

# SKY65186-11: 330 – 2700 MHz Dual-Channel, Variable Gain Amplifier Front-End Module

## Applications

- Cellular, 3G and LTE infrastructure
- Microwave radio
- Repeaters
- High performance radio links

## Features

- Frequency range: 330 to 2700 MHz
- Dual channel
- 6-bit digital step attenuator for each channel
- 31.5 dB control range with 0.5 dB step size
- Single DC supply: +5 V
- Internal RF match and bias circuits
- Small footprint, MCM (32-pin, 7 x 7 mm) package (MSL3, 260 °C per JEDEC J-STD-020)



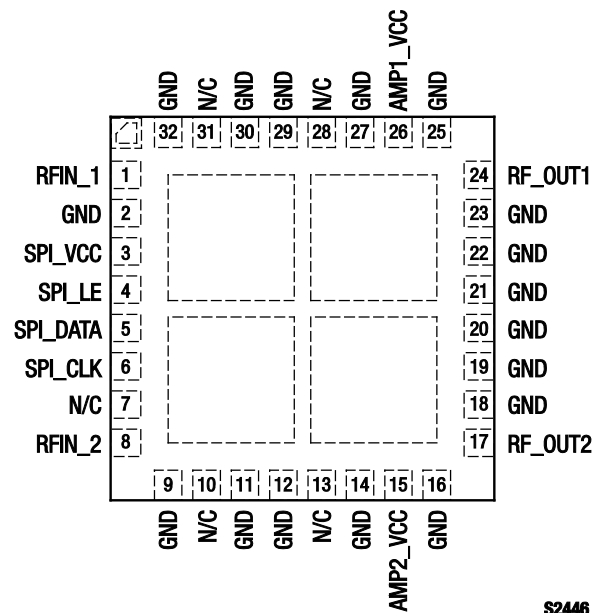
Skyworks Pb-free products are compliant with all applicable legislation. For additional information, refer to *Skyworks Definition of Lead (Pb)-Free*, document number SQ04-0073.

## Description

Skyworks SKY65186-11 is a high dynamic range receive Variable Gain Amplifier (VGA) Front-End Module (FEM) for 3G and LTE infrastructures and other applications that operate in the 0.4 to 2.7 GHz band.

The SKY65186-11 contains two Digital Step Attenuators (DSAs) and two Power Amplifiers (PAs). The DSA is a 6-bit attenuator with an 0.5 dB step size that provides 31.5 dB of total attenuation. The DSA is controlled using an on-chip Serial Peripheral Interface (SPI) logic circuit.

The SKY65186-11 is provided in a 32-pin, 7 x 7 mm Multi-Chip Module (MCM) package, which allows for a highly manufacturable low cost solution. The device package and pinout for the 32-pin MCM are shown in Figure 1. A block diagram of the SKY65186-11 is shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.



**Figure 1. SKY65186-11 Pinout – 32-Pin MCM (Top View)**

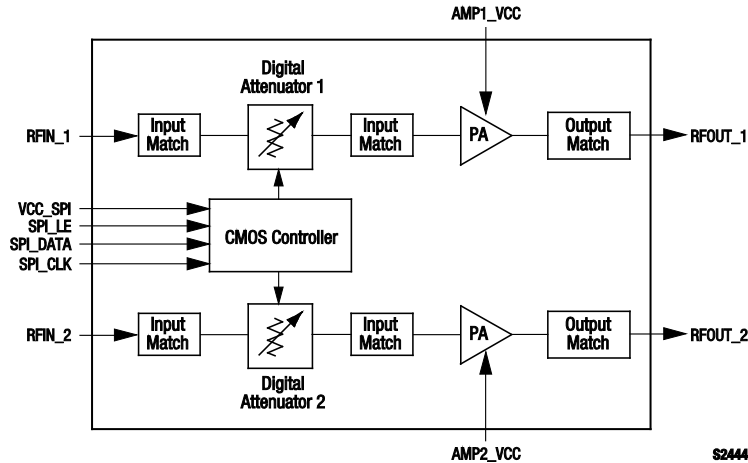


Figure 2. SKY65186-11 Block Diagram

Table 1. SKY65186-11 Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	RF_IN1	RF input 1	17	RF_OUT2	RF output 2
2	GND	Ground	18	GND	Ground
3	SPI_VCC	Supply voltage for SPI	19	GND	Ground
4	SPI_LE	Serial latch enable input	20	GND	Ground
5	SPI_DATA	Serial data input	21	GND	Ground
6	SPI_CLK	Serial clock input	22	GND	Ground
7	N/C	No connection	23	GND	Ground
8	RF_IN2	RF input 2	24	RF_OUT1	RF output 1
9	GND	Ground	25	GND	Ground
10	N/C	No connection	26	AMP1_VCC	Supply voltage for amplifier 1
11	GND	Ground	27	GND	Ground
12	GND	Ground	28	N/C	No connection
13	N/C	No connection	29	GND	Ground
14	GND	Ground	30	GND	Ground
15	AMP2_VCC	Supply voltage for amplifier 2	31	N/C	No connection
16	GND	Ground	32	GND	Ground

### Technical Description

The SKY65186-11 VGA FEM contains all of the needed RF matching and DC biasing circuits. The device is a dual-channel, digitally controlled VGA that features high linearity and a low Noise Figure (NF). These features make the device suitable for 3G infrastructures and other applications operating in the 330 to 2700 MHz frequency range.

### Serial I/O Control Interface

The three-wire serial bus consists of the SPI\_CLK, SPI\_LE, and SPI\_DATA control signals. The serial bus timing is shown in Figure 3. Timing parameters are defined in Table 2. The serial data is sent MSB first and should be sampled with the rising edge of the serial clock (SPI\_CLK). The rising edge of the latch enable (SPI\_LE) signal should be used to capture the data into holding registers.

Serial data is formatted as a 12-bit word. As shown in Figure 3, the 12-bit word contains logic for both attenuators. Each word contains the following sequence:

**Attenuator 1:**

- Bit[11]: attenuation = 16 dB
- Bit[10]: attenuation = 8 dB
- Bit[9]: attenuation = 4 dB
- Bit[8]: attenuation = 2 dB
- Bit[7]: attenuation = 1 dB
- Bit[6]: attenuation = 0.5 dB

**Attenuator 2:**

- Bit[5]: attenuation = 16 dB
- Bit[4]: attenuation = 8 dB
- Bit[3]: attenuation = 4 dB
- Bit[2]: attenuation = 2 dB
- Bit[1]: attenuation = 1 dB
- Bit[0]: attenuation = 0.5 dB

The minimum attenuation (0 dB) for each attenuator is achieved using the binary data sequence 111111b. Maximum attenuation (31.5 dB) corresponds to the binary data sequence 000000b.

The state of the SKY65186-11 is determined by the attenuation logic provided in Table 3 (DSA 1) and Table 4 (DSA 2).

**Electrical and Mechanical Specifications**

The absolute maximum ratings of the SKY65186-11 are provided in Table 5. Recommended operating conditions are specified in Table 6 and electrical specifications are provided in Table 7.

Typical performance characteristics are shown in Figures 4 through 8 (330 MHz), Figures 9 through 12 (400 MHz), Figures 13 through 16 (700 MHz), Figures 17 through 20 (900 MHz), Figures 21 through 24 (1900 MHz), and Figures 25 through 28 (2700 MHz).

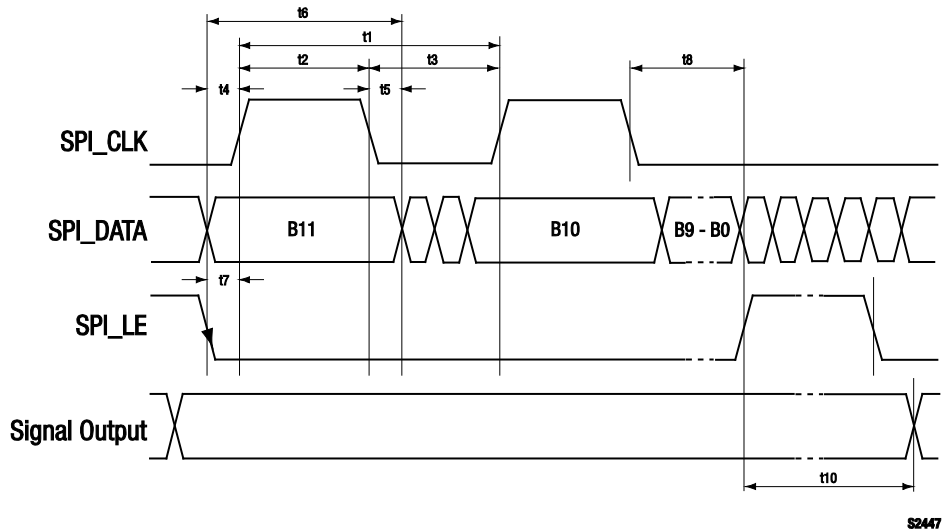


Figure 3. Serial Input Timing Diagram

**Table 2. Serial Input Timing Parameters**

Parameter	Value	Description
t1	25 MHz maximum	Clock frequency
t2	20 ns minimum	CLK high
t3	20 ns minimum	CLK low
t4	5 ns minimum	DATA to CLK setup time
t5	5 ns minimum	DATA to CLK hold time
t6	30 ns minimum	DATA valid
t7	5 ns minimum	LE to CLK setup time
t8	5 ns minimum	CLK to LE setup time
t9	10 ns minimum	LE pulse width
t10	20 ns minimum	Output set

**Table 3. Attenuation Logic Truth Table (DSA 1)**

Attenuator Control Word (Channel 1)						Attenuation Relative to Maximum Gain (dB)
B11 (MSB)	B10	B9	B8	B7	B6 (LSB)	
1	1	1	1	1	1	0
1	1	1	1	1	0	0.5
1	1	1	1	0	1	1.0
1	1	1	0	1	1	2.0
1	1	0	1	1	1	4.0
1	0	1	1	1	1	8.0
0	1	1	1	1	1	16.0
0	0	0	0	0	0	31.5

**Table 4. Attenuation Logic Truth Table (DSA 2)**

Attenuator Control Word (Channel 2)						Attenuation Relative to Maximum Gain (dB)
B5 (MSB)	B4	B3	B2	B1	B0 (LSB)	
1	1	1	1	1	1	0
1	1	1	1	1	0	0.5
1	1	1	1	0	1	1.0
1	1	1	0	1	1	2.0
1	1	0	1	1	1	4.0
1	0	1	1	1	1	8.0
0	1	1	1	1	1	16.0
0	0	0	0	0	0	31.5

**Table 5. SKY65186-11 Absolute Maximum Ratings (Note 1)**

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	AMP1_VCC, AMP2_VCC	4.0	5.5	V
RF input power	P <sub>IN</sub>		+14	dBm
Operating temperature	T <sub>c</sub>	-40	+85	°C
Storage temperature	T <sub>ST</sub>	-65	+150	°C
Junction temperature	T <sub>J</sub>		+150	°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 6. SKY65186-11 Recommended Operating Conditions**

Parameter	Symbol	Minimum	Typical	Maximum	Units
Frequency range	f	330		2700	MHz
Supply voltage (AMP1_VCC, AMP2_VCC)	V <sub>CC</sub>	4.75		5.25	V
Serial port interface supply voltage (SPI_VCC)		4.75		5.25	V
Control voltage, high level (SPI_LE, SPI_DATA, SPI_CLK)		3.0		3.3	V
Operating current	I <sub>CC</sub>		220		mA

**Table 7. SKY65186-11 Electrical Specifications (1 of 2) (Note 1)**

**(AMP1\_VCC = AMP2\_VCC = 5.0 V, T<sub>c</sub> = 25 °C, Attenuation = 0 dB, CW Input = -30 dBm, Unless Otherwise Noted)**

Parameter	Symbol	Operating Frequency (MHz)	Min	Typical	Max	Units
Small signal gain	IS <sub>211</sub>	330 (Note 2)		13.6		dB
		400		13.6		dB
		700		13.0		dB
		900		13.5		dB
		1900		13.3		dB
		2700		13.0		dB
Attenuation	Attn	330 (Note 2)		31.5		dB
		400		31.5		dB
		700		31.5		dB
		900		31.5		dB
		1900		31.5		dB
		2700		31.5		dB
Attenuation step	Attn <sub>STEP</sub>	330 (Note 2)		0.5		dB
		400		0.5		dB
		700		0.5		dB
		900		0.5		dB
		1900		0.5		dB
		2700		0.5		dB

**Table 7. SKY65186-11 Electrical Specifications (2 of 2) (Note 1)**  
**(AMP1\_VCC = AMP2\_VCC = 5.0 V, Tc = 25 °C, Attenuation = 0 dB, CW Input = -30 dBm, Unless Otherwise Noted)**

Parameter	Symbol	Operating Frequency (MHz)	Min	Typical	Max	Units
Attenuation step error	Attn_ERROR	330 (Note 2)		0.1 ± 0.5%		dB
		400		0.1 ± 0.5%		dB
		700		0.1 ± 0.5%		dB
		900		0.1 ± 0.5%		dB
		1900		0.1 ± 0.5%		dB
		2700		0.2 ± 0.5%		dB
1 dB Output Compression Point	OP1dB	330 (Note 2)		+20.3		dBm
		400		+20.3		dBm
		700		+20.0		dBm
		900		+20.3		dBm
		1900		+20.2		dBm
		2700		+19.5		dBm
3 <sup>rd</sup> Order Output Intercept Point (output power = 0 dBm, 1 MHz spacing)	OIP3	330 (Note 2)		+34.3		dBm
		400		+36.8		dBm
		700		+35.2		dBm
		900		+36.4		dBm
		1900		+33.6		dBm
		2700		+32.0		dBm
Noise Figure	NF	330 (Note 2)		7.9		dB
		400		7.8		dB
		700		6.5		dB
		900		5.8		dB
		1900		5.0		dB
		2700		4.8		dB
Input return loss	IS11I	330 (Note 2)		17.7		dB
		400		19.0		dB
		700		21.4		dB
		900		19.0		dB
		1900		12.4		dB
		2700		12.0		dB
Output return loss	IS22I	330 (Note 2)		9.2		dB
		400		11.0		dB
		700		15.3		dB
		900		26.2		dB
		1900		11.7		dB
		2700		10.8		dB
Quiescent current/amplifier	Icq	No RF		105		mA

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

**Note 2:** Performance at 330 MHz requires components C24 = C11 = 30 pF and components C25 = C10 = 2.2 pF.

### Typical Performance Characteristics @ 330 MHz

(V<sub>cc</sub> = 5 V, T<sub>c</sub> = +25 °C, Schematic Components C24 = C11 = 30 pF and C25 = C10 = 2.2 pF, Unless Otherwise Noted)

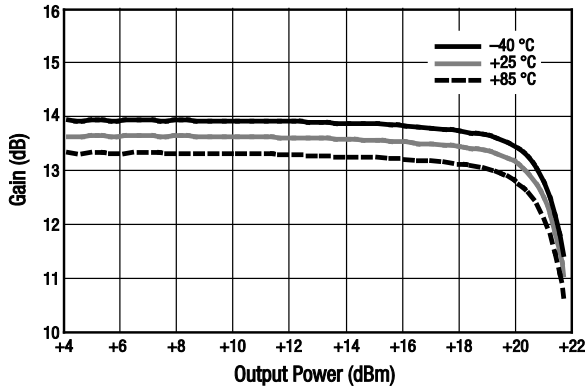


Figure 4. Gain vs Output Power Over Temperature

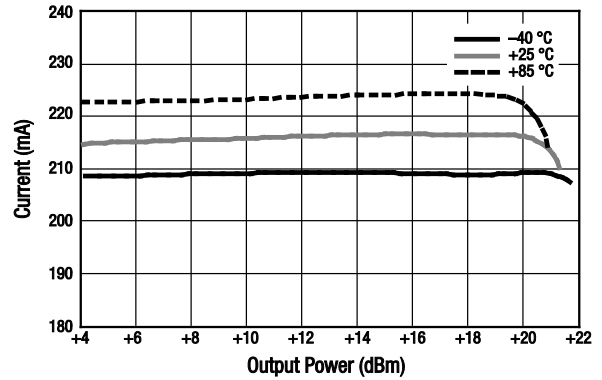


Figure 5. Current vs Output Power Over Temperature

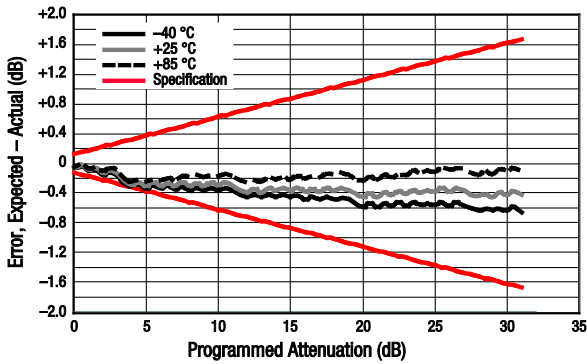


Figure 6. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting (Spec: 0.1 + 5%)

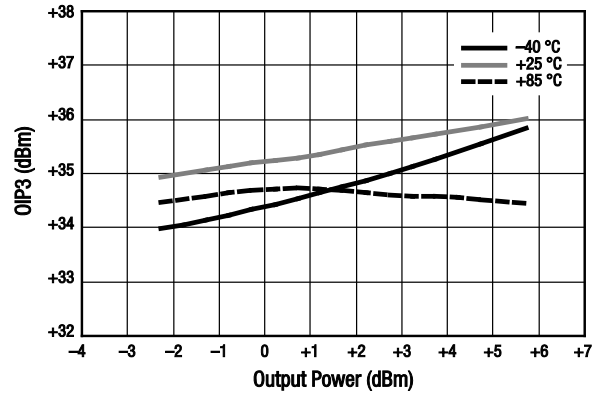


Figure 7. OIP3 vs Output Power Over Temperature (1 MHz Spacing)

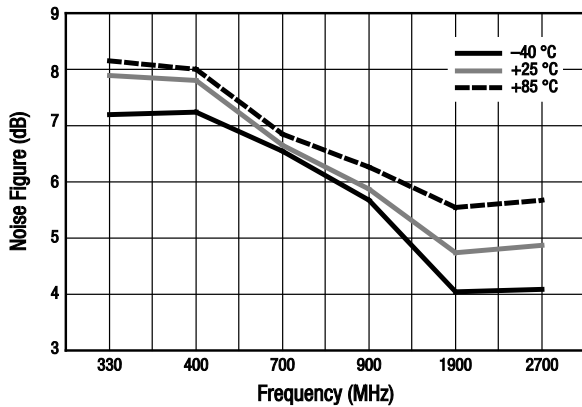
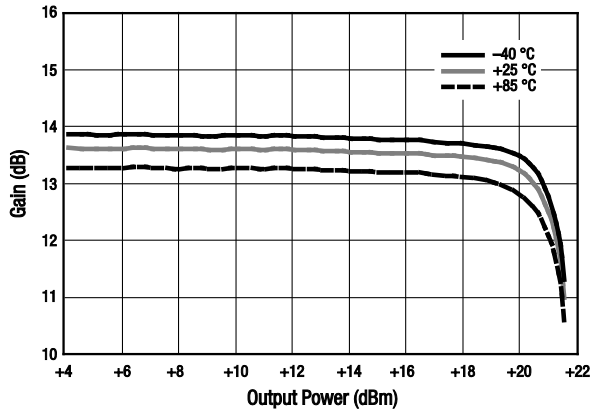
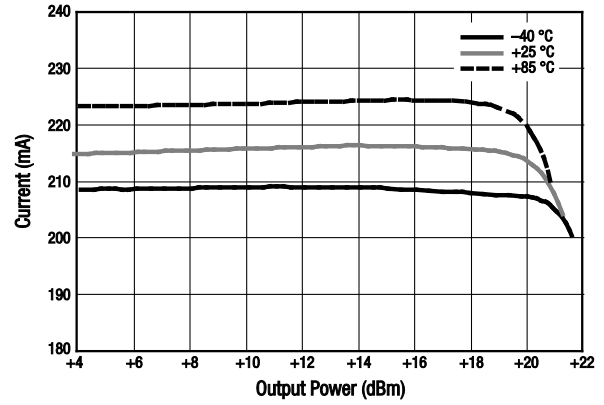


Figure 8. Noise Figure vs Frequency Over Temperature

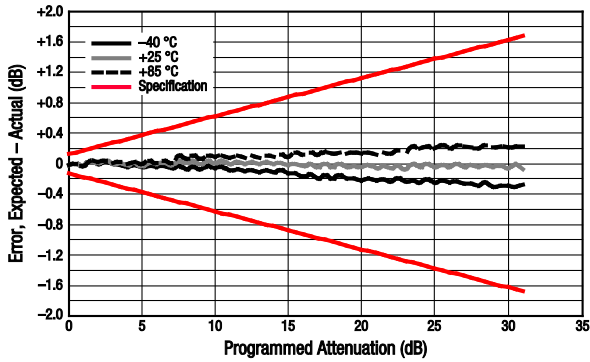
**Typical Performance Characteristics @ 400 MHz**  
 (V<sub>CC</sub> = 5 V, T<sub>c</sub> = +25 °C, Unless Otherwise Noted)



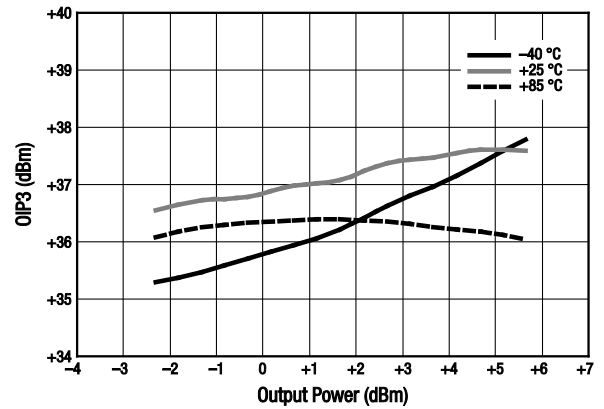
**Figure 9. Gain vs Output Power Over Temperature**



**Figure 10. Current vs Output Power Over Temperature**



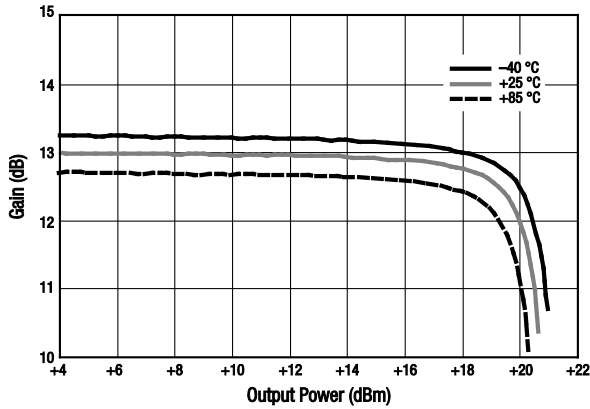
**Figure 11. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting**



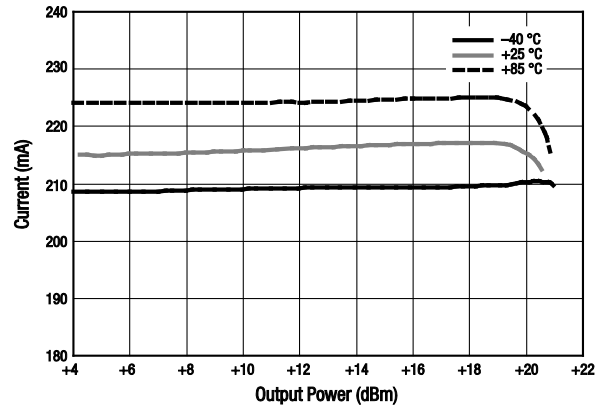
**Figure 12. OIP3 vs Output Power Over Temperature (1 MHz Spacing)**



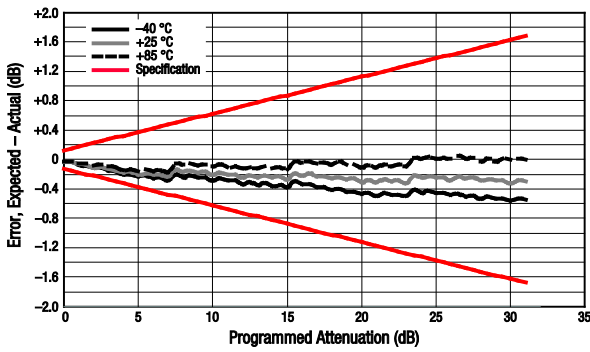
**Typical Performance Characteristics @ 700 MHz**  
 (V<sub>CC</sub> = 5 V, T<sub>c</sub> = +25 °C, Unless Otherwise Noted)



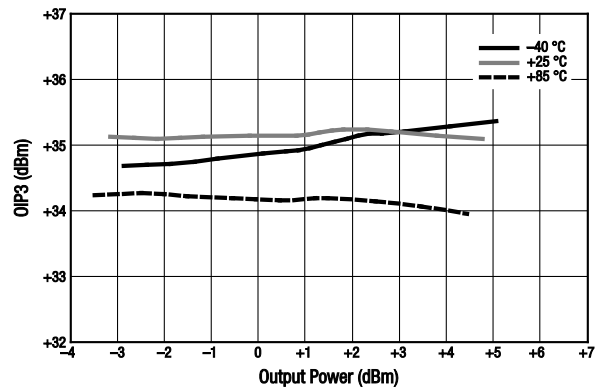
**Figure 13. Gain vs Output Power Over Temperature**



**Figure 14. Current vs Output Power Over Temperature**

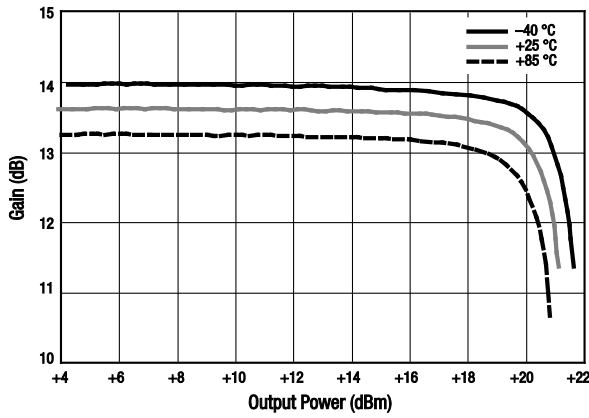


**Figure 15. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting**

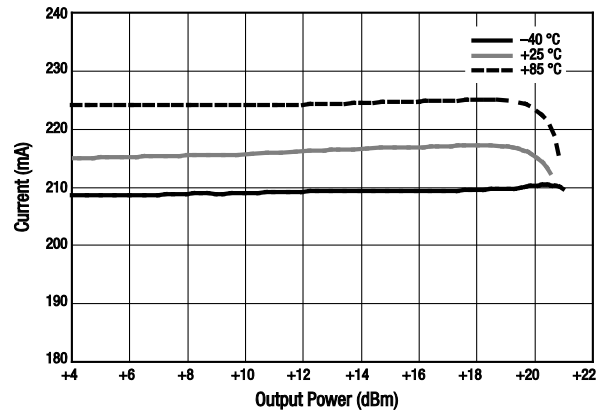


**Figure 16. OIP3 vs Output Power Over Temperature (1 MHz Spacing)**

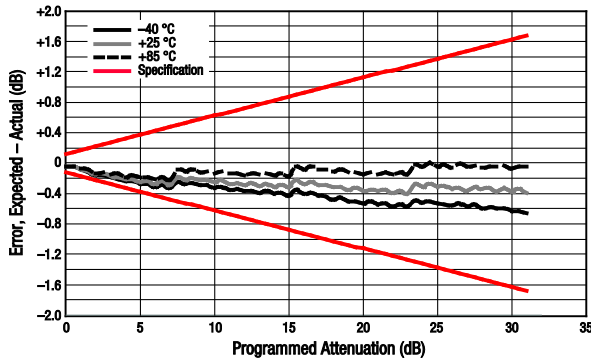
**Typical Performance Characteristics @ 900 MHz**  
 (V<sub>CC</sub> = 5 V, T<sub>c</sub> = +25 °C, Unless Otherwise Noted)



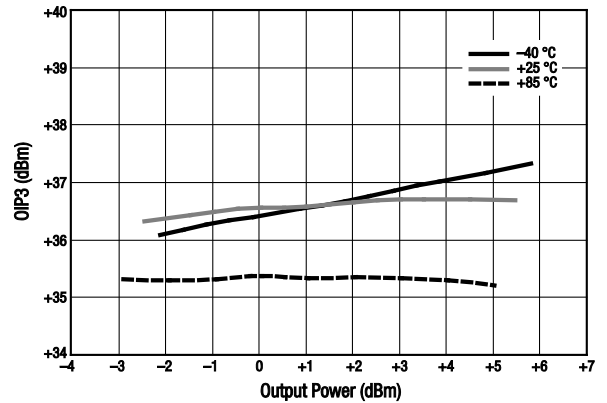
**Figure 17. Gain vs Output Power Over Temperature**



**Figure 18. Current vs Output Power Over Temperature**

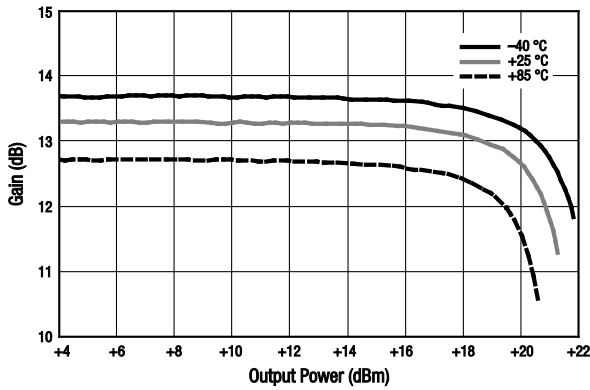


**Figure 19. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting**

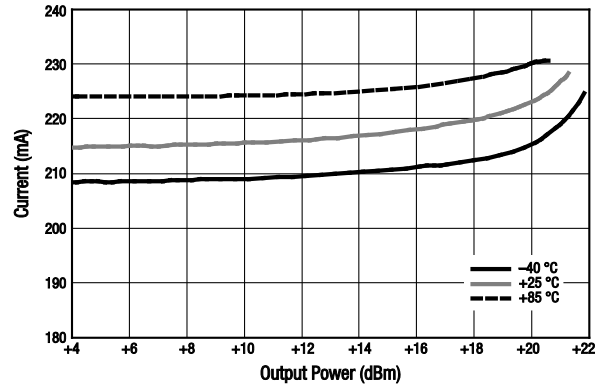


**Figure 20. OIP3 vs Output Power Over Temperature (1 MHz Spacing)**

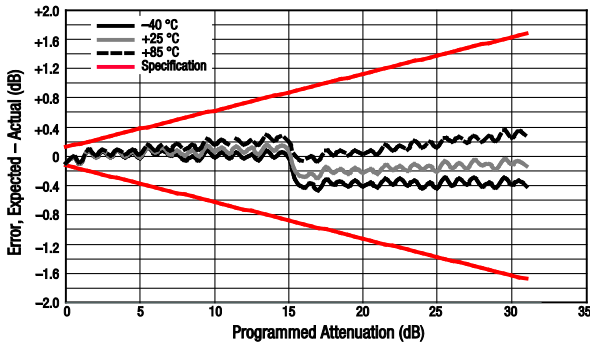
**Typical Performance Characteristics @ 1900 MHz**  
 (V<sub>CC</sub> = 5 V, T<sub>c</sub> = +25 °C, Unless Otherwise Noted)



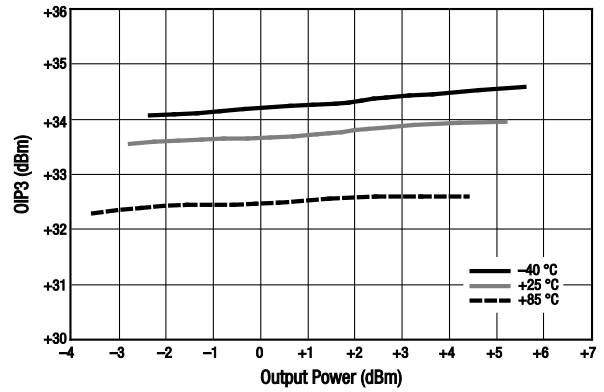
**Figure 21. Gain vs Output Power Over Temperature**



**Figure 22. Current vs Output Power Over Temperature**

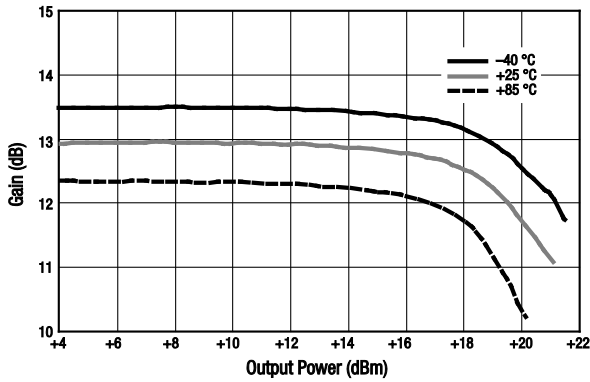


**Figure 23. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting**

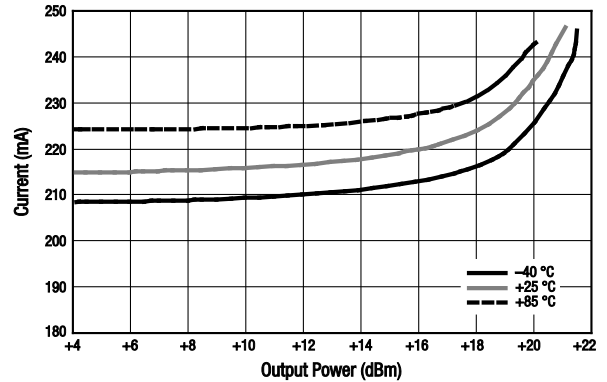


**Figure 24. OIP3 vs Output Power Over Temperature (1 MHz Spacing)**

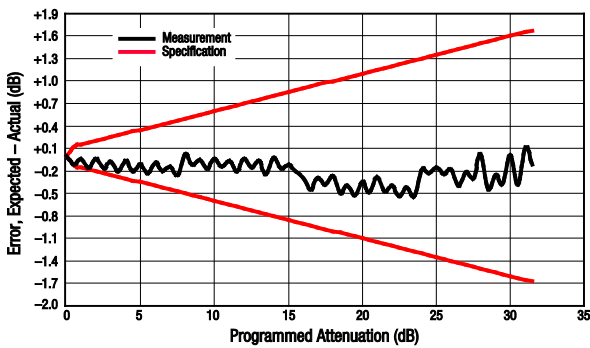
**Typical Performance Characteristics @ 2700 MHz**  
 (V<sub>CC</sub> = 5 V, T<sub>c</sub> = +25 °C, Unless Otherwise Noted)



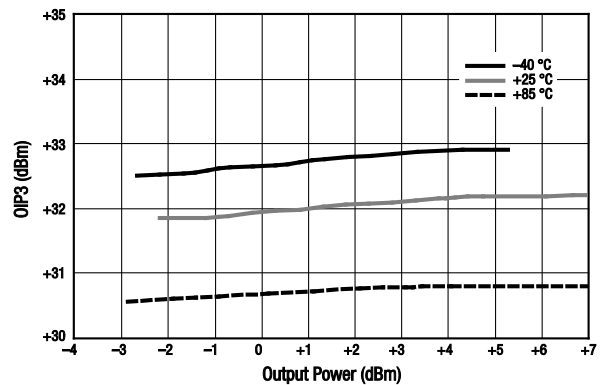
**Figure 25. Gain vs Output Power Over Temperature**



**Figure 26. Current vs Output Power Over Temperature**



**Figure 27. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting**



**Figure 28. OIP3 vs Output Power Over Temperature (1 MHz Spacing)**

## Evaluation Board Description

The SKY65186-11 Evaluation Board is used to test the performance of the SKY65186-11 VGA FEM. A schematic diagram of the SKY65186-11 Evaluation Board is shown in Figure 29. An assembly drawing for the Evaluation Board is shown in Figure 30 and the layer detail is provided in Figure 31. The layer detail physical characteristics are noted in Figure 32.

The SKY65186-11 requires DC blocking capacitors at the RF input ports (pins 1 and 8). The RF output ports (pins 17 and 24) are internally DC blocked. For applications operating from 330 MHz to 400 MHz, components C24 and C11 need to be populated with 30 pF capacitors and C25 and C10 need to be populated with 2.2 pF capacitors (see Figure 29).

## Package Dimensions

The PCB layout footprint for the SKY65186-11 is provided in Figure 33. Package dimensions for the 32-pin MCM are shown in Figure 34, and tape and reel dimensions are provided in Figure 35.

## 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 SKY65186-11 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 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.

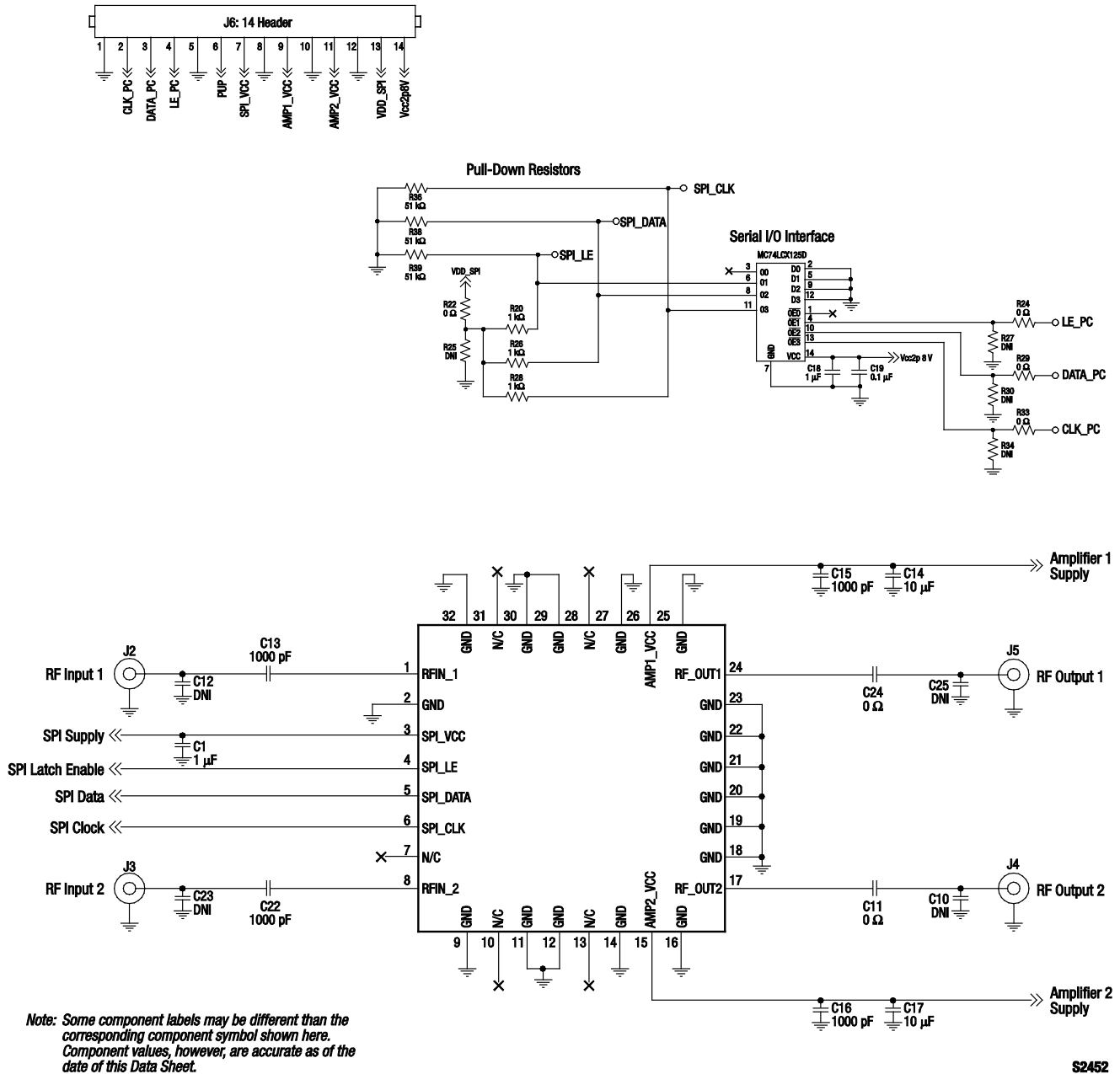


Figure 29. SKY65186-11 Evaluation Board Schematic

S2452

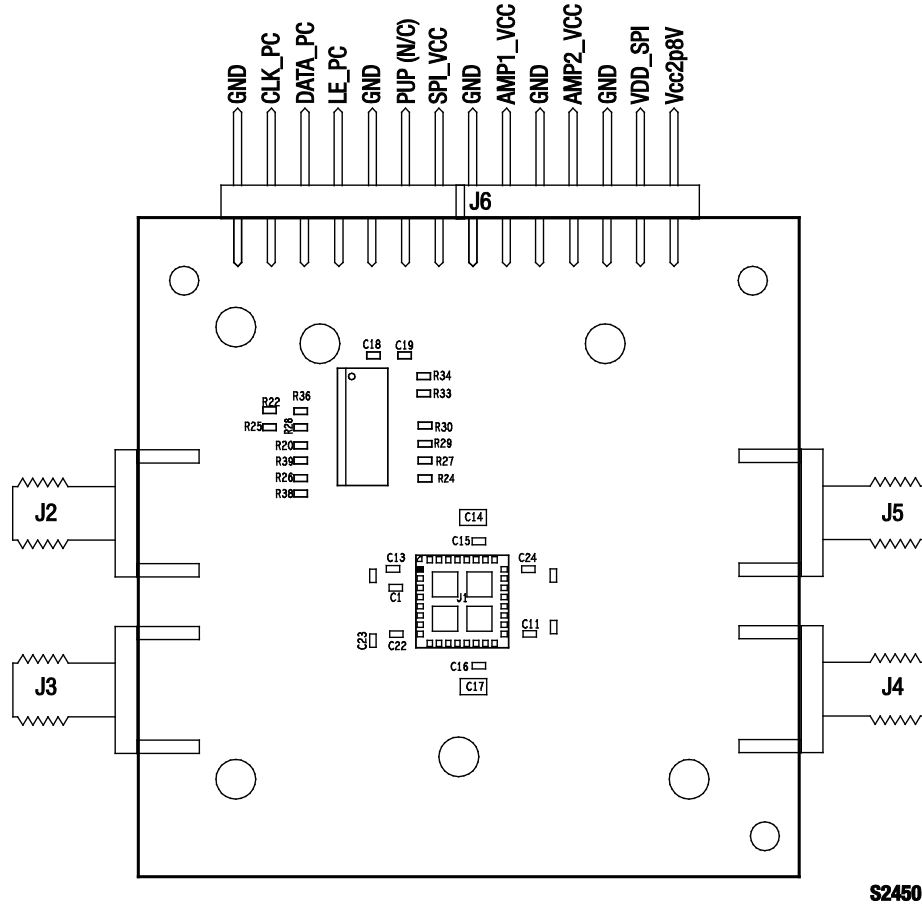
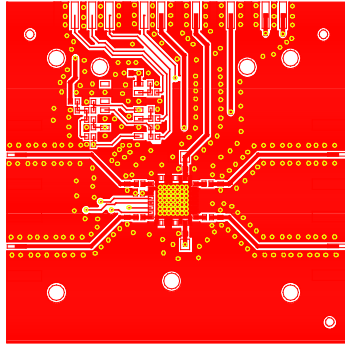
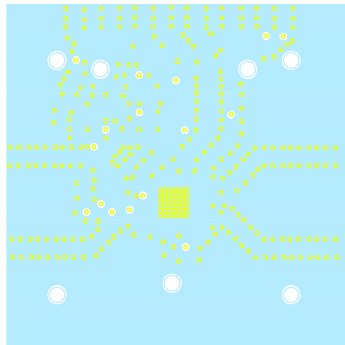


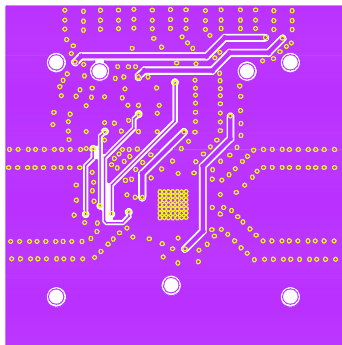
Figure 30. SKY65186-11 Evaluation Board Assembly Drawing



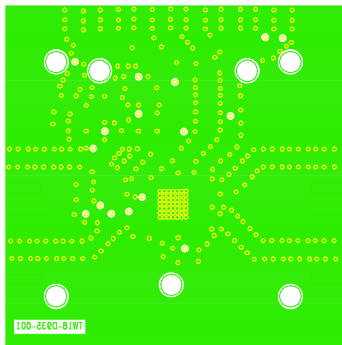
Layer 1: Top – Metal



Layer 2: Ground Plane



Layer 3: Signal Traces


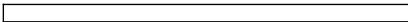
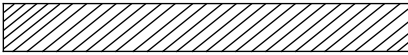

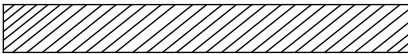
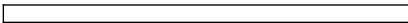





Layer 4: Bottom Ground Plane

S2451

Figure 31. SKY65186-11 Evaluation Board Layer Detail



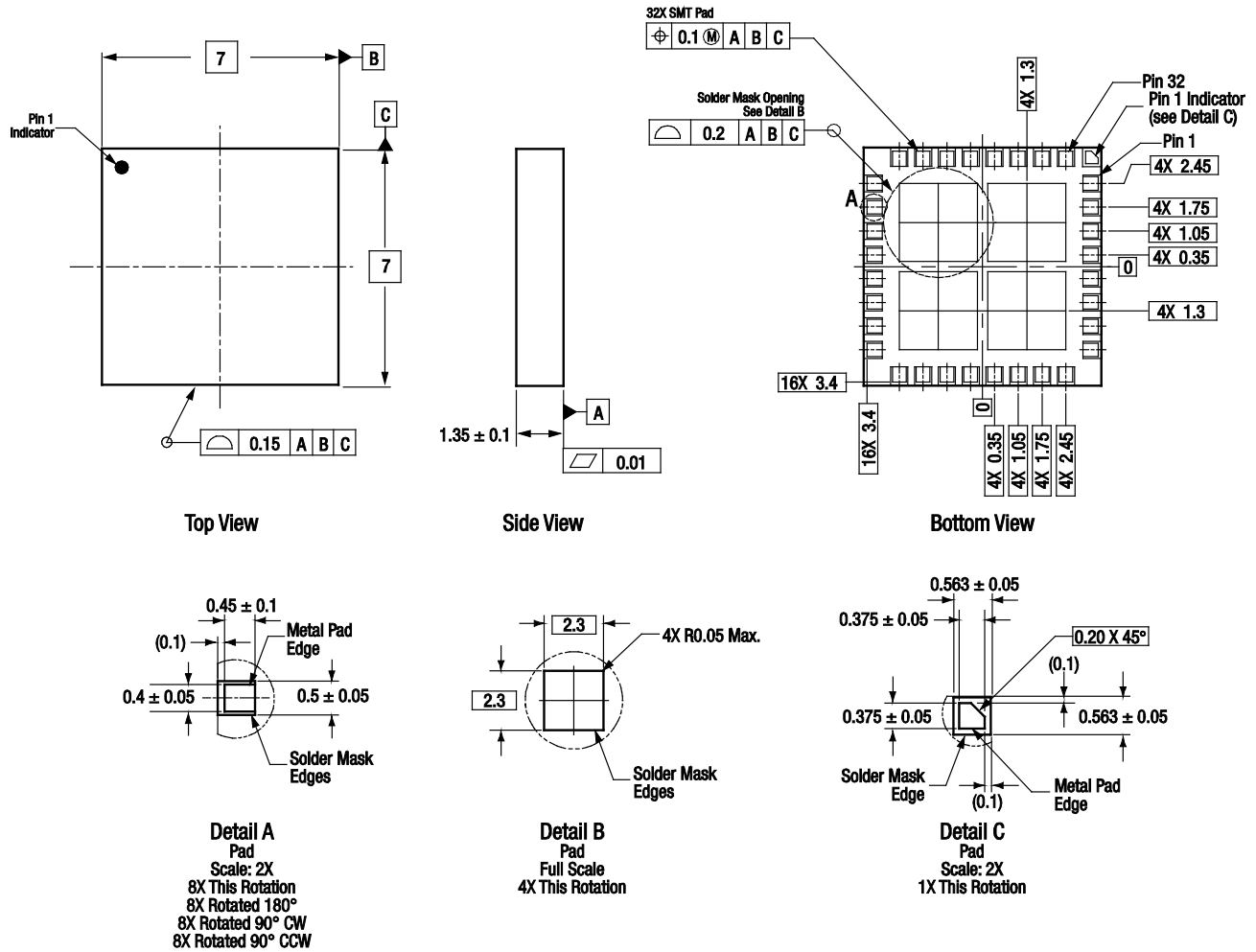
Cross Section	Name	Thickness (mm)	Material
	Tmask	0.010	Solder Resist
	L1	0.035	Cu, 1 oz.
	Dielectric	0.250	FR4
	L2	0.035	Cu, 1 oz
	Dielectric	1.000	FR4
	L3	0.035	Cu, 1 oz
	Dielectric	0.250	FR4
	L4	0.035	Cu, 1 oz
	Bmask	0.010	Solder resist

sz097

**Figure 32. Layer Detail Physical Characteristics**

\*\*\* TBD \*\*\*

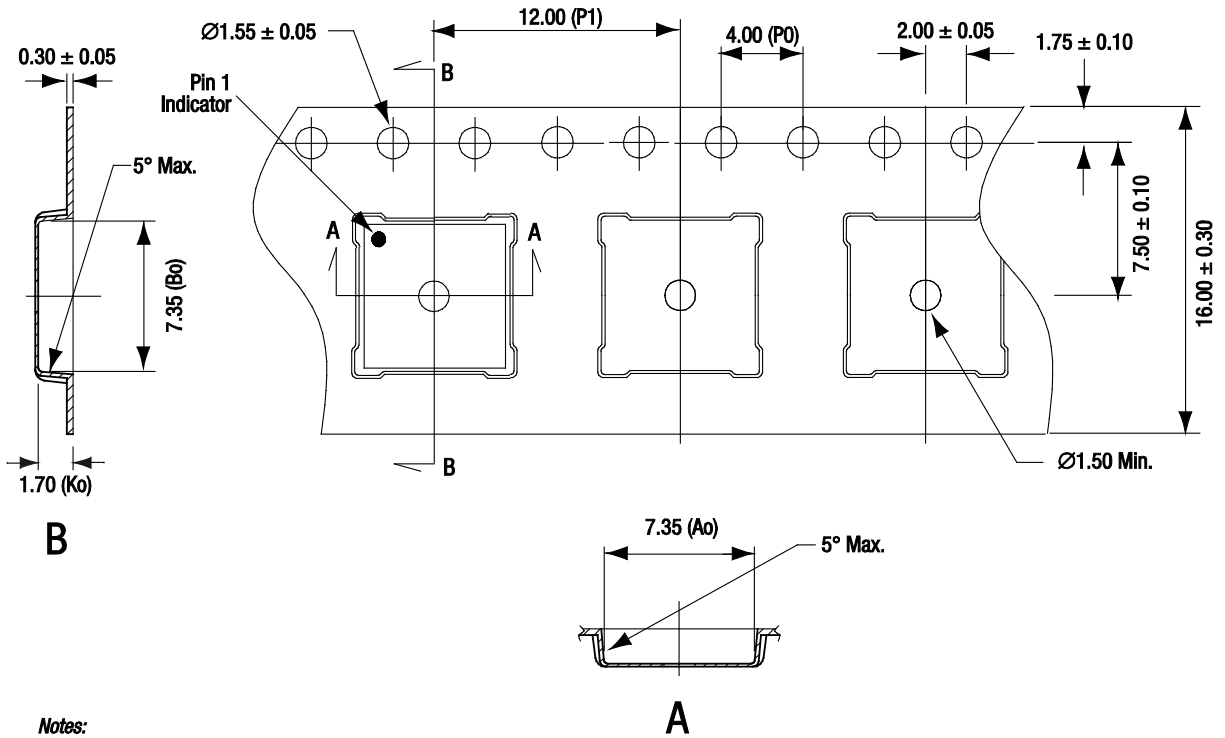
**Figure 33. SKY65186-11 PCB Layout Footprint**



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

S2554

Figure 34. SKY65186-11 32-Pin MCM Package 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. ESD surface resistivity is  $\leq 1 \times 10^{10}$  Ohms/square per EIA JEDEC specification.
5. P0/P1, 10 pitches cumulative tolerance on tape:  $\pm 0.20$  mm.
6. Ao and Bo measurement point to be 0.30 mm from bottom pocket.
7. All measurements are in millimeters

**S2920**

**Figure 35. SKY65186-11 32-Pin MCM Tape and Reel Dimensions**

## Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY65186-11 Dual-Channel VGA FEM	SKY65186-11	TW18-D930-001

Copyright © 2012 Skyworks Solutions, Inc. All Rights Reserved.

Information in this document is provided in connection with Skyworks Solutions, Inc. ("Skyworks") products or services. These materials, including the information contained herein, are provided by Skyworks as a service to its customers and may be used for informational purposes only by the customer. Skyworks assumes no responsibility for errors or omissions in these materials or the information contained herein. Skyworks may change its documentation, products, services, specifications or product descriptions at any time, without notice. Skyworks makes no commitment to update the materials or information and shall have no responsibility whatsoever for conflicts, incompatibilities, or other difficulties arising from any future changes.

No license, whether express, implied, by estoppel or otherwise, is granted to any intellectual property rights by this document. Skyworks assumes no liability for any materials, products or information provided hereunder, including the sale, distribution, reproduction or use of Skyworks products, information or materials, except as may be provided in Skyworks Terms and Conditions of Sale.

THE MATERIALS, PRODUCTS AND INFORMATION ARE PROVIDED "AS IS" WITHOUT WARRANTY OF ANY KIND, WHETHER EXPRESS, IMPLIED, STATUTORY, OR OTHERWISE, INCLUDING FITNESS FOR A PARTICULAR PURPOSE OR USE, MERCHANTABILITY, PERFORMANCE, QUALITY OR NON-INFRINGEMENT OF ANY INTELLECTUAL PROPERTY RIGHT; ALL SUCH WARRANTIES ARE HEREBY EXPRESSLY DISCLAIMED. SKYWORKS DOES NOT WARRANT THE ACCURACY OR COMPLETENESS OF THE INFORMATION, TEXT, GRAPHICS OR OTHER ITEMS CONTAINED WITHIN THESE MATERIALS. SKYWORKS SHALL NOT BE LIABLE FOR ANY DAMAGES, INCLUDING BUT NOT LIMITED TO ANY SPECIAL, INDIRECT, INCIDENTAL, STATUTORY, OR CONSEQUENTIAL DAMAGES, INCLUDING WITHOUT LIMITATION, LOST REVENUES OR LOST PROFITS THAT MAY RESULT FROM THE USE OF THE MATERIALS OR INFORMATION, WHETHER OR NOT THE RECIPIENT OF MATERIALS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.

Skyworks products are not intended for use in medical, lifesaving or life-sustaining applications, or other equipment in which the failure of the Skyworks products could lead to personal injury, death, physical or environmental damage. Skyworks customers using or selling Skyworks products for use in such applications do so at their own risk and agree to fully indemnify Skyworks for any damages resulting from such improper use or sale.

Customers are responsible for their products and applications using Skyworks products, which may deviate from published specifications as a result of design defects, errors, or operation of products outside of published parameters or design specifications. Customers should include design and operating safeguards to minimize these and other risks. Skyworks assumes no liability for applications assistance, customer product design, or damage to any equipment resulting from the use of Skyworks products outside of stated published specifications or parameters.

Skyworks, the Skyworks symbol, and "Breakthrough Simplicity" are trademarks or registered trademarks of Skyworks Solutions, Inc., in the United States and other countries. Third-party brands and names are for identification purposes only, and are the property of their respective owners. Additional information, including relevant terms and conditions, posted at [www.skyworksinc.com](http://www.skyworksinc.com), are incorporated by reference.