PRELIMINARY DATA SHEET

SKY65387-11: 2110-2170 MHz Variable Gain Amplifier

Applications

- WCDMA base stations
- Femto cells

Features

- Frequency range: 2110 to 2170 MHz
- High gain: >30 dB
- Attenuation range: > 35 dB
- OP1dB: >+28 dBm
- ACLR < –65 dBc for P_{OUT} = +12 dBm
- Single DC supply: +5 V
- Small MCM (12-pin, 8.385 x 8.385 mm) SMT package (MSL3, 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.

Description

Skyworks SKY65387-11 is a high linearity, Variable Gain Amplifier (VGA) module. The device includes an input Low-Noise Amplifier (LNA), a variable voltage attenuator, and an output Power Amplifier (PA). The two amplifiers and voltage attenuator are optimized for superior ACLR performance with WCDMA signals.

The high linearity (high OP1dB, OIP3, and ACLR) and high efficiency of this device make it ideal for use at the final stage (or close to the final stage) of a WCDMA transmit chain.

The output of the first PA (PA1) is matched to the input of the VCA. The output of the VCA is matched to the input of the second PA (PA2). The RF_IN and RF_OUT signals (pins 1 and 8, respectively) are both internally matched, including DC blocking capacitors.

The SKY65387-11 VGA uses low-cost Surface Mount Technology (SMT) in the form of a compact, 8 x 8 mm 12-pin Multi-Chip Module (MCM), 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.

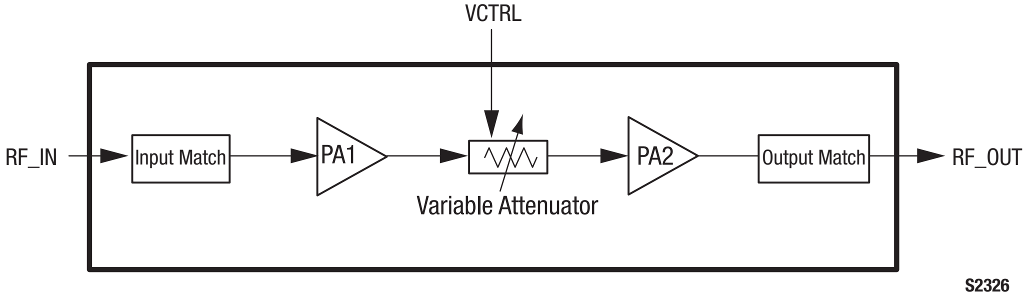


Figure 1. SKY65387-11 Block Diagram

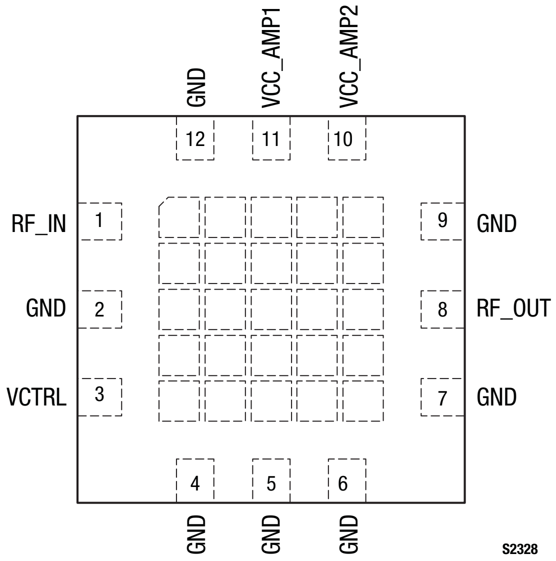


Figure 2. SKY65387-11 Pinout – 12-Pin MCM (Top View)

Table 1. SKY65387-11 Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	RF_IN	RF input	7	GND	Ground
2	GND	Ground	8	RF_OUT	RF output
3	VCTRL	Variable attenuator control voltage	9	GND	Ground
4	GND	Ground	10	VCC_AMP2	Voltage supply for PA2 (after the variable voltage attenuator)
5	GND	Ground	11	VCC_AMP1	Voltage supply for PA1 (before the variable voltage attenuator)
6	GND	Ground	12	GND	Ground

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY65387-11 are provided in Table 2. The recommended operating conditions are specified in Table 3 and electrical specifications are provided in Table 4.

Typical performance characteristics of the SKY65387-11 are illustrated in Figures 3 through 9.

Table 2. SKY65387-11 Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	VCC_AMP1, VCC_AMP2		5.5	V
Control voltage	V_{CTL}		5.0	V
RF output power (CW)	P_{OUT}		+29	dBm
Thermal resistance	$_{JC}$		38.6	°C/W
Operating case temperature	T_C	–40	+85	°C
Storage case temperature	T_{STG}	–55	+125	°C
Junction temperature	T_J		+150	°C

Note: 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.

***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. SKY65387-11 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
Frequency range	f	2110		2170	MHz
RF output power (CW)	P_{OUT}			+25	dBm
Supply voltage, measured at terminals of Evaluation Board	VCC_AMP1, VCC_AMP2	4.75	5.00	5.25	V
Variable voltage attenuator control range	VCTRL	0		4.5	V
Ruggedness, load VSWR with no permanent damage	P_{MAX_LOAD}			10:1	–
Operating case temperature	T_C	–40		+85	°C

Table 4. SKY65387-11 Electrical Specifications (Note 1)
(VCC_AMP1 = VCC_AMP2 = 5 V, VCTRL = 0 V, f = 2.14 GHz, T_C = +25 °C, Characteristic Impedance [Z_O] = 50 , Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Frequency range	f		2110		2170	MHz
Small signal gain	$\lvert S_{21} \rvert$	CW		30		dB
Gain control range	$G_{\_RANGE}$	CW		35		dB
Gain flatness	$G_{\_FLATNESS}$	CW			0.8	dB
Output 1dB Compression Point	OP1dB	CW		+28		dBm
3rd Order Output Intercept Point	OIP3	P_{TONE} = +12 dBm, f = 1 MHz		+42		dBm
ACLR for P_{OUT} = +12 dBm	ACLR	WCDMA, test mode 1		–66.5		dBc
Noise Figure	NF	At maximum gain		3.5		dB
Input return loss	$\lvert S_{11} \rvert$			20		dB
Output return loss	$\lvert S_{22} \rvert$			10		dB
Quiescent current	I_Q	No RF		295		mA
Operating current	I_{OP}	P_{OUT} = +12 dBm		300		mA
Maximum VSWR for stable operation	$VSWR_{\_MAX}$	CW, P_{OUT} = +12 dBm	8:1			–

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

Typical Performance Characteristics

(VCC_AMP1 = VCC_AMP2 = 5 V, VCTRL = 0 V, f = 2.14 GHz, Tc = +25 °C, Characteristic Impedance [Zo] = 50 , Unless Otherwise Noted)

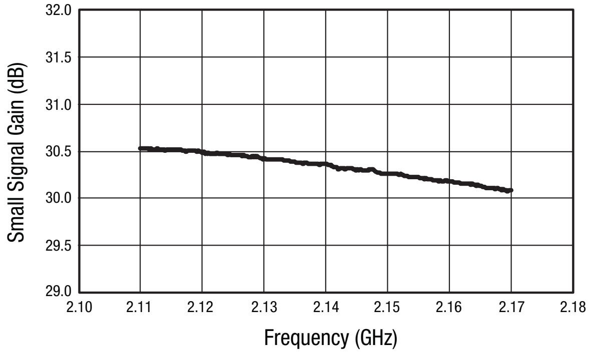


Figure 3. Small Signal Gain vs Frequency

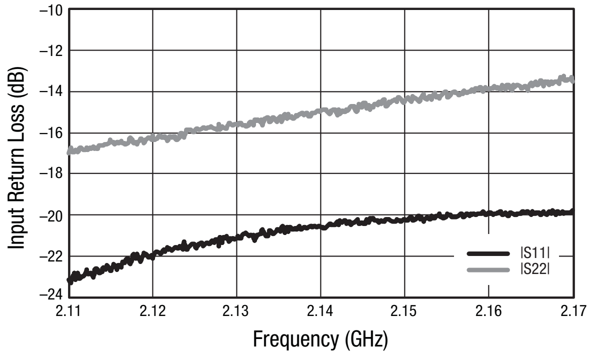


Figure 4. Return Loss vs Frequency

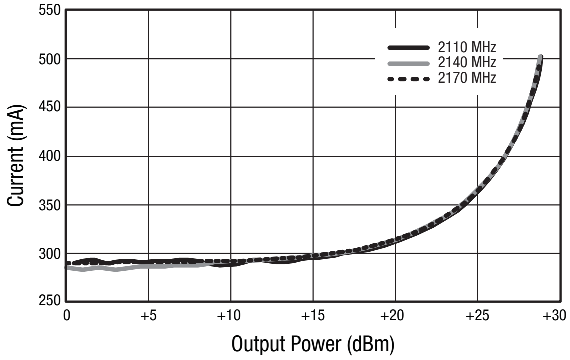


Figure 5. Current vs Output Power

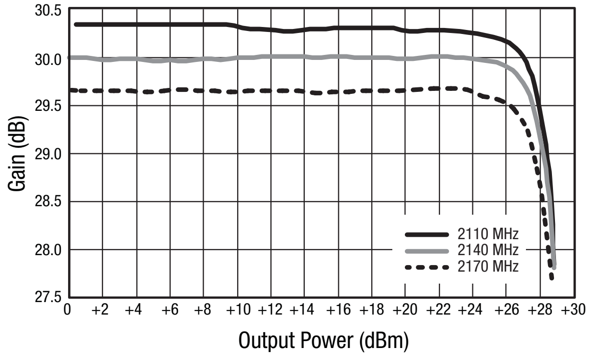


Figure 6. Gain vs Output Power

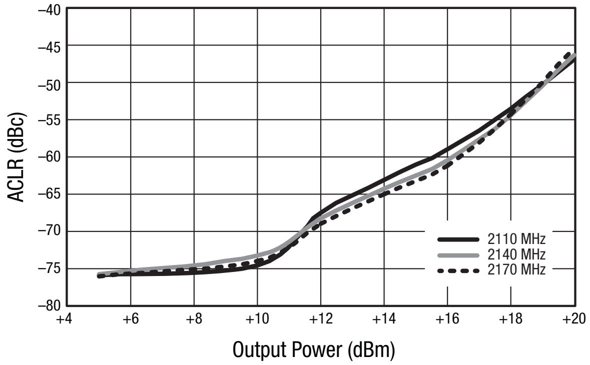


Figure 7. ACLR vs Output Power (WCDMA Test Model 1 w/64 DPCH)

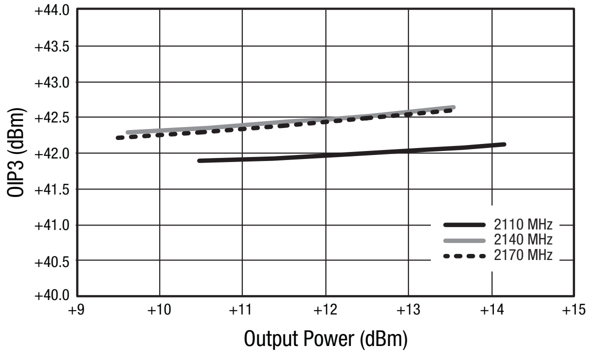


Figure 8. OIP3 vs Output Power (f = 1 MHz)

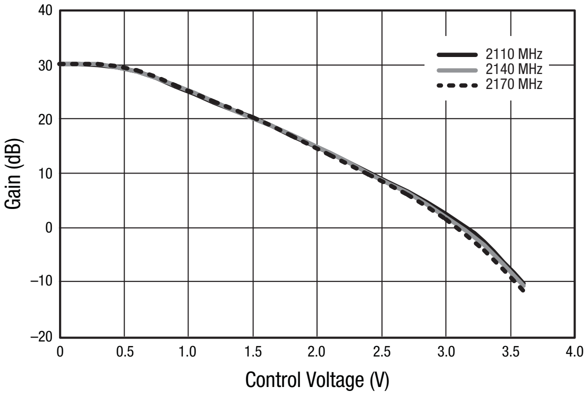


Figure 9. Gain vs Control Voltage

Evaluation Board Description

The Skyworks SKY65387-11 Evaluation Board is used to test the performance of the SKY65387-11 VGA. An Evaluation Board schematic diagram is provided in Figure 10. An assembly drawing for the Evaluation Board is shown in Figure 11 and the layer detail is provided in Figure 12. The layer detail physical characteristics are noted in Figure 13.

Capacitors C1, C2, and C3 provide DC bias decoupling and RF bypass for VCC_AMP1 (pin 11). Capacitors C4, C5, and C6 provide DC bias decoupling and RF bypass for VCC_AMP2 (pin 10). Capacitor C7 provides decoupling for VCTRL (pin 3).

Pins 1 and 8 are the RF input and output signals, respectively. Pins 2, 4, 5, 6, 7, 9, 12, and the package backside metal are ground pins that provide the DC, RF, and thermal ground.

Circuit Design Configurations

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

1. Proper isolation must be provided between the VCC_AMP1 and VCC_AMP2 pins.
2. Paths to ground should be made as short as possible.
3. The ground pad of the SKY65387-11 VGA 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 amplifier. As such, design the connection to the ground pad to dissipate the maximum wattage produced to the circuit board. Multiple vias to the grounding layer are required. Filled or capped vias are recommended.
4. It is recommended that the layout for the VCC_AMP1 and VCC_AMP2 signals follow what is shown in Figure 11. The VCC_AMP1 and VCC_AMP2 traces can be tied together to share the same power supply. The connecting node should not be placed close to the package pins. The connecting node should be connected closer to components C1 and C4 (see Figure 10). This is to provide isolation between VCC_AMP1 and VCC_AMP2.

NOTE: Junction temperature (Tj) of the device increases with a poor connection to the slug and ground. This reduces the lifetime of the device.

Testing Procedure

Use the following procedure to set up the SKY65387-11 Evaluation Board for testing:

1. Connect a 5.0 V supply to the VCC_AMP1 and VCC_AMP2 pins. Connect the VCTRL signal to a power supply and set the power supply to 0 V. If available, enable the current limiting function of the power supply to 450 mA.
2. Connect a signal generator to the RF signal input port. Set it to the desired RF frequency at a power level of –20 dBm or less to the Evaluation Board but do NOT enable the RF signal.
3. Connect a spectrum analyzer to the RF signal output port.
4. Enable the power supply.
5. Enable the RF signal.
6. Take measurements.

***CAUTION**: If any of the output signals exceed the rated maximum values, the SKY65387-11 Evaluation Board can be permanently damaged.*

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 SKY65387-11 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 & 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.

Package Dimensions

The PCB footprint drawing for the SKY65387-11 is shown in Figure 14. Package dimensions for the 12-pin MCM are shown in Figure 15, and tape and reel dimensions are provided in Figure 16.

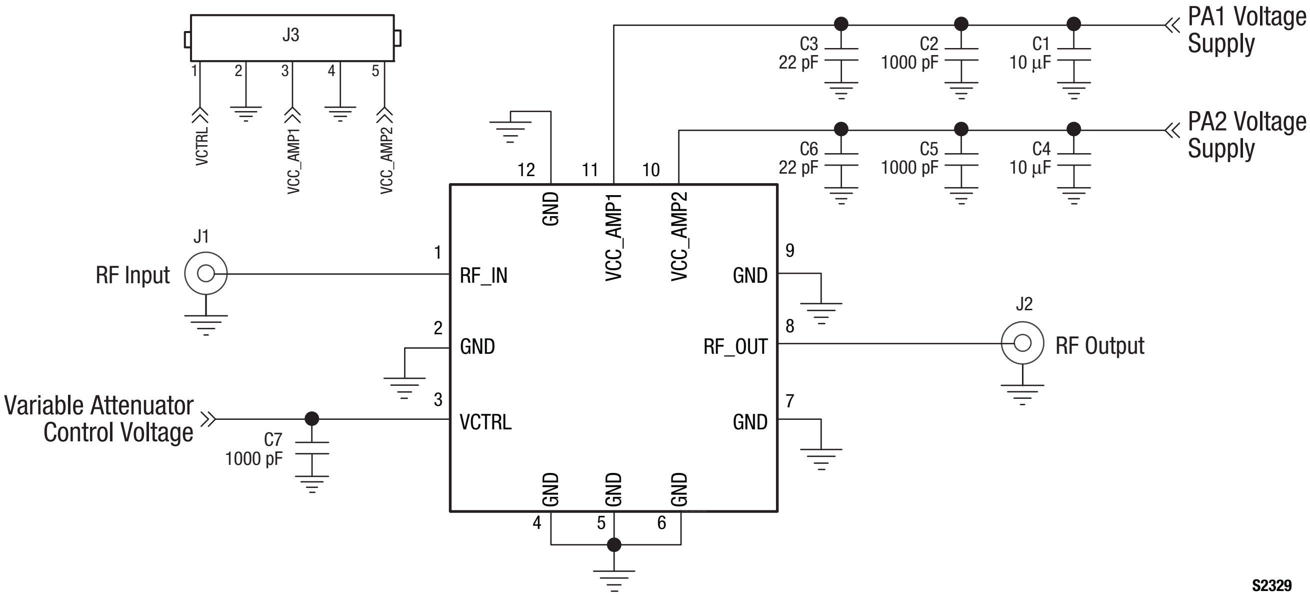


Figure 10. SKY65387-11 Evaluation Board Schematic

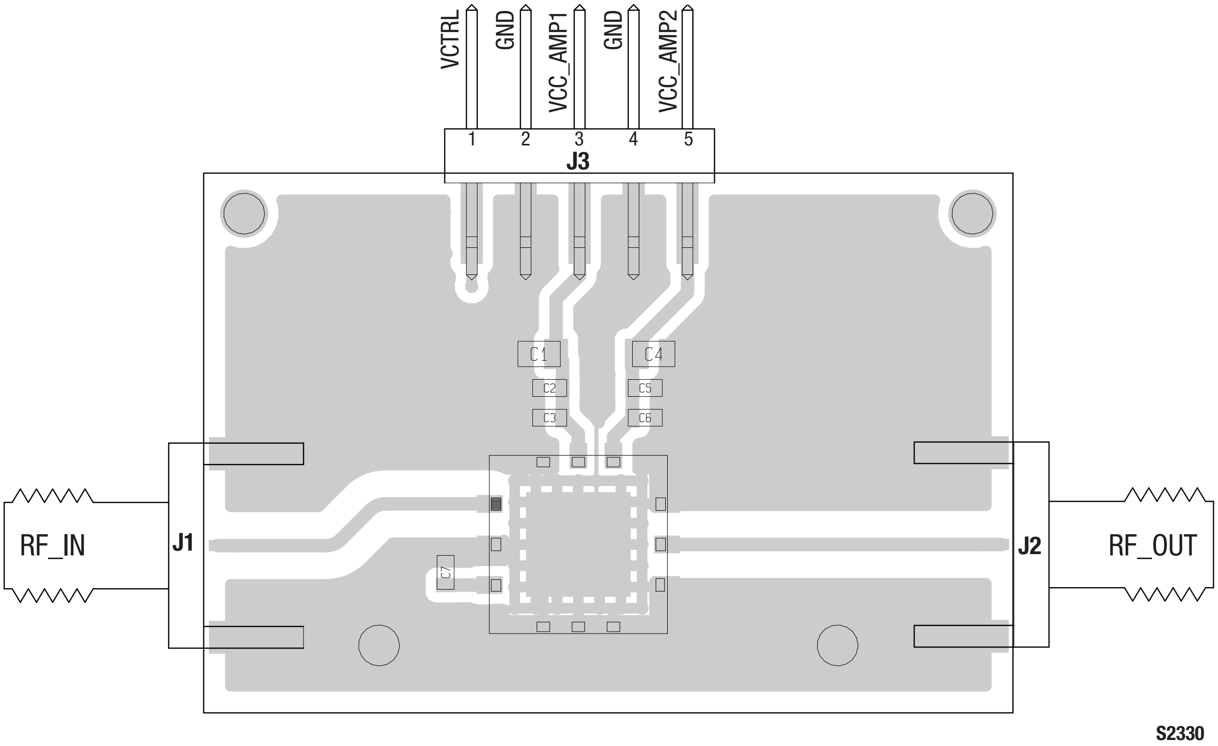
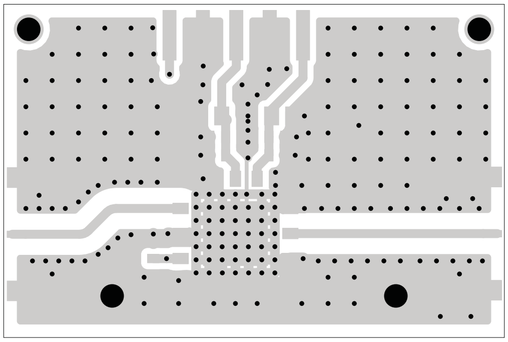
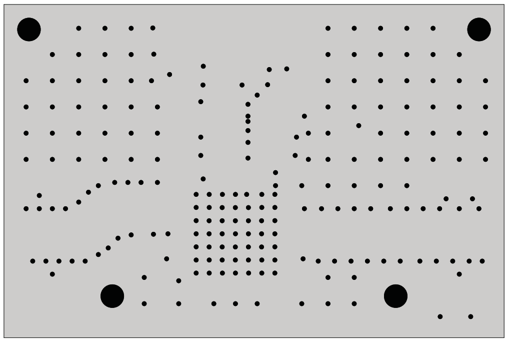


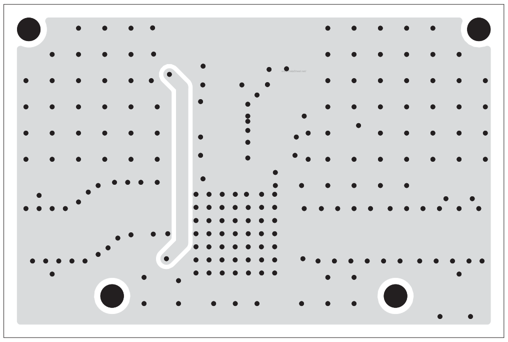
Figure 11. SKY65387-11 Evaluation Board Assembly Drawing



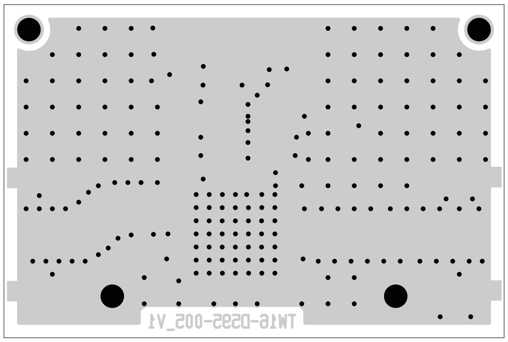
Layer 1: Top – Metal



Layer 2: Ground



Layer 3: Power Plane



Layer 4: Solid Ground Plane

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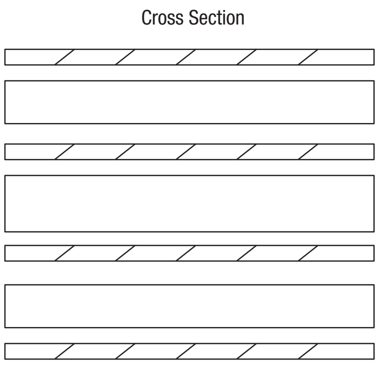
Figure 12. SKY65387-11 Evaluation Board Layer Detail



Name	Thickness (mm)	Material	ε_r
Pri	0.035	Cu-1 oz.	–
Die1	0.250	Rogers 4350	–
L2	0.035	Cu-1 oz.	–
Die2	0.200	FR4	4.0
L3	0.035	Cu-1 oz.	–
Die3	0.250	FR4	4.0
Sec	0.035	Cu-1 oz.	–

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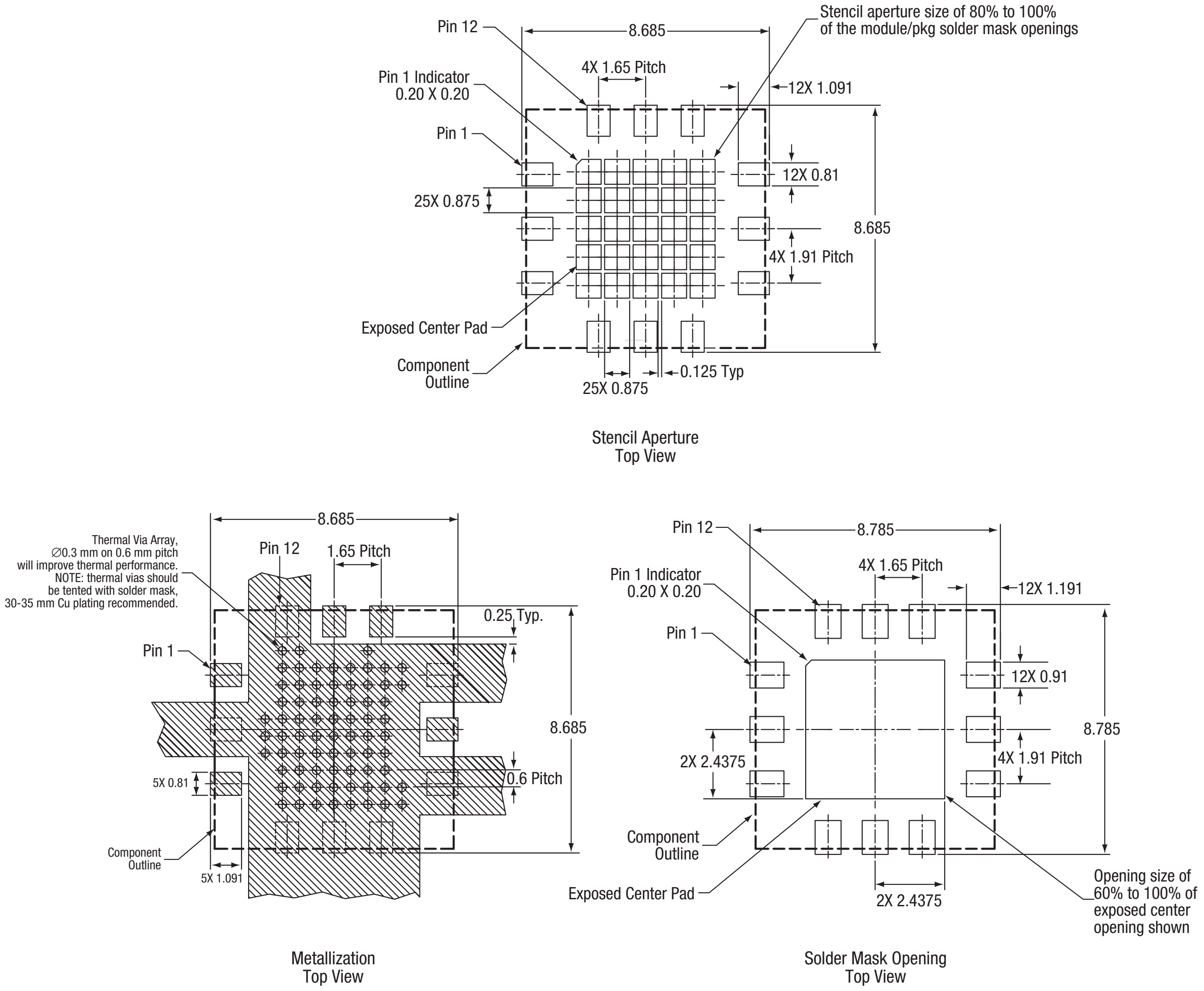
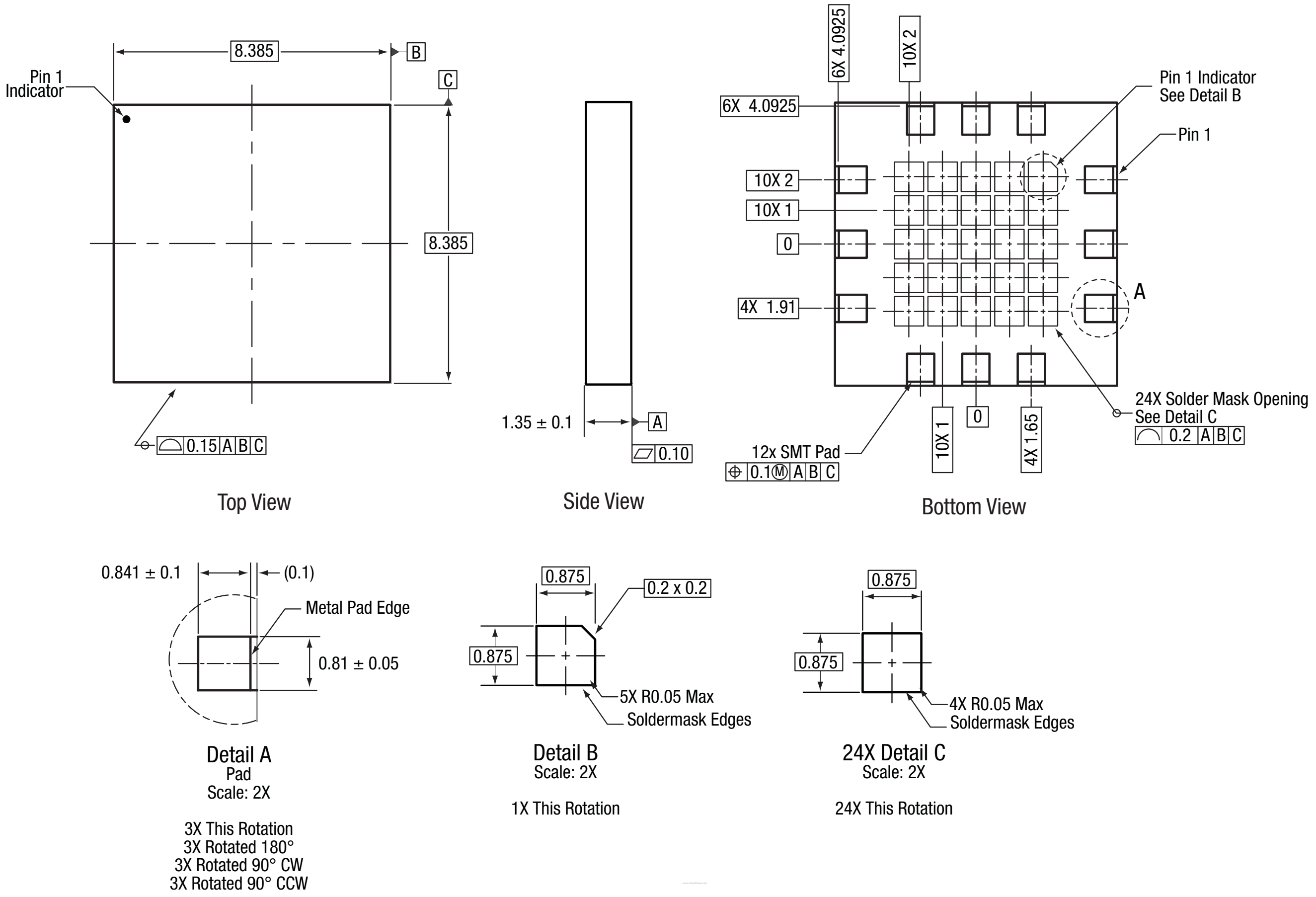
Figure 13. Layer Detail Physical Characteristics



All dimensions are in millimeters

S2367

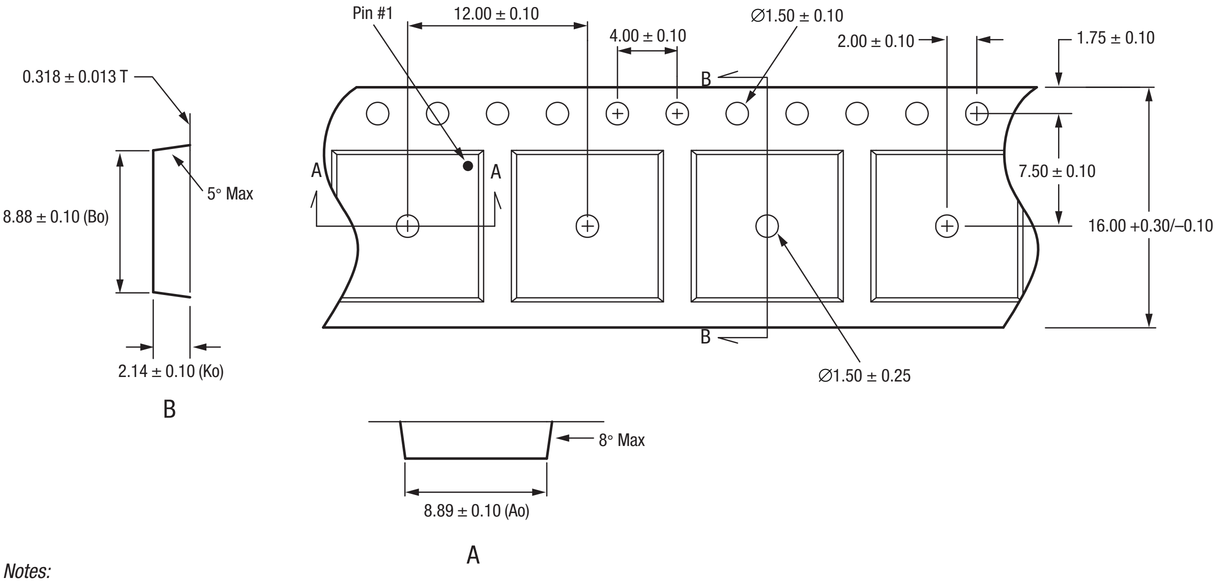
Figure 14. SKY65387-11 PCB Layout Footprint



Dimensioning and tolerancing according to ASME Y14.5M-1994.
Pads are metal defined.
All measurements are in millimeters

S2366

Figure 15. SKY65387-11 12-Pin MCM Package Dimensions



Notes:
1. *Carrier tape material: black conductive polycarbonate or polystyrene.*
2. *Cover tape material: transparent conductive PSA.*
3. *Cover tape size: 13.3 mm width.*
4. *Typical ESD surface resistivity is ≤10^8 Ohms/square per EIA, JEDEC tape and reel specification.*
5. *Tolerance: .XX = ±0.10 mm.*
6. *All measurements are in millimeters.*

S2630

Figure 16. SKY65387-11 Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY65387-11 2000-2230 MHz Variable Gain Amplifier	SKY65387-11	TW16-D590

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