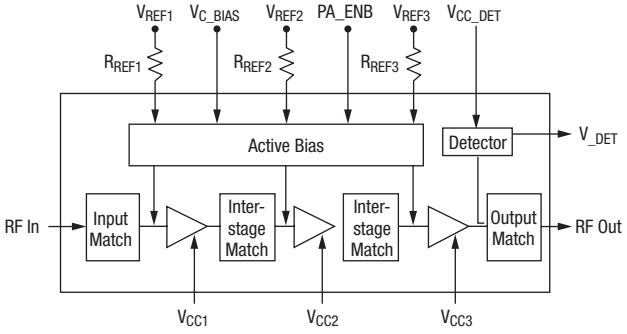
Skyworks SKY65152 is a Microwave Monolithic Integrated Circuit (MMIC) Power Amplifier (PA) with superior output power, linearity, and efficiency. These features make the SKY65152 ideal for Wireless Local Area Network (WLAN) applications. The high linearity (low EVM) and high efficiency of this device makes it ideal for use in the transmit chain of WLAN access point or modems.

The SKY65152 is fabricated using Skyworks high reliability Aluminum (Al) Gallium Arsenide (GaAs) Heterojunction Bipolar Transistor (HBT) 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.

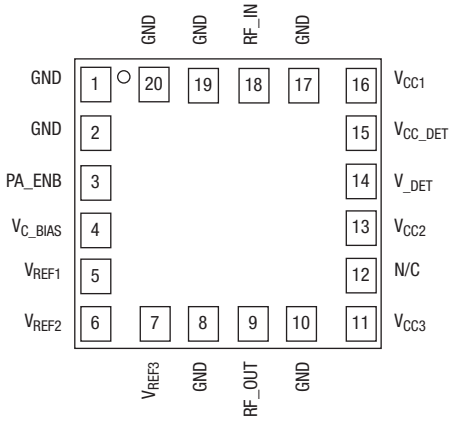
The module can operate over the temperature range of -40 °C to +85 °C. A populated evaluation board is available upon request.

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

Block Diagram



Package Diagram



Preliminary Data Sheet: Based on engineering results. Sampling quantities available. Pin out and package have been determined.

Electrical Specifications

$V_{CC1} = V_{CC2} = V_{CC3} = V_{REF1} = V_{REF2} = V_{REF3} = V_{C\_BIAS} = V_{CC\_DET}$ = PA_ENB = 5 V, Z_O = 50 Ω, T_C = 25 °C, Frequency = 2.442 GHz, unless otherwise noted[5]

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
IEEE802.11b Complimentary Code Keying Input Signal, Data Rate = 11 Mbps						
Total supply current	I_{CC}_total	Output power set to P_{OUT}		1070		mA
Output power[1]	P_{OUT}			31		dBm
Power-added efficiency[2]	PAE	Output power set to P_{OUT}		23		%
Ramp-up/ramp-down[3]	TS	Small signal		<0.5		µs
IEEE802.11g Orthogonal Frequency Division Multiplexing Input Signal, Data Rate = 54 Mbps						
Total supply current	I_{CC}_total	Output power set to P_{OUT}_EVM		750		mA
Output power[4]	P_{OUT}			30		dBm
Output power @ EVM=2.5%	P_{OUT}_EVM	Output power set to P_{OUT}		27		dBm
Power-added efficiency[2]	PAE	Output power set to P_{OUT}		20		%
Continuous Wave Input Signal						
Small signal gain	G	P_{IN} = –25 dBm		31		dB
Gain flatness over band	P_{OUT}	From 2.4 GHz to 2.5 GHz		±0.5		dB
Gain flatness over channel (16.25 MHz)	P_{OUT}_EVM	Over any 16.25 MHz within band		±0.1		dB
Output power @ 1 dB compression	$P_{1\ dB}$			33		dBm
Output IP3	OIP3	P_{OUT}/tone = 23 dBm, ΔF = 5 MHz		42		dBm
Quiescent current	I_{CCQ}	No RF		465		mA
Noise figure	NF			5		dB
Power-added efficiency	PAE	@ $P_{1\ dB}$		33		%
Thermal resistance	θ_{JC}	Junction to case		20		°C/W
Power Up/Down Control						
Power up	PA_ENB On		3	5		V
Power down	PA_ENB Off			0	0.5	V
Standby current	ISB	PA_ENB = 0 V		5		µA

1. Defined as the maximum power level for which the IEEE802.11b transmit mask requirements are met.
2. Measured at the specified average output RF power and modulation type.
3. Ramp-up and ramp-down times are defined from the 10% to 90% power points.
4. Defined as the maximum power level for which the IEEE802.11g transmit mask requirements are met.
5. Voltage measured at evaluation board pins.

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
RF input power	P_{IN}			-3	dBm
Supply voltages[1]	V_{CC}, V_{C_BIAS}		5.0		V
Reference voltage[1]	V_{REF}		2.5		V
Detector supply voltage[1]	V_{CC_DET}		3.6		V
Operating frequency	F_O	2412		2462	MHz
Operating case temperature	T_C	-40	+25	+85	°C

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.

Absolute Maximum Ratings

Characteristic	Value
RF output power (P_{OUT})	28 dBm
Supply voltage (V_{CC}, V_{C_BIAS} and PA_ENB)[1]	5.5 V
Supply current (I_{CC})	850 mA
Reference voltage (V_{REF})[1]	4 V
Detector supply voltage (V_{CC_DET})[1]	4 V
Power dissipation (P_{DISS})	1.1 W
Operating case temperature (T_C)	-40 °C to +85 °C
Storage temperature (T_{ST})	-55 °C to +125 °C
Junction temperature (T_J)	150 °C

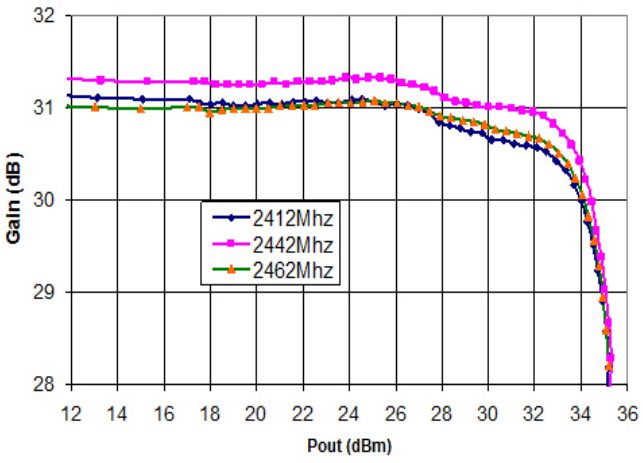
1. Voltage levels measured at the pins of the package. The evaluation board supply voltage levels may be different. Refer to the evaluation board schematic diagram.

Performance is guaranteed only under the conditions listed in the specifications table and is not guaranteed under the full range(s) described by the Absolute Maximum specifications. Exceeding any of the absolute maximum/minimum specifications may result in permanent damage to the device and will void the warranty. Each absolute maximum rating listed is an individual parameter. Operating the amplifier with more than one condition at its absolute maximum or minimum rating value may result in permanent damage to the device. Exposure to maximum rating conditions for extended periods may reduce device reliability.

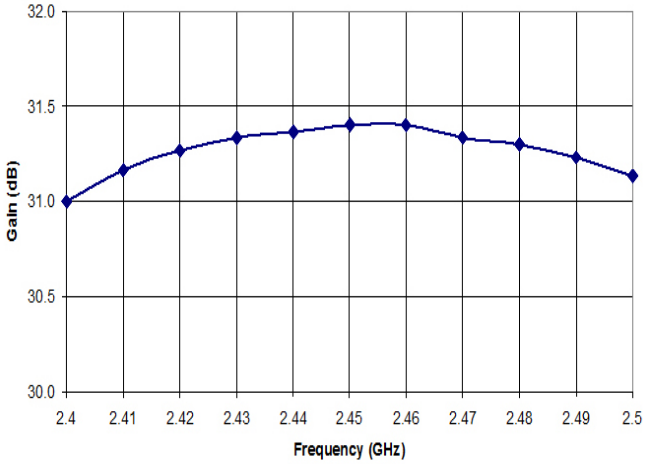
CAUTION: *Although this device is designed to be as robust as possible, ESD (Electrostatic Discharge) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions must be employed at all times.*

Electrical Specifications

V_{CC1} = V_{CC2} = V_{CC3} = V_{REF1} = V_{REF2} = V_{REF3} = V_{C_BIAS} = V_{CC_DET} = PA_ENB = 5 V, Z_O = 50 Ω, T_C = 25 °C, CW, Frequency = 2.442 GHz, unless otherwise noted



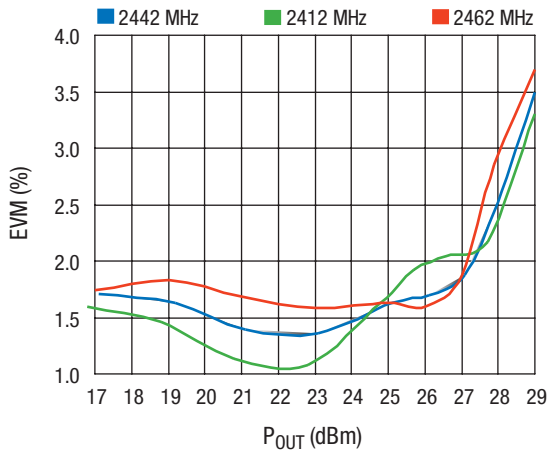
Gain vs. Power Out Across Frequency



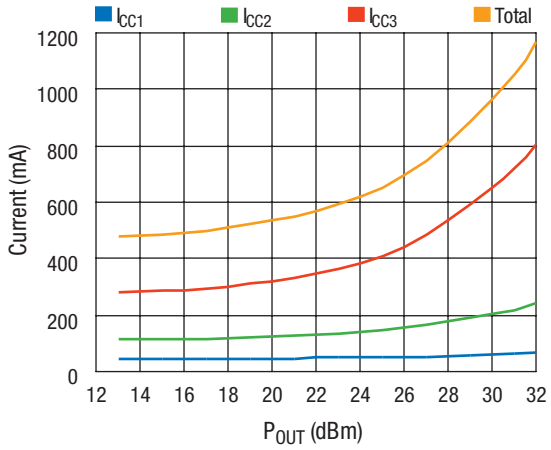
Small Signal Gain vs. Frequency

Electrical Specifications

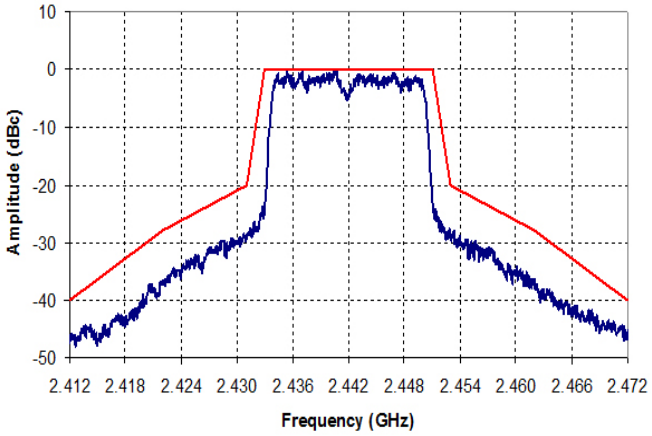
V_{CC1} = V_{CC2} = V_{CC3} = V_{REF1} = V_{REF2} = V_{REF3} = V_{C_BIAS} = V_{CC_DET} = PA_ENB = 5 V, Z_O = 50 Ω, T_C = 25 °C, CW, Frequency = 2.442 GHz, unless otherwise noted



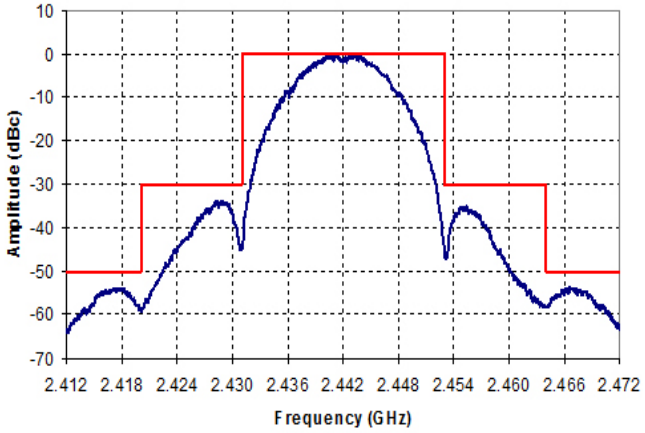
EVM vs. P_{OUT} Across Frequency



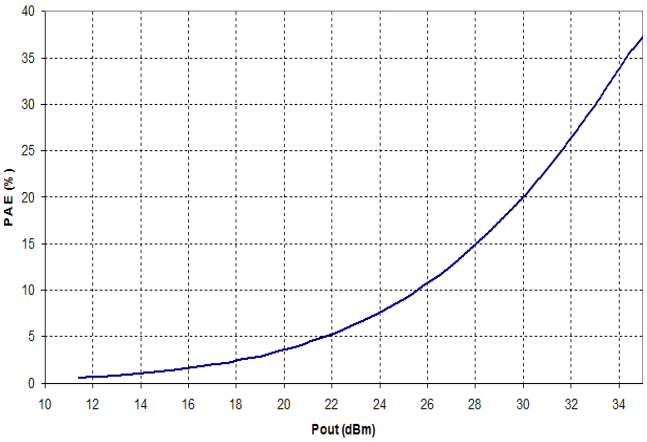
Current vs. P_{OUT}



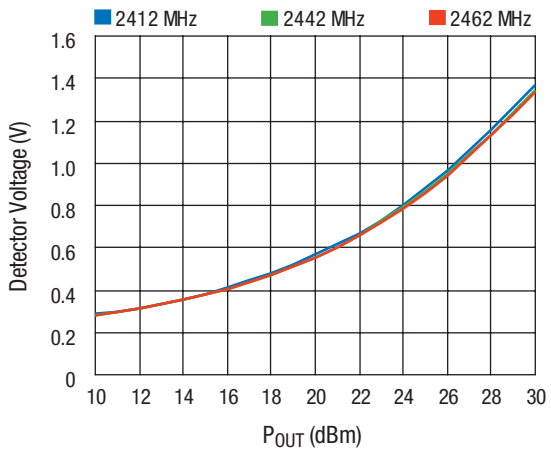
Spectral Response @ P_{OUT} = 30 dBm (802.11g, OFDM, 64 QAM @ 54 Mbps)



Spectral Response @ P_{OUT} = 31 dBm (802.11b, CCK @ 11 Mbps)



PAE vs. P_{OUT}



Detector Voltage vs. Power Out

Theory of Operation

The SKY65152 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 providing for excellent gain tracking over temperature and voltage variations. The first, second and output stages are independently supplied using the V_{CC1}, V_{CC2} and V_{CC3} supply lines, pins 16, 14 and 11,respectively. The DC control voltage that sets the bias for all 3 stages is supplied via V_{C_BIAS}, pin 4. The evaluation board includes shunt decoupling caps on these pins to suppress any possible bias affect on the RF at low frequencies.

The bias reference voltages for stages 1, 2 and 3 are supplied using common lines V_{REF1}, V_{REF2} and V_{REF3} (Pins 5, 6 and 7). The maximum reference voltage at the package 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 SKY65152 includes an internal PA Enable control pin (Pin 3) for fast RF On/Off control of < 0.5 µs. Zero volts turns off the PA while 3–5 V will turn on the PA. The device also provides an output power detector voltage V_{DET} at Pin 14. A bias voltage is required to operate the detector. The detector supply voltage is supplied via V_{CC_DET} (Pin 15). The maximum voltage at the package 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. Ground is achieved through several ground pins and the package backside, 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.

Application Circuit Notes

Center Ground. It is extremely important that the device paddle be sufficiently grounded for both thermal and stability reasons. Multiple small vias are acceptable and will work well under the device if solder migration is an issue.

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

PA_ENB (Pin 3). PA_ENB is the internal PA Enable control pin for fast RF On/Off control of < 0.5 µs. Zero volts turns off the PA while 3–5 V will turn on the PA.

V_{C_BIAS} (Pin 4). V_{C_BIAS} is the bias supply voltage for stages 1 and 2, typically set to 5 V.

V_{REF1} (Pin 5). Bias reference voltage for amplifier stage 1. V_{REF1} should be operated over the same voltage range as V_{CC}, with a nominal voltage of 5 V.

V_{REF2} (Pin 6). Bias reference voltage for amplifier stage 2. V_{REF2} should be operated over the same voltage range as V_{CC}, with a nominal voltage of 5 V.

V_{REF3} (Pin 7). Bias reference voltage for amplifier stage 3. V_{REF3} 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_O = 50 Ω. The module includes an onboard internal DC blocking capacitor. All impedance matching is provided internal to the module.

V_{CC3} (Pin 11). Supply voltage for the output (final) stage collector bias (typically 5 V). bypassing of V_{CC3} is accomplished with C10 and C17 and should be placed in the approximate location shown on the evaluation board, but placement is not critical.

No Connect (Pin 12). The pin is open and may or may not be connected to ground.

V_{CC2} (Pin 13). Supply voltage for the second stage collector bias (typically 5 V). Bypassing of V_{CC2} is accomplished with C8 and C16 and should be placed in the approximate location shown on the evaluation board, but placement is not critical.

V_{DET} (Pin 14). Output power detector voltage pin. The detector load and settling time constant are set external to the device. Inductor L2 and capacitor C7 are set to yield a settling time of less than 0.5 µs.

V_{CC_DET} (Pin 15). Power detector supply voltage. Proper bias and bypassing is V_{CC_DET} is accomplished with Resistor R5 and capacitor C5 provided. V_{CC_DET} may be connected to PA_ENB supply. The benefit of doing this is the current draw consumed by the detector will not be wasted with the PA in the "Off" state.

V_{CC1} (Pin 16). Supply voltage for the first stage collector bias (typically 5 V). Bypassing of V_{CC1} is accomplished with C5 and C15 and should be placed in the approximate location shown on the evaluation board, but placement is not critical.

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

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.

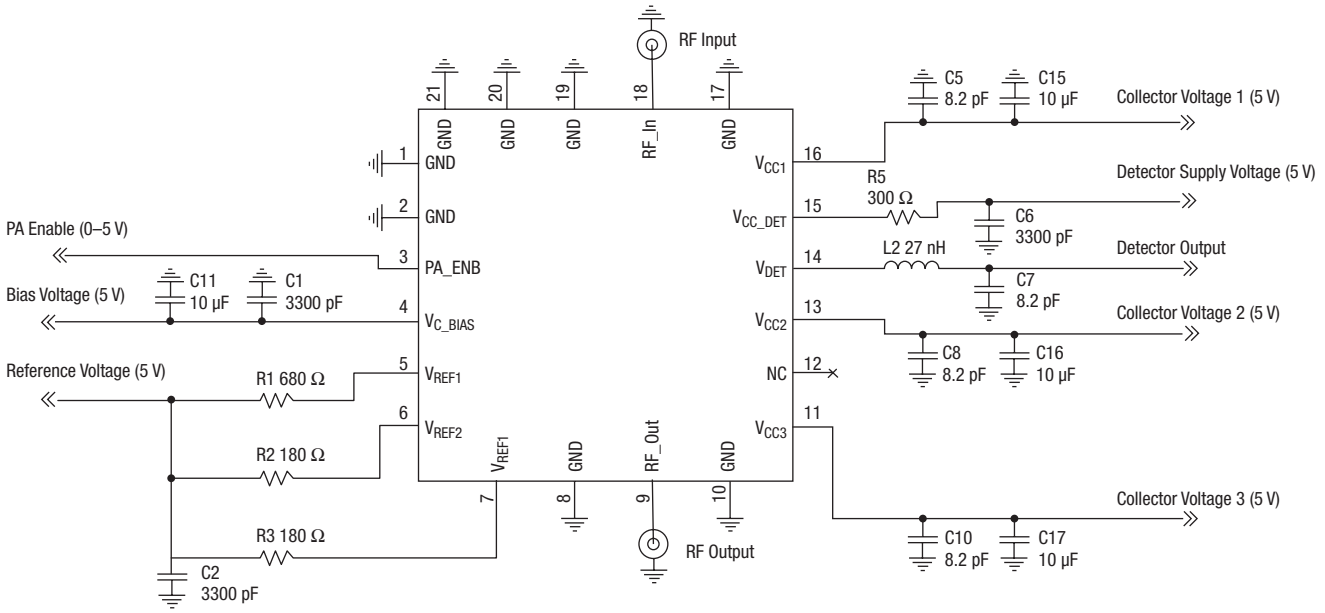
Please refer to Skyworks *Solder Reflow* application note, available at www.skyworksinc.com, for instructions on mounting the SKY65152 to a printed circuit board.

Production quantities of this product are shipped in a standard tape and reel format. For packaging details, refer to the Skyworks Application Note, *Tape and Reel*, document number 101568.

Electrostatic Discharge (ESD) Sensitivity

The SKY65152 is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.

Application Circuit



Pin Assignments

Pin #	Name	Description
1	GND	Ground
2	GND	Ground
3	PA_ENB	PA ON/OFF control signal; OFF: 0 V to 0.5 V; ON: 3 V to V_{CC}
4	V_{C_BIAS}	Bias voltage
5	V_{REF1}	Bias reference voltage 1
6	V_{REF2}	Bias reference voltage 2
7	V_{REF3}	Bias reference voltage 3
8	GND	Ground
9	RF_OUT	RF output
10	GND	Ground
11	V_{CC3}	Stage 3 collector voltage
12	NC	No connection
13	V_{CC2}	Stage 2 collector voltage
14	V_{DET}	Detector output signal
15	V_{CC_DET}	Detector supply voltage
16	V_{CC1}	Stage 1 collector voltage
17	GND	Ground
18	RF_IN	RF input
19	GND	Ground
20	GND	Ground

Center attachment pad must have a low inductance and low thermal resistance connection to the customer's printed circuit board ground plane.

Bill of Material for Evaluation Board

Component	Value	Units	Qty.	Size	Product Number	Manufacturer	Manufacturer's Part Number	Characteristics
C1, C2, C6	3300	pF	3	0603	5404R28-015	Murata	GRM188R71H332KD01J	X7R, 50 V, ± 10%
C5, C7, C8, C10	8.2	pF	4	0603	5404R98-010	Murata	GRM1885C1H8R2CZ01D	C0G, 50 V, ± 0.25 pF
C11, C15, C16, C17	10	µF	4	0603	5404R91-005	TDK	C3216X5R0J106KT	X5R, 6 V, ± 10%
L2	27	nH	1	0603	5332R34-030	Taiyo-Yuden	HK160827NJ-T	± 5%, SRF 2200 MHz
R1	680	Ω	1	0603	5424R20-045	Rohm	MCR03EZHUJ680	50 V, 0.063 W, ± 5%
R2, R3	180	Ω	2	0603	5424R20-031	Rohm	MCR03EZHUJ180	50 V, 0.063 W, ± 5%
R5	300	Ω	1	0603	5424R20-036	Rohm	MCR03EZHUJ300	50 V, 0.063 W, ± 5%

Evaluation Board Description

The Skyworks SKY65152 Evaluation Board is used to test the performance of the SKY65152 power amplifier module. 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 SKY65152 power amplifier module 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 amplifiers. As such, design the connection to the ground pad to dissipate the maximum wattage produced to the circuit. Multiple vias to the grounding layer are required.
3. Bypass capacitors should be used on the DC supply lines. RF inductor is required on the Vcc supply line to block RF signal from the DC supply. See Evaluation Board schematic drawing for more 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: *Junction temperature (T_J) of the device increases with a poor connection to the slug and ground. This reduces the lifetime of the device.*

Evaluation Board Test Procedure

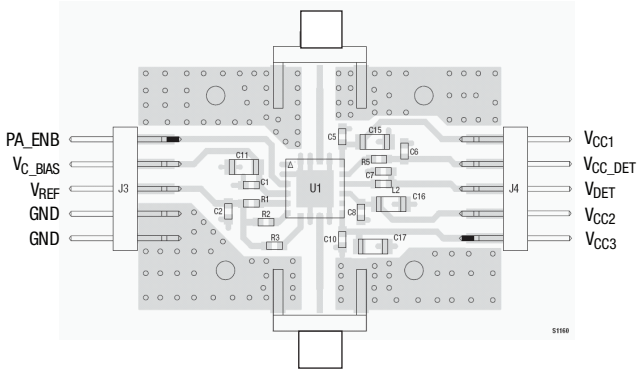
Use the following procedure to set up the SKY65152 evaluation board for testing.

1. Connect a 5.0 V supply to V_{CC1}, V_{CC2}, V_{CC3}, V_{REF1}, V_{REF2}, V_{REF3}, V_{C_BIAS}, V_{CC_DET}, PA_ENB. If available, enable the current limiting function of the power supply of the V_{CC} supply to 850 mA.
2. If desired, connect a voltage meter to V_{DET}.
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, but do NOT enable the RF signal.
4. Connect a spectrum analyzer to the RF signal output port.
5. Enable the power supply.
6. Enable the RF signal.
7. Take measurements.

CAUTION: *If the input signal exceeds the rated power, the SKY65152 Evaluation Board can be permanently damaged.*

NOTE: *It is important that the V_{CC} voltage source be adjusted such 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.*

Evaluation Board



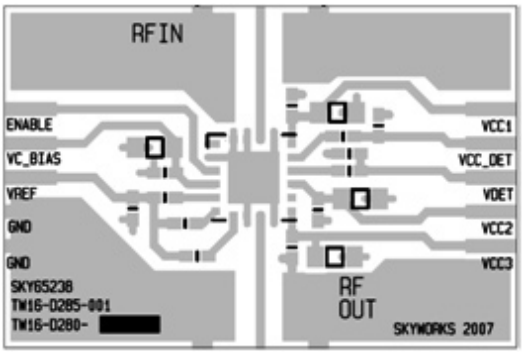
Recommended Solder Reflow Profiles

Refer to the *"Recommended Solder Reflow Profile"* Application Note.

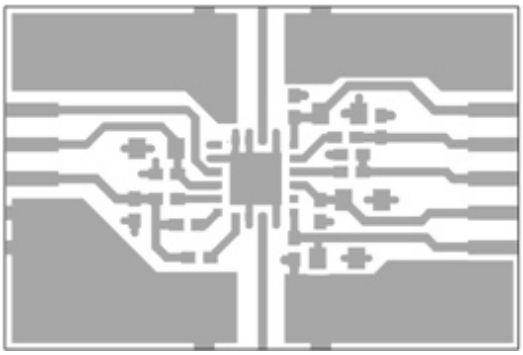
Tape and Reel Information

Refer to the *"Discrete Devices and IC Switch/Attenuators Tape and Reel Package Orientation"* Application Note.

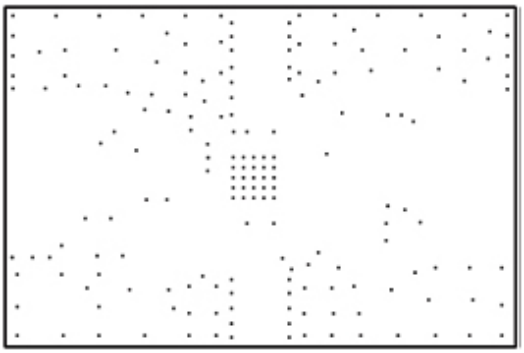
Evaluation Board Layer Detail



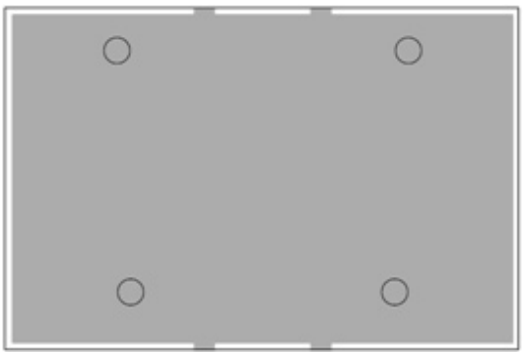
Layer 1: Silk Screen



Layer 1: Top Metal



Layer 2 and 3: Ground

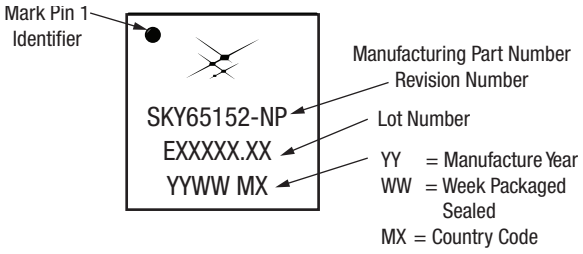


Layer 4: Backside Ground

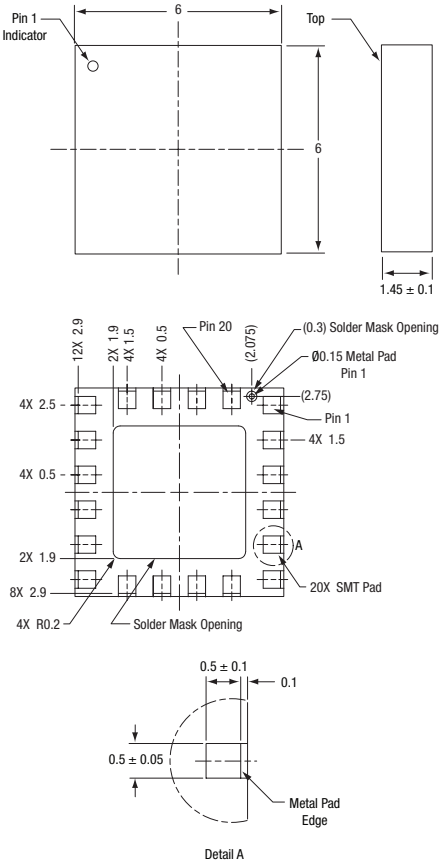
Evaluation Board Stack-Up

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.	–

Branding Specifications

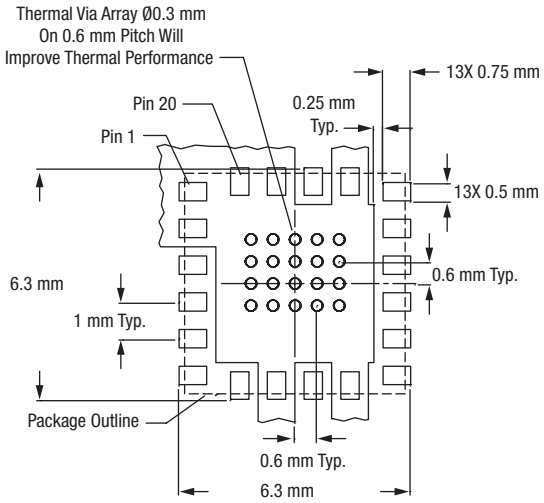


Evaluation Board Layer Detail

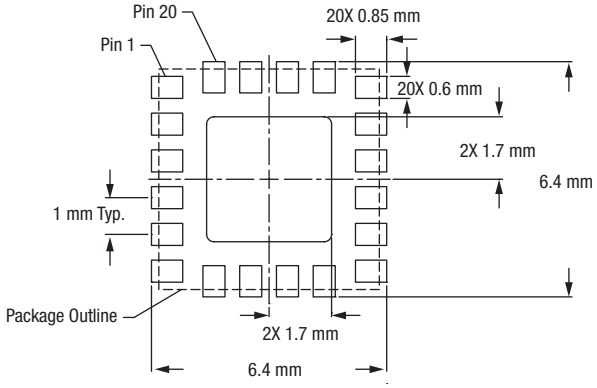


All dimensions are in millimeters
Dimensioning and tolerancing according to ASME Y14.5M-1994

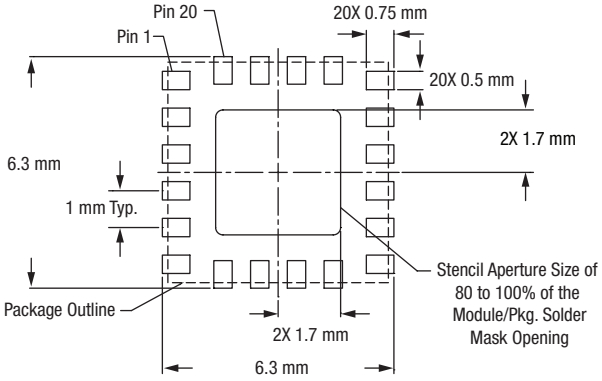
Recommended Footprint



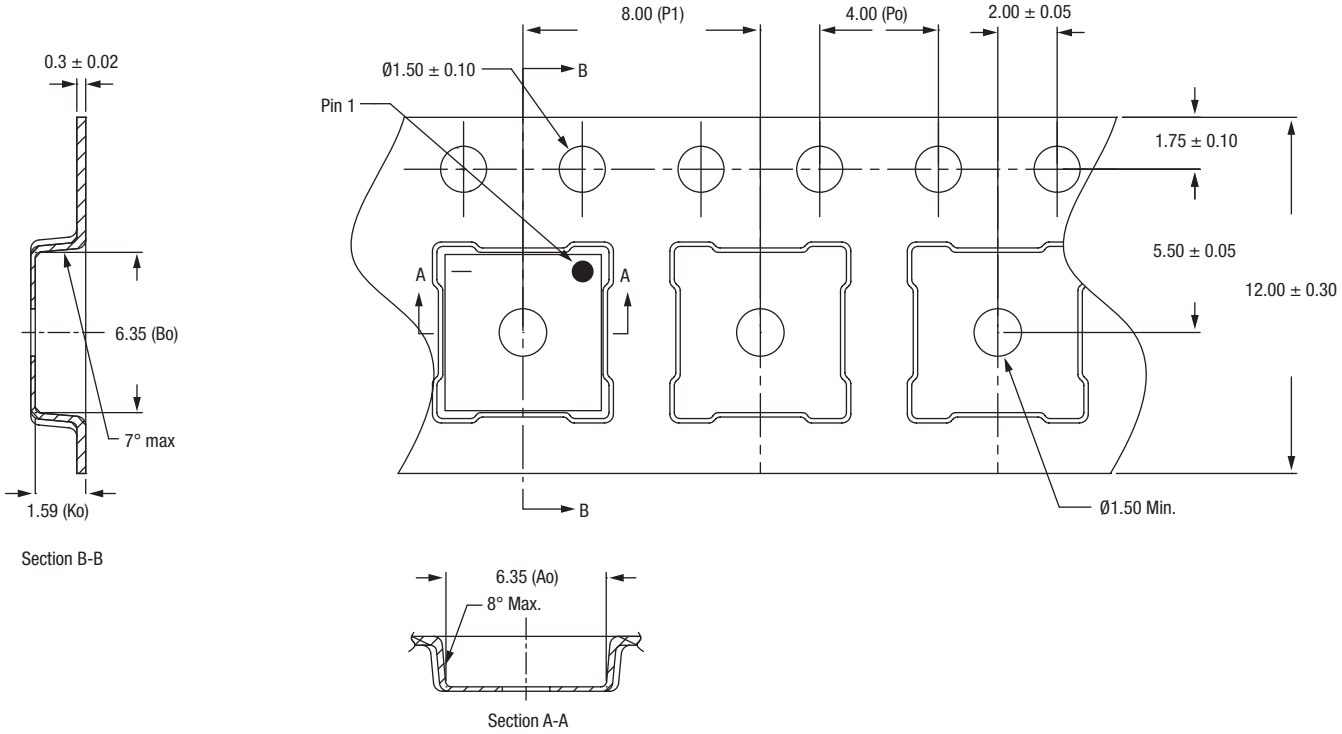
Solder Mask



Stencil Pattern



Tape and Reel Dimensions



1. Carrier tape: black conductive polystyrene
2. Cover tape material: transparent conductive PSA
3. Cover tape size: 9.3 mm width
4. All dimensions are in millimeters

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Kit Part Number
SKY65152: 2.4–2.5 GHz WLAN Power Amplifier	SKY65152-NP (Pb-free package)	TW17-D560-001