PRELIMINARY DATA SHEET

SKY65142: 100–1000 MHz Ultra Wideband Variable Gain Amplifier

Applications

- AMPS/PCS/DCS/GSM/EDGE/GPRS
- VHF/UHF TV/TETRA
- Base stations
- Repeaters

Features

- Wideband frequency operation: 100–1000 MHz
- Gain control range: 20 dB
- Gain at zero attenuation: 22 dB
- Linear output power > 27 dBm
- Output IP3 > 35 dBm
- Single DC supply: 5 V
- Internal PA RF match with DC block
- Low power consumption, PAE > 35%
- MCM (12-pin 8 x 8 mm) lead (Pb)-free package (MSL-3, 260 °C per JEDEC J-STD-020)

Description

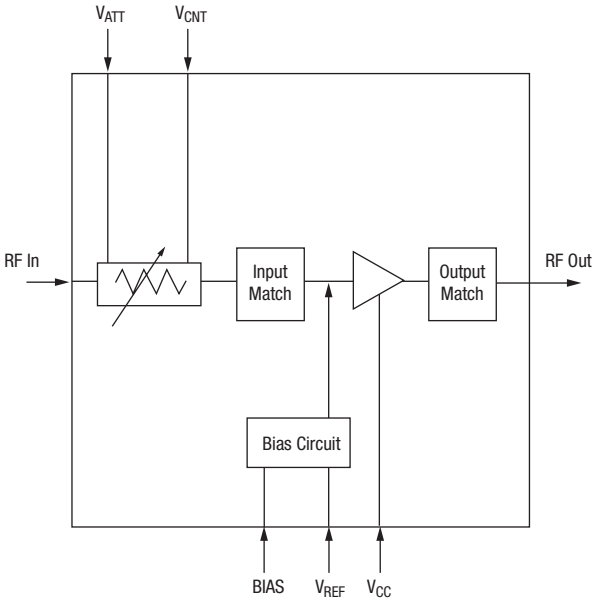
The Skyworks SKY65142 is an ultra-wideband Variable Gain Amplifier (VGA) in a small footprint, 12-pin, 8 x 8 mm^2, surface mount, multichip module (MCM). The module contains a variable voltage attenuator with gain control range of over 20 dB. The device is internally matched for 50 Ω on all RF ports.

The VGA maintains very linear performance over a wide frequency bandwidth of 100 MHz to 1 GHz with a $P_{1\ dB}$ greater than 27 dBm, OIP3 greater than 35 dBm and gain at zero attenuation greater than 20 dB.

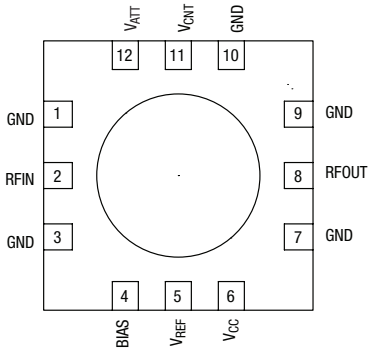
All active circuitry in the module is contained in a single Microwave Monolithic Integrated Circuit (MMIC). The device is fabricated using Skyworks high reliability Aluminum (Al) Gallium Arsenide (GaAs) Heterojunction Bipolar Transistor (HBT) process, which allows for single supply operation while maintaining high efficiency and good linearity.

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

Block Diagram



Package Diagram



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

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

Operating Characteristics

V_{CC} = V_{REF} = V_{ATT} = BIAS = 5 V, V_{CNT} = 0 V, T_C = 25 °C, Z_0 = 50 Ω, unless otherwise noted

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
Frequency	F			156		MHz
Gain at minimum attenuation	Gmax	CW P_{IN} = -15 dBm	22	24	26	dB
Gain control range	Grange	CW	20	23		dB
Output power at 1 dB compression	$P_{1\ dB}$	CW	27	28.5		dBm
PAE at output $P_{1\ dB}$	PAE	CW	38	44		%
Output 3rd order intercept point	OIP3	P_{OUT}/tone = 5 dBm, ΔF = 1 MHz	32	36		dBm
Current at output $P_{1\ dB}$	I_{CC}	CW		330		mA

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
Frequency	F			450		MHz
Gain at minimum attenuation	Gmax	CW P_{IN} = -15 dBm	20	22	24	dB
Gain control range	Grange	CW	18	20		dB
Output power at 1 dB compression	$P_{1\ dB}$	CW	26	27.5		dBm
PAE at output $P_{1\ dB}$	PAE	CW	32	38		%
Output 3rd order intercept point	OIP3	P_{OUT}/tone = 5 dBm, ΔF = 1 MHz	32	36.5		dBm
Current at output $P_{1\ dB}$	I_{CC}	CW		290		mA

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
Frequency	F			905		MHz
Gain at minimum attenuation	Gmax	CW P_{IN} = -15 dBm	18.5	20.5	22.5	dB
Gain control range	Grange	CW	18	20		dB
Output power at 1 dB compression	$P_{1\ dB}$	CW	25	26.5		dBm
PAE at output $P_{1\ dB}$	PAE	CW	37	43		%
Output 3rd order intercept point	OIP3	P_{OUT}/tone = 5 dBm, ΔF = 1 MHz	32	36.5		dBm
Current at output $P_{1\ dB}$	I_{CC}	CW		240		v
Quiescent current	I_{CCQ}	No RF		120		mA

Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}, BIAS, V_{REF}, V_{ATT}	4.75	5	5.25	V
Control voltage (maximum atten.)	V_{CNT}			5	V
Control voltage (minimum atten.)	V_{CNT}	0			V
Operating frequency	F_O	100		1000	MHz
Operating case temperature	T_C	-40	+25	+85	°C

Absolute Maximum Ratings

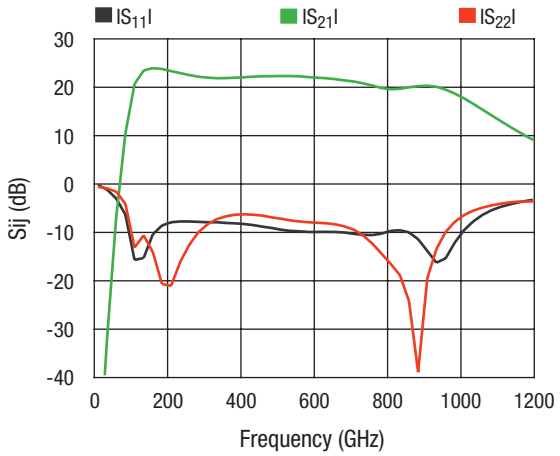
Characteristic	Value
RF output power	29 dBm
Supply voltage (V_{CC}, BIAS, V_{REF}, V_{ATT})	5.5 V
Supply current (I_{CC})	1300 mA
Power dissipation (P_{DISS})	2 W
Operating case temperature (T_C)	-40 °C to +85 °C
Storage temperature (T_{ST})	-55 °C to +125 °C
Junction temperature (T_J)	150 °C

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. Biasing and driving the amplifier with more than one absolute maximum rating listed may result in permanent damage to the device. Exposure to maximum rating conditions for extended periods may reduce device reliability.

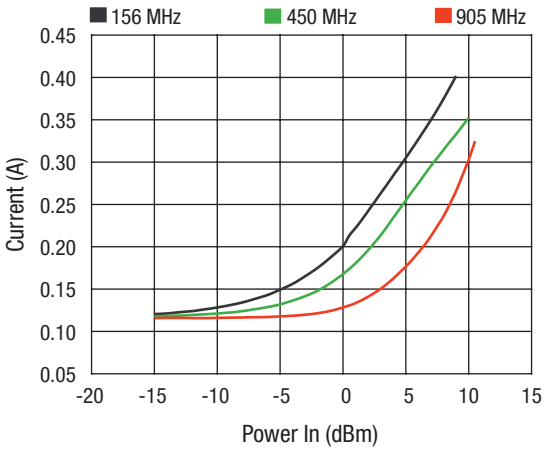
CAUTION: *Although this device is designed to be as robust as possible, Electrostatic Discharge (ESD) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without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

Typical Performance Data

V_{CC} = V_{REF} = V_{ATT} = BIAS = 5 V, V_{CNT} = 0 V, T_C = 25 °C, Z_0 = 50 Ω, unless otherwise noted



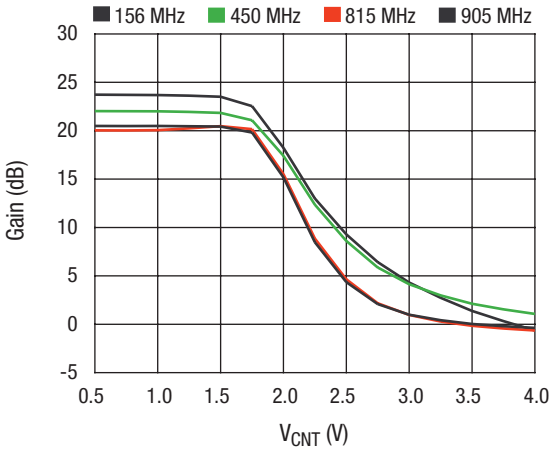
S-Parameters vs. Frequency



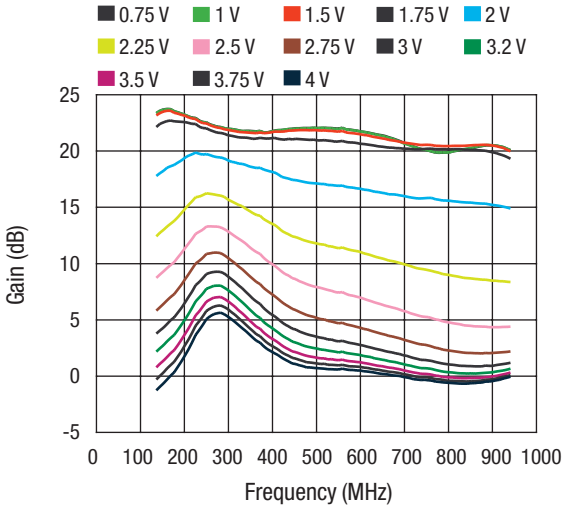
Current vs. Power In Across Frequency

Typical Performance Data

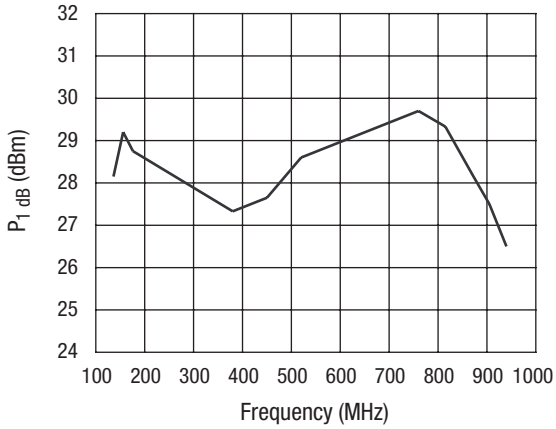
V_{CC} = V_{REF} = V_{ATT} = BIAS = 5 V, V_{CNT} = 0 V, T_C = 25 °C, Z_0 = 50 Ω, unless otherwise noted



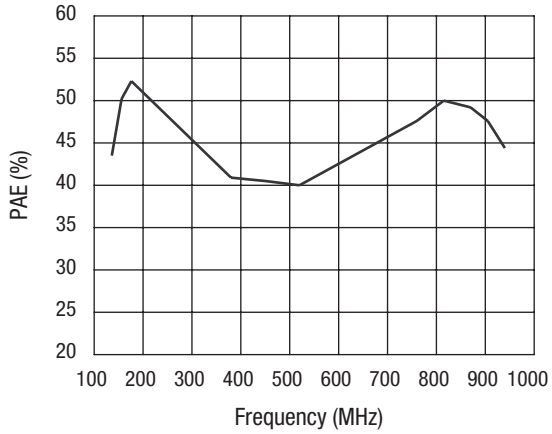
Gain vs. V_{CNT} Across Frequency



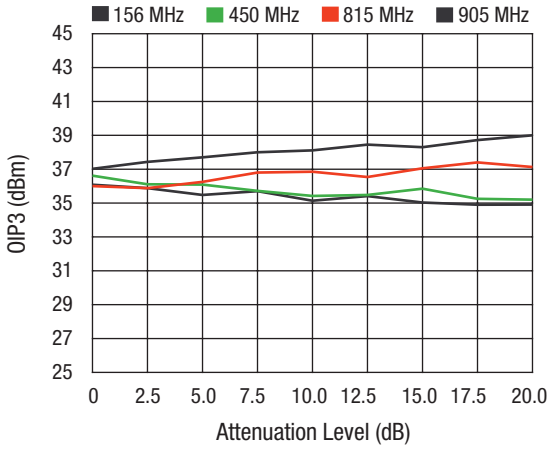
Gain vs. Frequency Across V_{CNT}



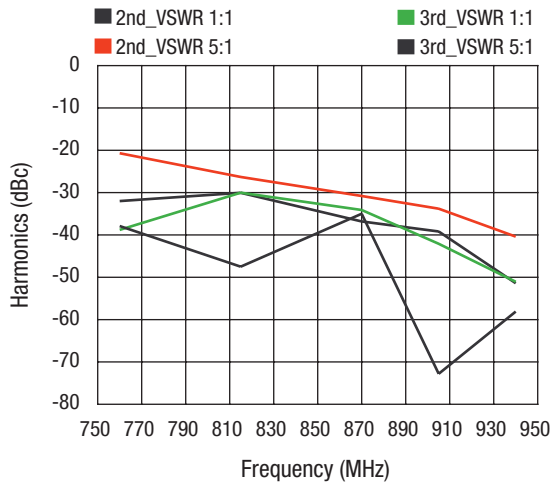
$P_{1\ dB}$ vs. Frequency



PAE at $P_{1\ dB}$ vs. Frequency



OIP3 vs. Attention Level Across Frequency
P_{OUT} = 5 dBm/Tone, ΔF = 1 MHz



2nd and 3rd Harmonics vs. Frequency Across VSWR

Theory of Operation

The SKY65142 variable gain amplifier is a module comprised of voltage variable attenuator with a gain control range of over 20 dB and a single amplifier stage providing 20 dB of gain at zero attenuation. The device is internally matched for 50 Ω on all RF ports. An in module active bias circuit is included within the device providing for excellent gain tracking over temperature and voltage variations.

The SKY65142 attenuator consists of 2 parallel, shunt PIN diodes controlled by an externally supplied bias via V_{CNT}, Pin 11. V_{CNT} operates over a range of 0–5 V with 5 V providing maximum attenuation. V_{ATT}, pin 12, is the bias voltage for the attenuator circuit.

The SKY65142 amplifier is internally matched for optimum linearity and efficiency. It is independently supplied using the V_{CC} supply line, pin 6. The bias reference voltage is supplied using the V_{REF} line, pin 5. The DC control voltage that sets the bias to the amplifier is supplied via the BIAS line, pin 4.

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, 3, 7, 9, 10). 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.

RFIN (Pin 2). Module RF Input Pin. $Z_O = 50\ \Omega$. The module includes an onboard internal DC blocking capacitor. All impedance matching is provided internal to the module.

BIAS (Pin 4). BIAS is the bias supply voltage for the amplifier, typically set to 5 V. Bypass capacitors C11and C14 have been utilized to ensure stability both in and out of the useable bandwidth of the device.

V_{REF} (Pin 5). Bias reference voltage for the amplifier. V_{REF} should be operated over the same voltage range as V_{CC}, with a nominal voltage of 5 V. Resistor, R1 sets the optimal voltage at the package pin.

V_{CC} (Pin 6). Supply voltage for the amplifier collector bias (typically 5 V). Bypassing of V_{CC} is accomplished with inductor L1 and capacitors C9, C10 and C15. They should be placed in the approximate location shown on the evaluation board, but placement is not critical.

RFOUT (Pin 8). Module RF Output Pin. $Z_O = 50\ \Omega$. The module includes an onboard internal DC blocking capacitor. All impedance matching is provided internal to the module.

V_{CNT} (Pin 11). V_{CNT} is the amplifier gain control voltage. Nominal operating range is between 0–5 V, with 5 V with 5 V providing maximum attenuation.

V_{ATT} (Pin 12). V_{ATT} is the bias voltage for the attenuator circuit (typically 5 V). DC bypass is provided by capacitor C7.

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 SKY65142 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

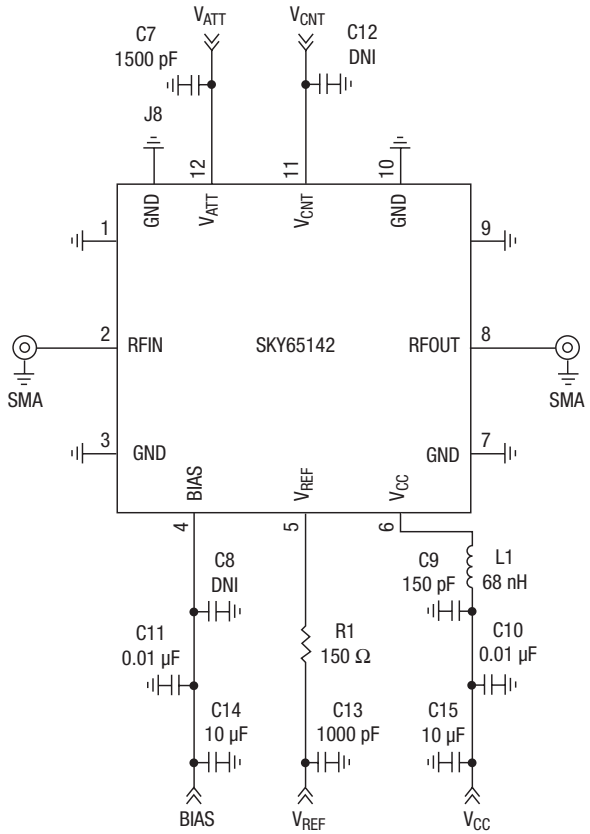
The SKY65142 is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.

Pin Assignments

Pin #	Name	Description
1	GND	Ground
2	RFIN	RF input
3	GND	Ground
4	BIAS	Amplifier bias voltage
5	V_{REF}	Amplifer reference voltage
6	V_{CC}	Amplifer supply voltage
7	GND	Ground
8	RFOUT	RF output
9	GND	Ground
10	GND	Ground
11	V_{CNT}	Amplifier gain control voltage
12	V_{ATT}	Attenuator bias voltage

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

Application Circuit



Evaluation Board Test Procedure

Use the following procedure to set up the SKY65142 evaluation board for testing.

1. Connect 5 V DC supply voltages to BIAS, and V_{REF}. If available, enable the current limiting function of these power supplies to 0.1 A.
2. Connect a 5 V to the attenuators supply voltages, V_{ATT} and V_{CNT}. If available, enable the current limiting function of the power supply to 0.05 A.
3. Connect a 5 V to the amplifier supply voltage, V_{CC}. If available, enable the current limiting function of the power supply to 1.3 A.
4. Connect signal generator(s) to the required RF input port. Set the desired RF signal frequency. Set RF power level to 8 dBm or less to the evaluation board but do NOT enable the RF signal.
5. Set the desired attenuation by adjusting the voltage level on V_{CNT} supply lines. (0 V = minimum attenuation, 5 V = maximum attenuation).
6. Enable the RF signal.
7. Take measurements.

CAUTION: *If the input signal exceeds the rated power, the SKY65142 Evaluation Board can be permanently damaged.*

NOTE: *It is important that the V_{CC} voltage source be adjusted such that 5.0 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.*

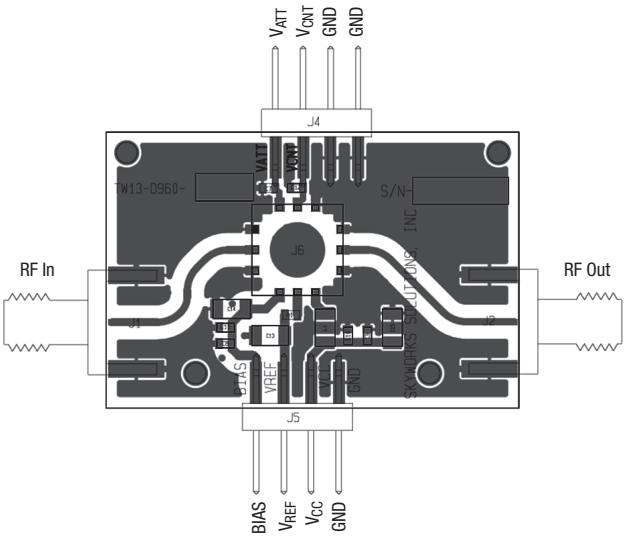
Recommended Solder Reflow Profiles

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



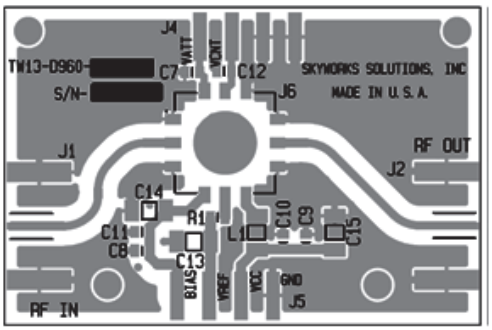
Evaluation Board Description

The Skyworks SKY65142 evaluation board is used to test the performance of the SKY65142 power amplifier module. The following design considerations are general in nature and must be followed regardless of final use or configuration.

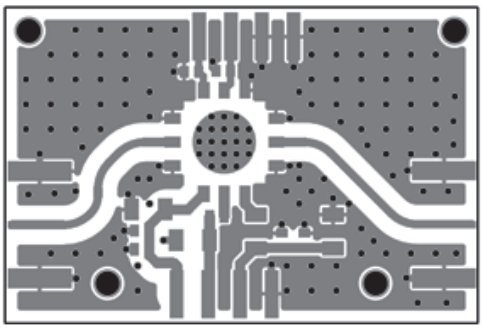
1. Paths to ground should be made as short as possible.
2. The ground pad of the SKY65142 power amplifier module has special electrical and thermal grounding requirements. This pad is the main thermal conduit for heat dissipation. Since the circuit board acts as the heat sink, it must shunt as much heat 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 V_{CC} 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.*

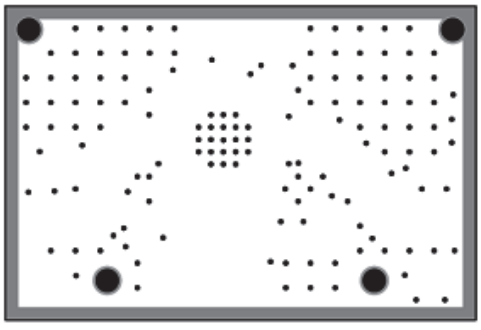
Evaluation Board Layer Detail



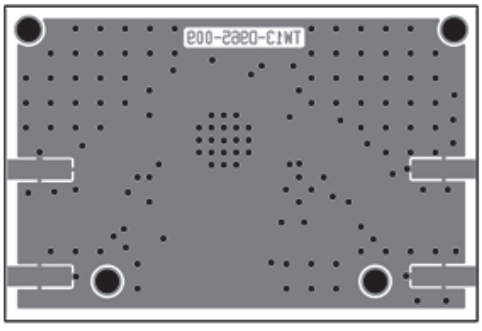
Layer 1: Silk Screen



Layer 1: Top Metal



Layer 2 and 3: Ground



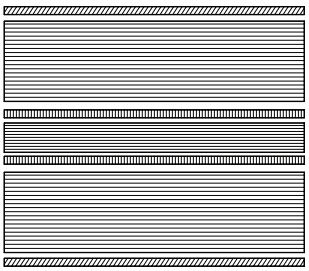
Layer 4: Ground

Bill of Material for Evaluation Board

Part	ID	Qty.	Size	Value	Units	Product Number	Manufacturer	Manufacturer's Part Number	Characteristics
1	C7	1	0603	1500	pF	SK204-000-003	Murata	GRM1885C1H152JA01D	C0G, 50 V, ± 5%
2	C9	1	0603	150	pF	SK204-000-020	Murata	GRM1885C1H151JA01D	C0G, 50 V, ± 5%
3	C10, C11	2	0603	0.01	µF	SK204-000-013	Murata	GCM188R71H103KA37D	X7R, 50 V, ± 5%
4	C13	1	0805	1000	pF	5404R19-037	Murata	GRM2195C1H102JDX1D	C0G, 50 V, ± 5%
5	C14, C15	2	1206	10	µF		Matsuo	267M1602106K-720	Tantalum, 16 V, ± 10%
6	L1	1	0805	68	nH		CoilCraft	0805CS-680XJLB	5%, SRF 1500 MHz
7	R1	1	0603	150	Ω	5424R36-029	Rohm	MCR03EZHUJ150	50 V, 0.063 W, ± 5%
8	C8, C12							Do Not Install	

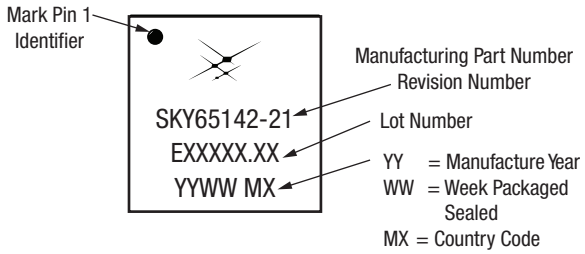
Evaluation Board Stack-Up

Cross Section

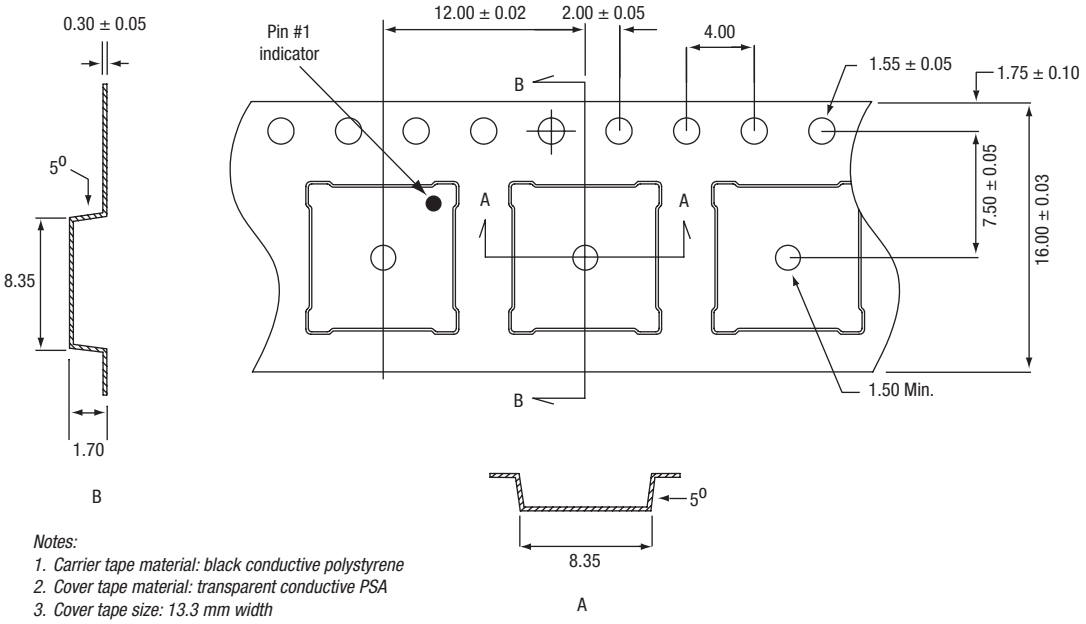


Name	Type	Thick	Material	ε_r
Pri	Electrical	0.035 mm	Cu	0.0
Die 1	Isolation	0.3 mm	R04003-12-3.38	3.38
L2	Plane	0.035 mm	CU	0.0
Die 2	Isolation	0.1 mm	FR4	4.0
L3	Plane	0.035 mm	CU	0.0
Die 3	Isolation	0.3 mm	FR4	4.0
Sec	Electrical	0.035 mm	CU	0.0

Branding Specifications



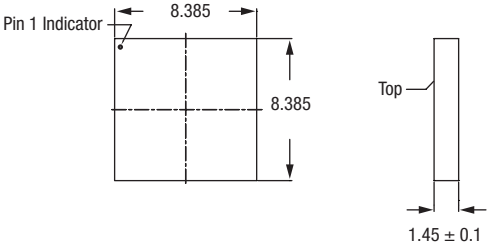
Tape and Reel Dimensions

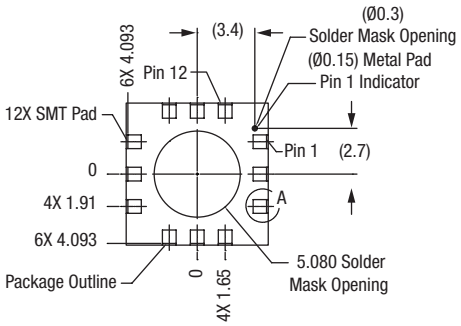


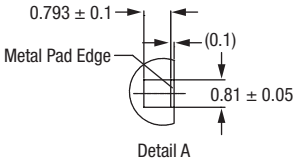
Notes:

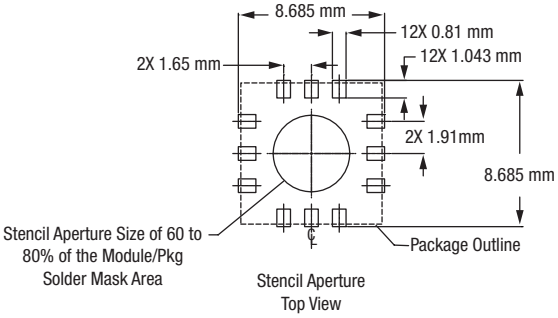
1. *Carrier tape material: black conductive polystyrene*
2. *Cover tape material: transparent conductive PSA*
3. *Cover tape size: 13.3 mm width*
4. *All measurements are in millimeters*

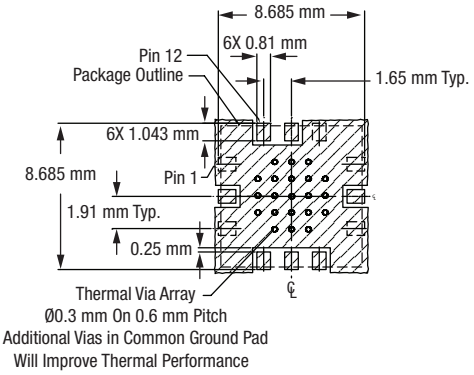
Package Outline and Recommended Footprint

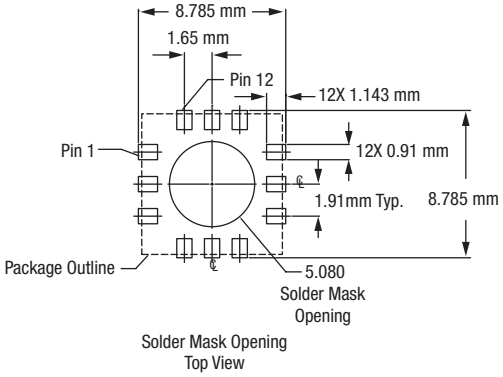












Ordering Information

Model Name	Manufacturing Part Number	Evaluation Kit Part Number
SKY65142: 100-1000 MHz Ultra Wideband Variable Gain Amplifier	SKY65142-21 (Pb-free package)	TW13-D965-009