PRELIMINARY DATA SHEET

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.

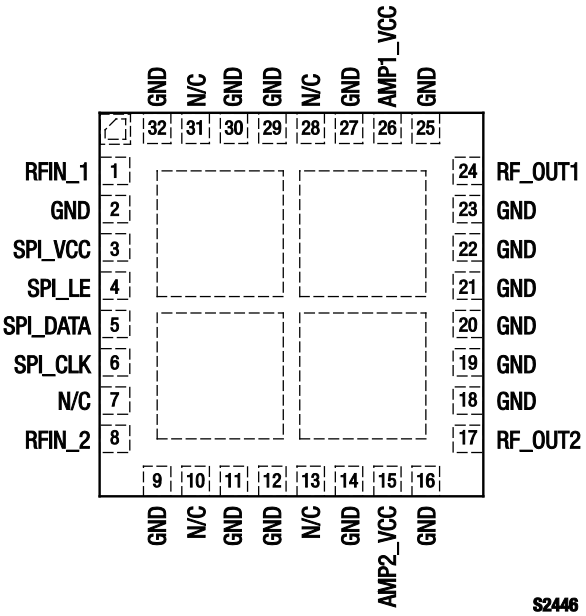


Figure 1. SKY65186-11 Pinout – 32-Pin MCM (Top View)

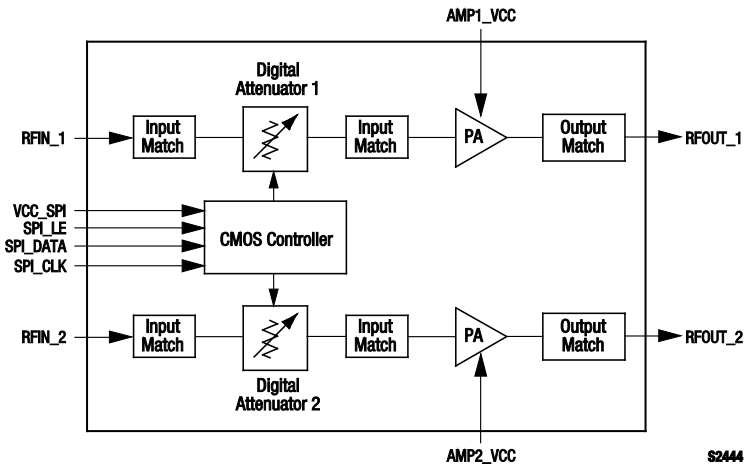


Figure 2. SKY65186-11 Block Diagram

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 amplfier 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).

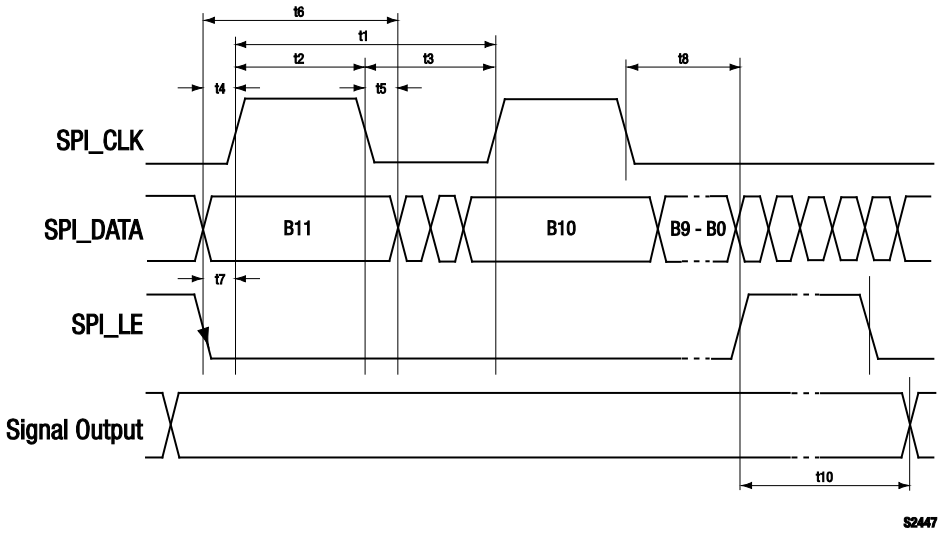


Figure 3. Serial Input Timing Diagram

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_{IN}		+14	dBm
Operating temperature	T_C	–40	+85	°C
Storage temperature	T_{ST}	–65	+150	°C
Junction temperature	T_J		+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_{CC}	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_{CC}		220		mA

Table 7. SKY65186-11 Electrical Specifications (1 of 2) (Note 1)
(AMP1_VCC = AMP2_VCC = 5.0 V, T_C = 25 °C, Attenuation = 0 dB, CW Input = –30 dBm, Unless Otherwise Noted)

Parameter	Symbol	Operating Frequency (MHz)	Min	Typical	Max	Units
Small signal gain	$\|S21\|$	330 (Note 2) 400 700 900 1900 2700		13.6 13.6 13.0 13.5 13.3 13.0		dB dB dB dB dB dB
Attenuation	Attn	330 (Note 2) 400 700 900 1900 2700		31.5 31.5 31.5 31.5 31.5 31.5		dB dB dB dB dB dB
Attenuation step	$Attn_{STEP}$	330 (Note 2) 400 700 900 1900 2700		0.5 0.5 0.5 0.5 0.5 0.5		dB dB dB dB dB 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) 400 700 900 1900 2700		0.1 ± 0.5% 0.1 ± 0.5% 0.1 ± 0.5% 0.1 ± 0.5% 0.1 ± 0.5% 0.2 ± 0.5%		dB dB dB dB dB dB
1 dB Output Compression Point	OP1dB	330 (Note 2) 400 700 900 1900 2700		+20.3 +20.3 +20.0 +20.3 +20.2 +19.5		dBm dBm dBm dBm dBm dBm
3rd Order Output Intercept Point (output power = 0 dBm, 1 MHz spacing)	OIP3	330 (Note 2) 400 700 900 1900 2700		+34.3 +36.8 +35.2 +36.4 +33.6 +32.0		dBm dBm dBm dBm dBm dBm
Noise Figure	NF	330 (Note 2) 400 700 900 1900 2700		7.9 7.8 6.5 5.8 5.0 4.8		dB dB dB dB dB dB
Input return loss	|S11|	330 (Note 2) 400 700 900 1900 2700		17.7 19.0 21.4 19.0 12.4 12.0		dB dB dB dB dB dB
Output return loss	|S22|	330 (Note 2) 400 700 900 1900 2700		9.2 11.0 15.3 26.2 11.7 10.8		dB dB dB dB dB dB
Quiescent current/amplifier	I_{CQ}	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_{CC} = 5 V, T_C = +25 °C, Schematic Components C24 = C11 = 30 pF and C25 = C10 = 2.2 pF, Unless Otherwise Noted)

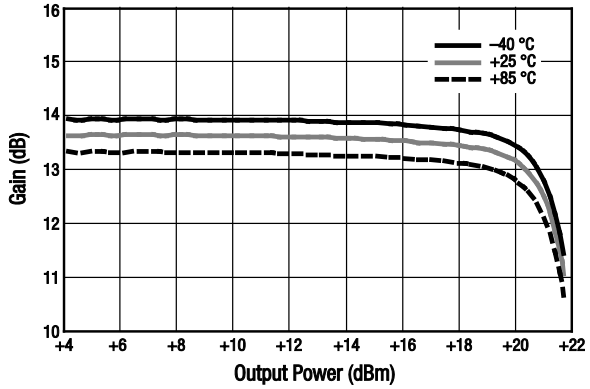


Figure 4. Gain vs Output Power Over Temperature

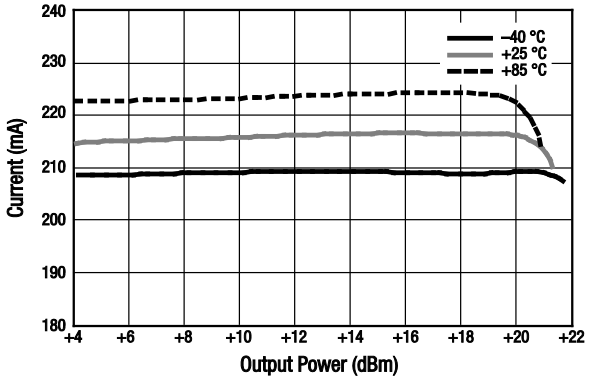


Figure 5. Current vs Output Power Over Temperature

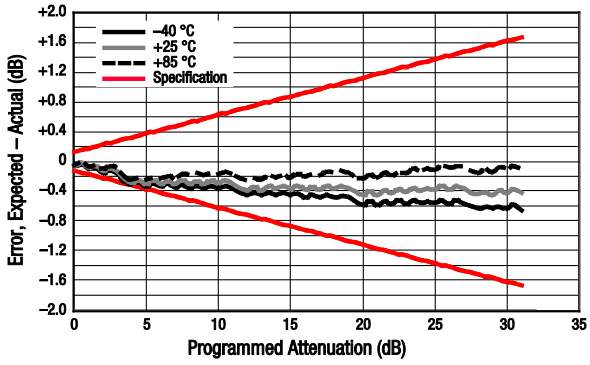


Figure 6. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting (Spec: 0.1 + 5%)

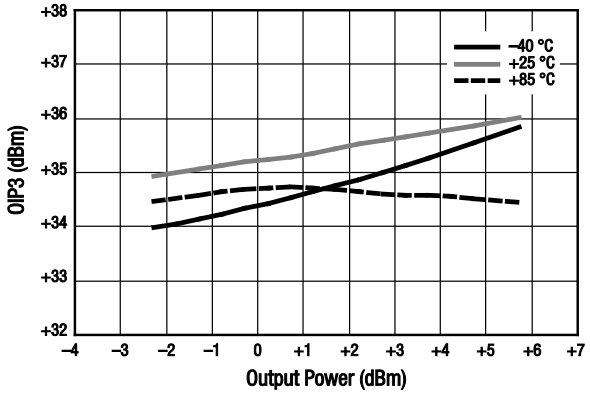


Figure 7. OIP3 vs Output Power Over Temperature (1 MHz Spacing)

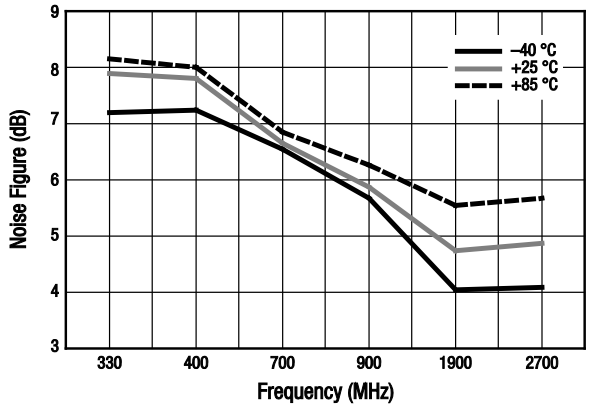


Figure 8. Noise Figure vs Frequency Over Temperature

Typical Performance Characteristics @ 400 MHz

(V_{CC} = 5 V, T_C = +25 °C, Unless Otherwise Noted)

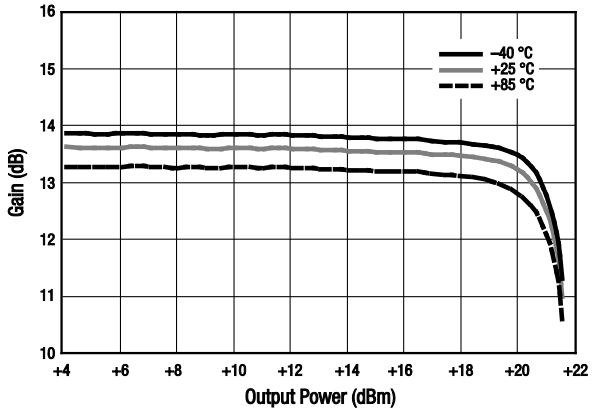


Figure 9. Gain vs Output Power Over Temperature

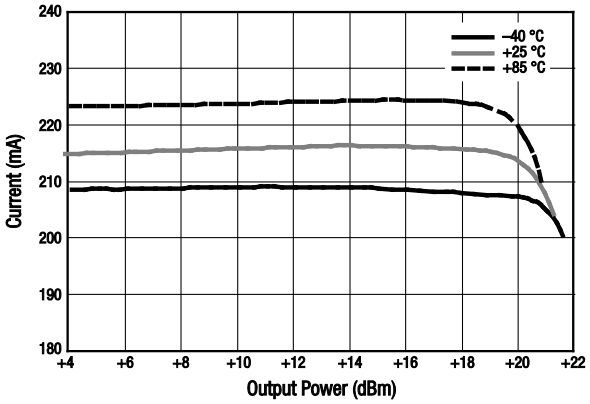


Figure 10. Current vs Output Power Over Temperature

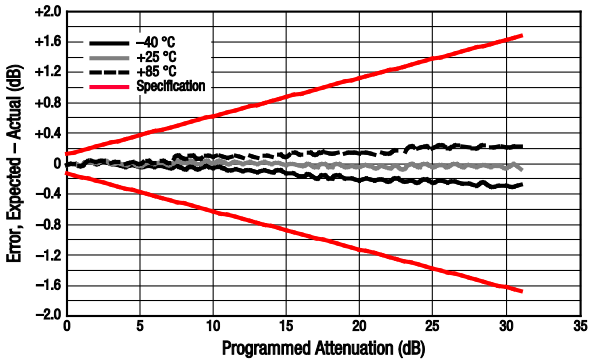


Figure 11. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting

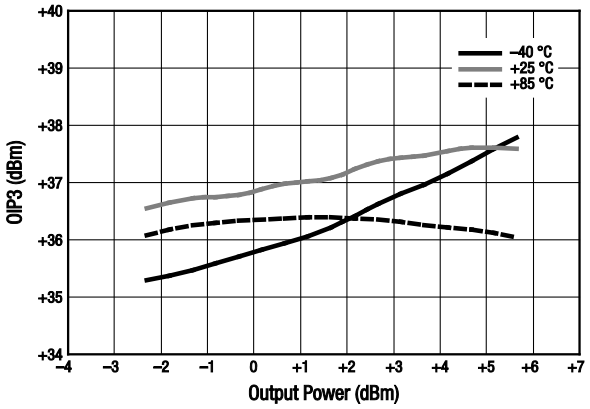


Figure 12. OIP3 vs Output Power Over Temperature (1 MHz Spacing)

Typical Performance Characteristics @ 700 MHz

(V_{CC} = 5 V, T_C = +25 °C, Unless Otherwise Noted)

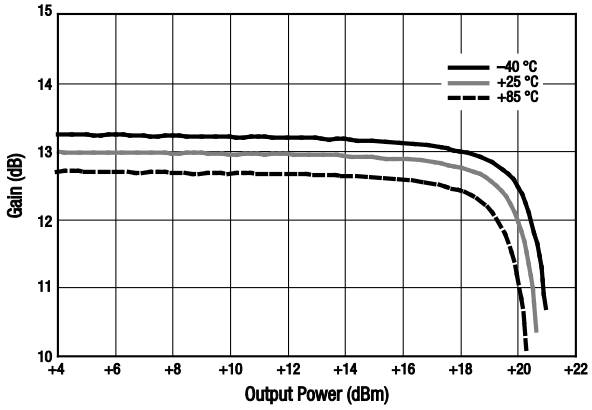


Figure 13. Gain vs Output Power Over Temperature

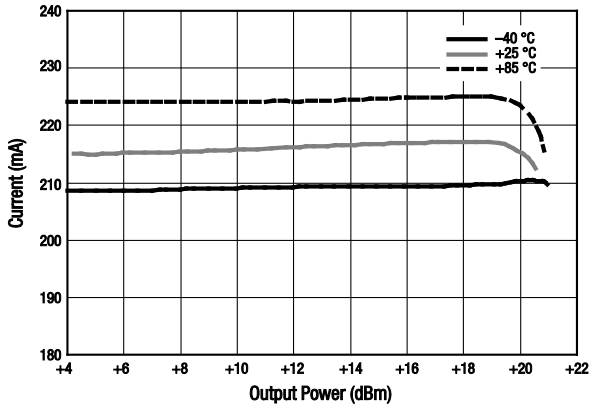


Figure 14. Current vs Output Power Over Temperature

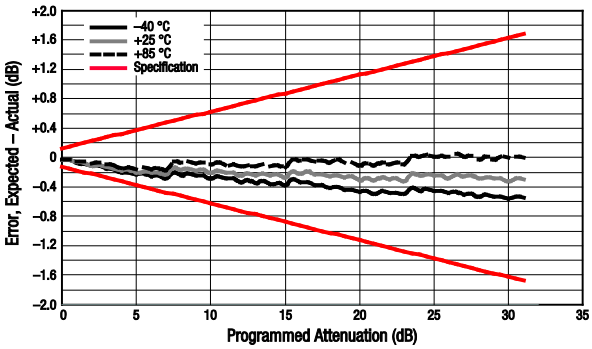


Figure 15. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting

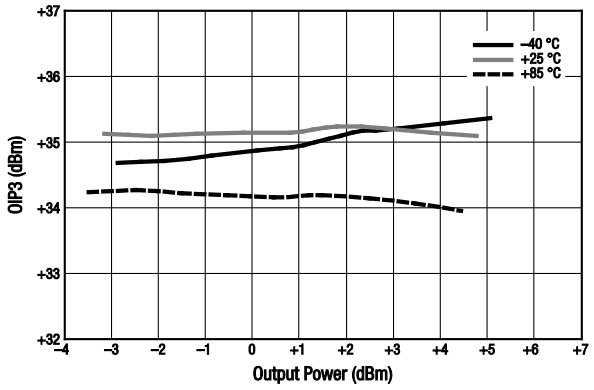


Figure 16. OIP3 vs Output Power Over Temperature (1 MHz Spacing)

Typical Performance Characteristics @ 900 MHz

(V_{CC} = 5 V, T_C = +25 °C, Unless Otherwise Noted)

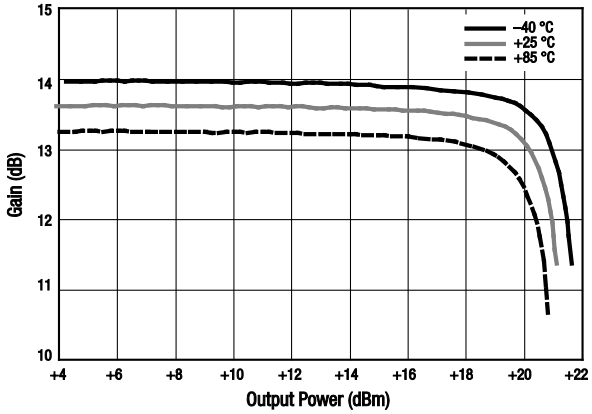


Figure 17. Gain vs Output Power Over Temperature

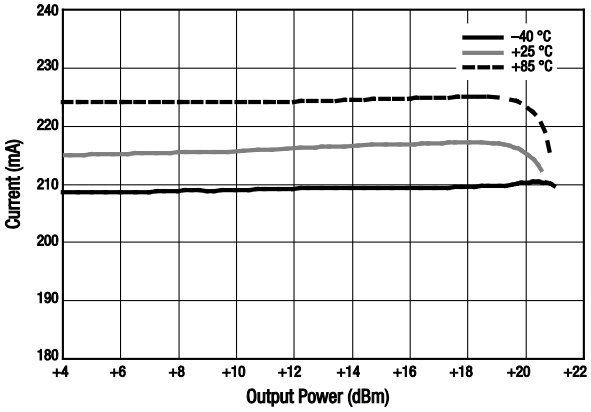


Figure 18. Current vs Output Power Over Temperature

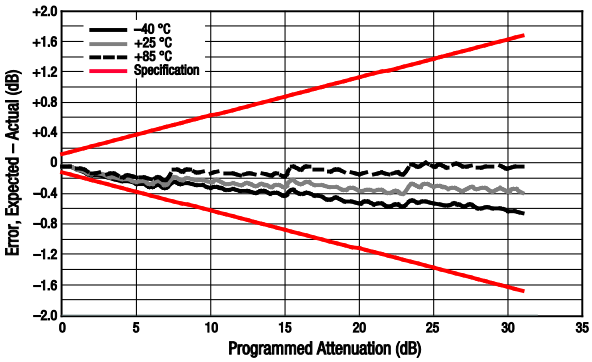


Figure 19. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting

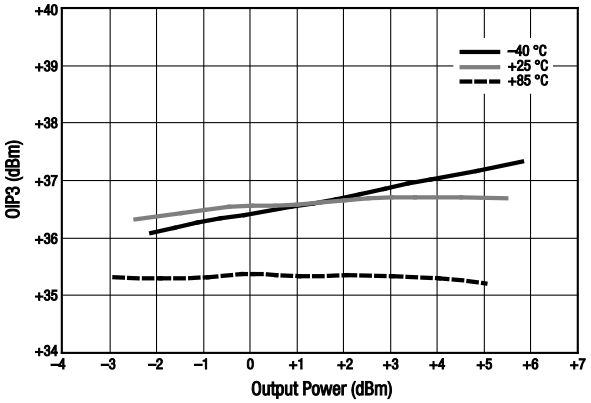


Figure 20. OIP3 vs Output Power Over Temperature (1 MHz Spacing)

Typical Performance Characteristics @ 1900 MHz

(V_{CC} = 5 V, T_C = +25 °C, Unless Otherwise Noted)

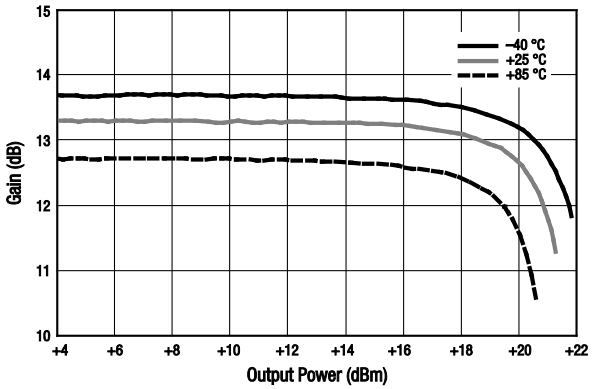


Figure 21. Gain vs Output Power Over Temperature

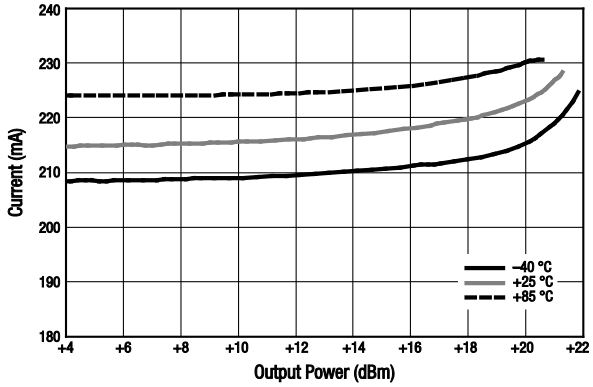


Figure 22. Current vs Output Power Over Temperature

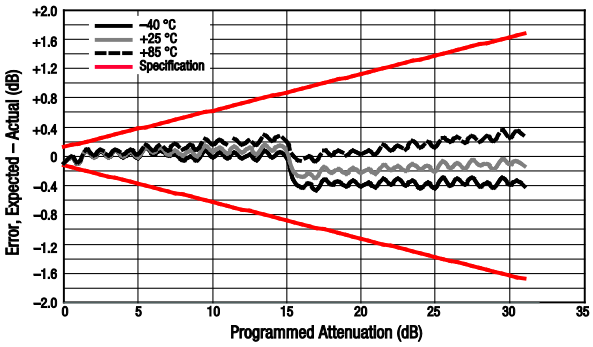


Figure 23. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting

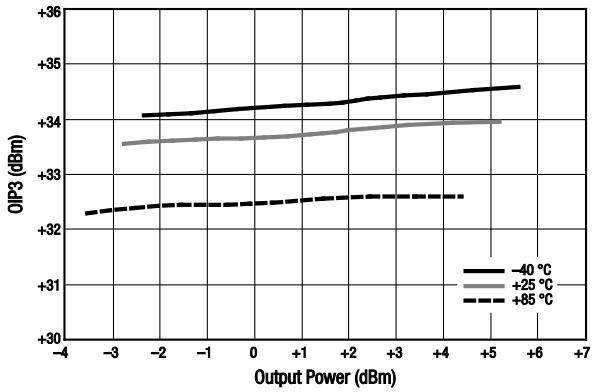


Figure 24. OIP3 vs Output Power Over Temperature (1 MHz Spacing)

Typical Performance Characteristics @ 2700 MHz

(V_{CC} = 5 V, T_C = +25 °C, Unless Otherwise Noted)

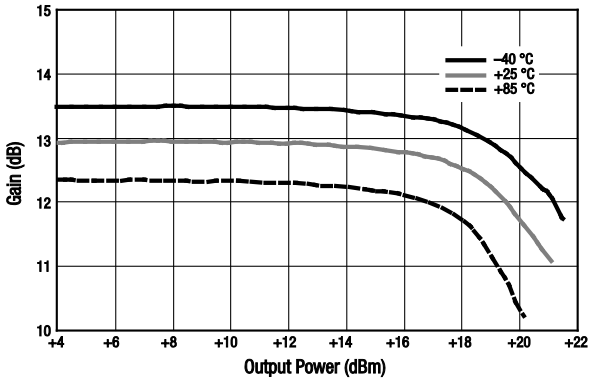


Figure 25. Gain vs Output Power Over Temperature

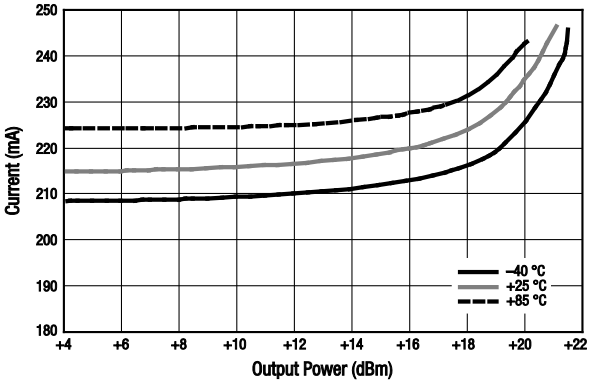


Figure 26. Current vs Output Power Over Temperature

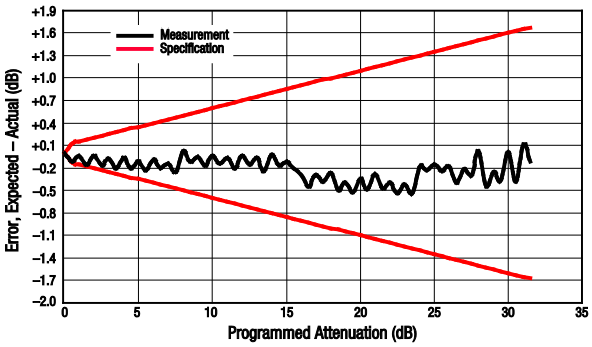


Figure 27. Cascaded Performance, Attenuation Accuracy vs Attenuation Setting

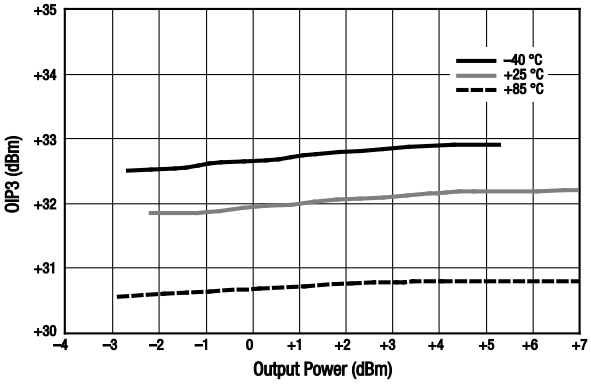


Figure 28. OIP3 vs Output Power Over Temperature (1 MHz Spacing)

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

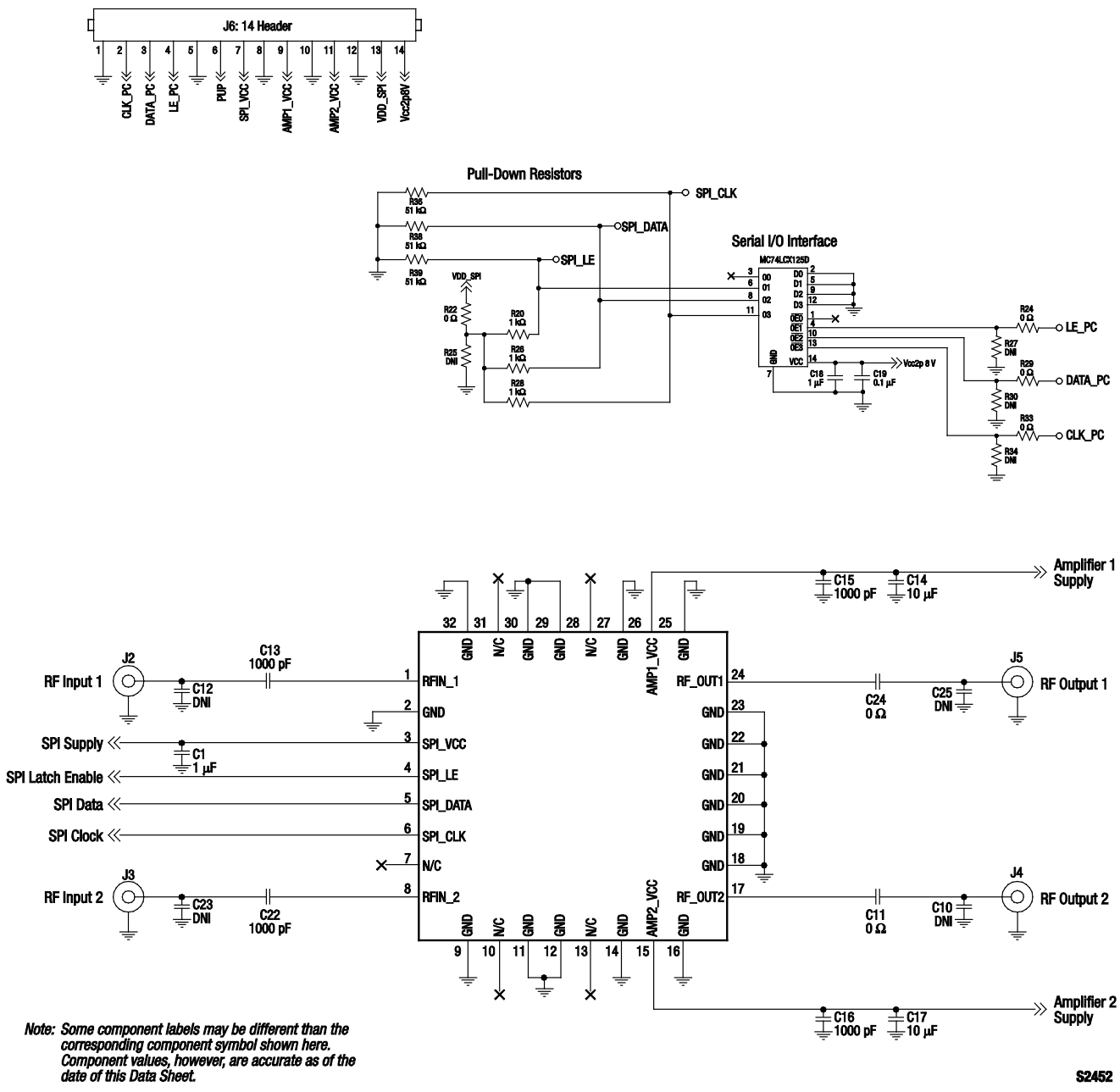
The PCB layout footprint for the SKY65186-11 is provided in Figure 33. Package dimensions for the 32-pin MCM are shown in Figure 34, and tape and reel dimensions are provided in Figure 35.

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.



Note: Some component labels may be different than the corresponding component symbol shown here. Component values, however, are accurate as of the date of this Data Sheet.

Figure 29. SKY65186-11 Evaluation Board Schematic

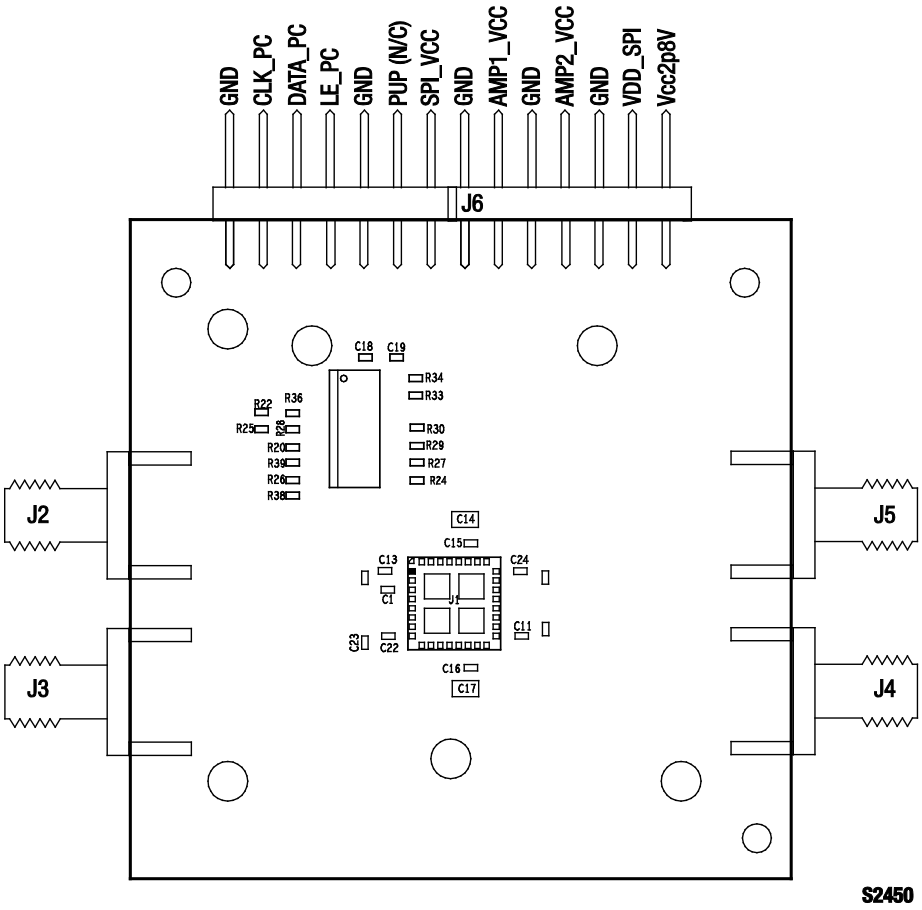
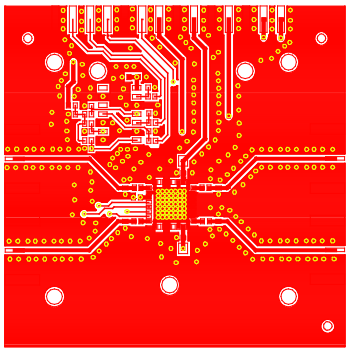
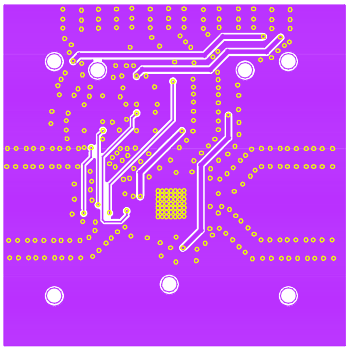


Figure 30. SKY65186-11 Evaluation Board Assembly Drawing

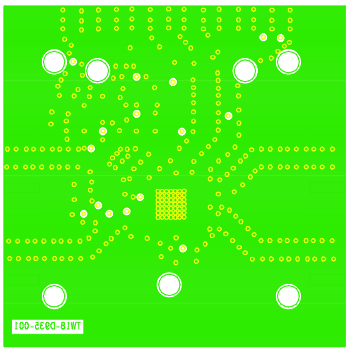


Layer 1: Top – Metal

Layer 2: Ground Plane



Layer 3: Signal Traces



Layer 4: Bottom Ground Plane

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Figure 31. SKY65186-11 Evaluation Board Layer Detail

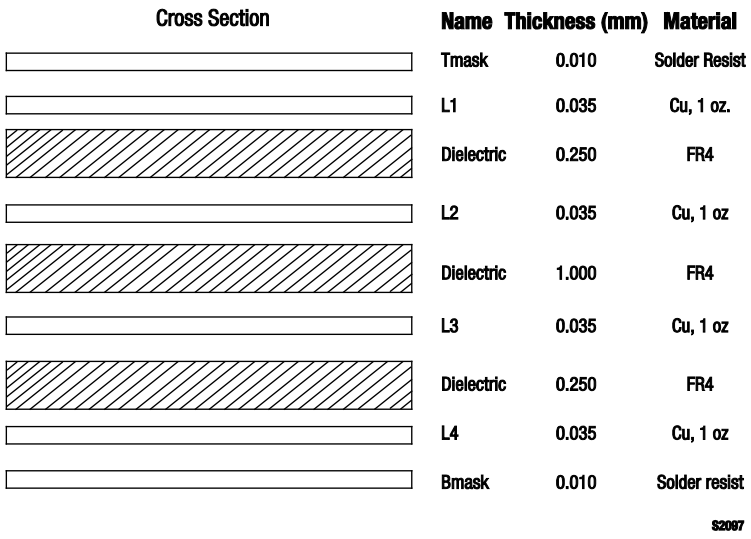


Figure 32. Layer Detail Physical Characteristics

*** TBD ***

Figure 33. SKY65186-11 PCB Layout Footprint

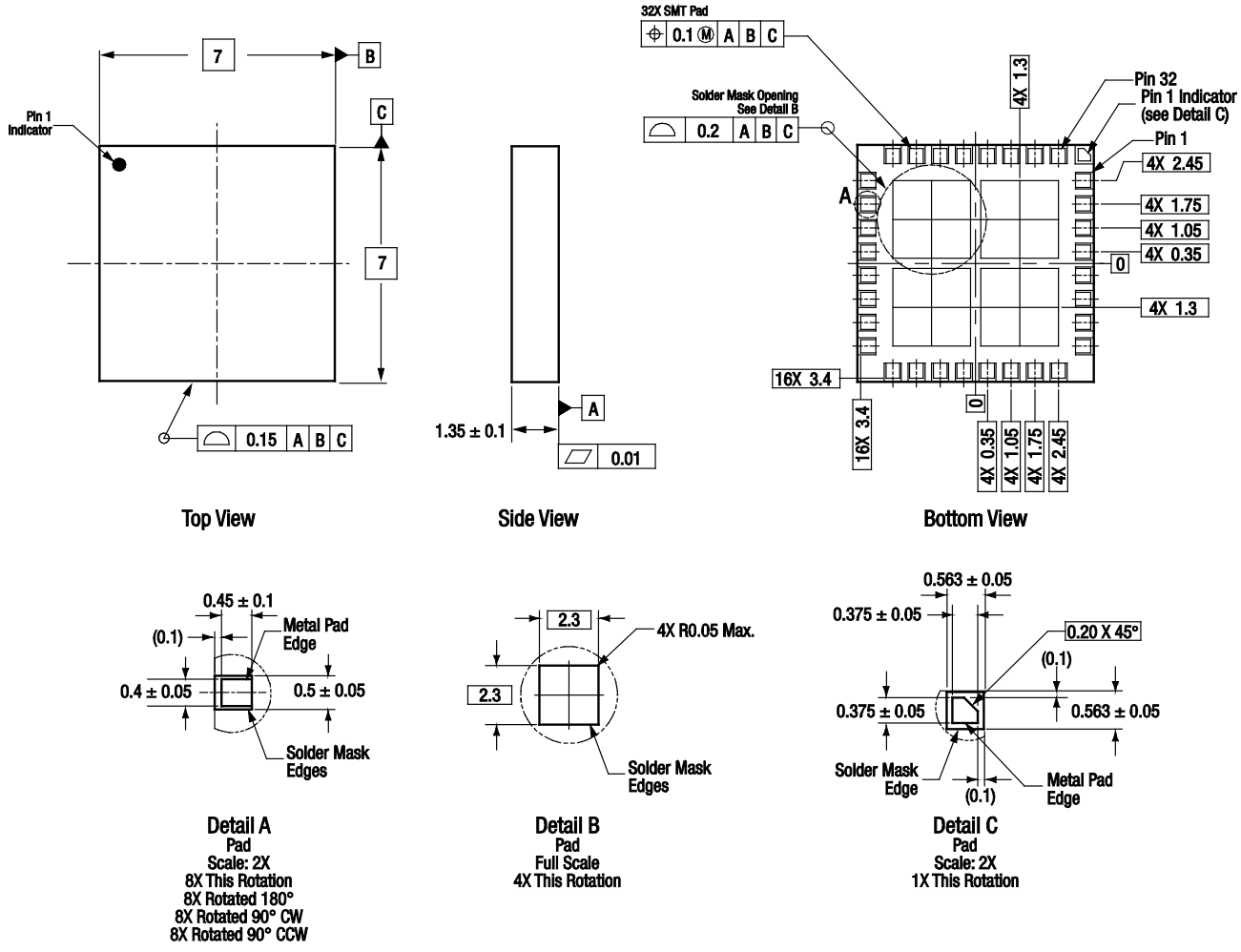
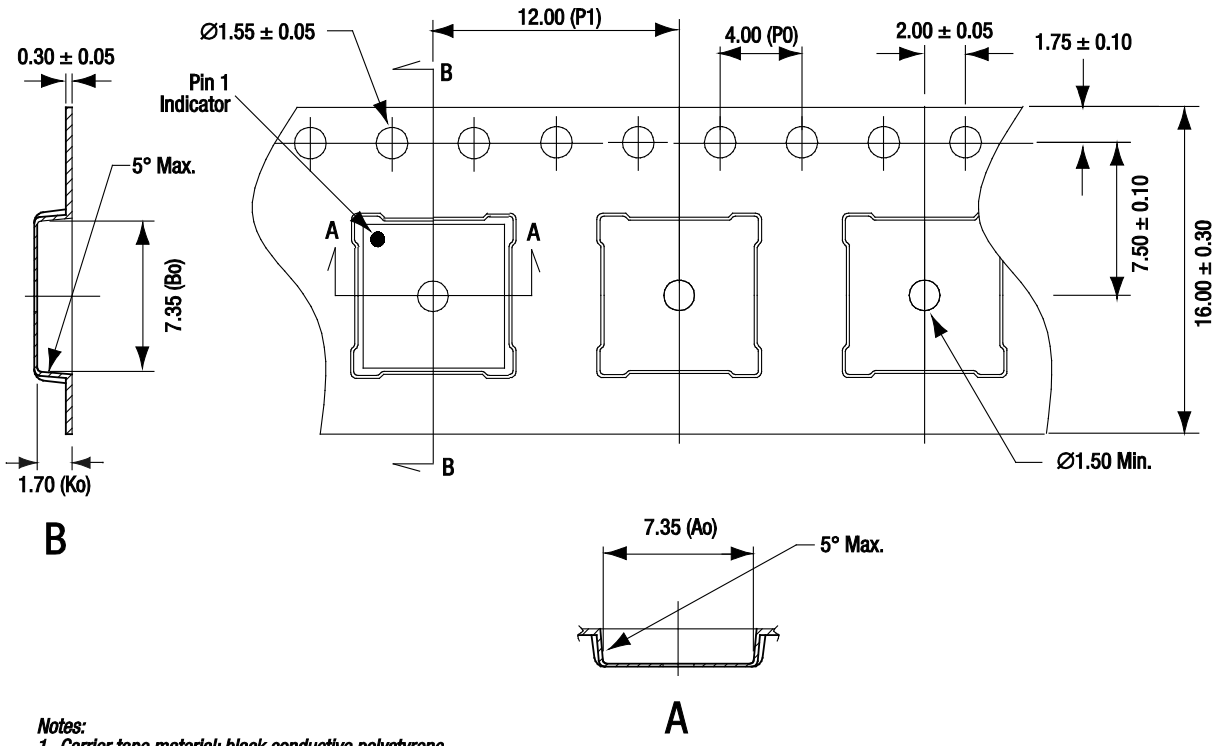


Figure 34. SKY65186-11 32-Pin MCM Package Dimensions



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 ≤1 x 10^{10} Ohms/square per EIA JEDEC specification.*
5. *P0/P1, 10 pitches cumulative tolerance on tape: ±0.20 mm.*
6. *Ao and Bo measurement point to be 0.30 mm from bottom pocket.*
7. *All measurements are in millimeters*

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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