

**DATA SHEET**

# SKY65228-11: WLAN 802.11n Single Band 4.9–5.85 GHz MIMO Intera™ Front-End Module

**Features**

- Single band 4.9–5.85 GHz MIMO architecture
- Two full 4.9–5.85 GHz transmit/receive chains
- Backward-compatible with 802.11a standards
- Pin compatible with SKY65225-11 (4.9–5.85 GHz)
- $P_{OUT}$  @ 2.5% EVM: 16 dBm (-11a)
- Gain matching: <2 dB
- Internal voltage regulation
- Single 3.0–3.6 V power supply
- Temperature-compensated PA bias networks
- Separate digital controls for each PA
- Temperature-compensated directional power detection
- Package size: 10 x 14 x 0.9 mm
- Lead (Pb)-free and RoHS-compliant MSL-3 @ 250 °C per JEDEC J-STD-020


**Description**

The SKY65228-11 Intera nFEM contains two complete 4.9–5.85 GHz transmit/receive chains in one compact RF front-end module optimized for single band 4.9–5.85 GHz MIMO (multiple in—multiple out) operation, in compliance with the 802.11n draft standard. The SKY65228-11 includes two 4.9–5.85 GHz PAs with integrated input filtering for 3–4 GHz rejection, and temperature-compensated, directional power detector with 20 dB dynamic range. Also included are low loss, high rejection GaAs harmonic filters and T/R switches which provide high linearity in all transmit paths and low loss in all receive paths.

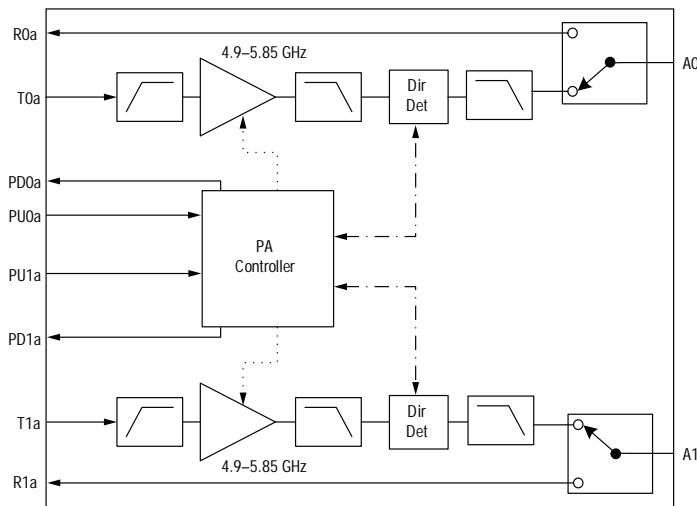
The SKY65228-11 Intera nFEM achieves outstanding gain matching which is a critical requirement for MIMO operation. This is accomplished through mirrored layout symmetry.

The SKY65228-11 is packaged in a lead (Pb)-free, RoHS-compliant laminate package, which measures 10 x 14 x 0.9 mm. This FEM is designed as a pin to pin compatible version of the SKY65225-11 for 4.9–5.85 GHz only.

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



**Functional Block Diagram**



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### Absolute Maximum Ratings

| Parameter                   | Symbol           | Condition | Min. | Typ. | Max. | Unit |
|-----------------------------|------------------|-----------|------|------|------|------|
| V <sub>CC</sub>             | V <sub>CC</sub>  |           | -0.3 |      | 5.5  | V    |
| PU0a, PU1a                  | PU               |           | -0.3 |      | 5.5  | V    |
| T0a, T1a                    | RFin             |           |      |      | 10   | dBm  |
| Operating temperature range | T <sub>OP</sub>  |           | 0    |      | 85   | °C   |
| Storage temperature range   | T <sub>STO</sub> |           | -65  |      | 125  | °C   |
| Moisture sensitivity level  | MSL-3            |           |      |      | 250  | °C   |
| Thermal resistance          | θ <sub>JC</sub>  |           |      |      | 60   | °C/W |

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.

### Recommended Operating Conditions

| Parameter             | Symbol          | Condition | Min. | Typ. | Max. | Unit |
|-----------------------|-----------------|-----------|------|------|------|------|
| Supply Voltage        | V <sub>CC</sub> |           | 3    | 3.3  | 3.6  | V    |
| Operating Temperature | T <sub>OP</sub> |           | 0    | 25   | 85   | °C   |

### DC Characteristics

**Conditions: V<sub>CC</sub> = 3.3 V, T<sub>OP</sub> = 25 °C. Measurements made on Skyworks EVB with all losses de-embedded.**

**All unused ports terminated into 50 Ω unless otherwise specified.**

| Parameter                                      | Symbol            | Condition                                                                              | Min. | Typ. | Max. | Unit |
|------------------------------------------------|-------------------|----------------------------------------------------------------------------------------|------|------|------|------|
| Total 802.11a Tx supply current, T0a or T1a    | I <sub>CC-a</sub> | P <sub>OUT</sub> = 15 dBm, 54 Mbps OFDM,<br>PU0g or PU1g = 0 V<br>PU0a or PU1a = 3.3 V |      | 180  |      | mA   |
| Total 802.11a Tx quiescent current, T0a or T1a | I <sub>CQ-a</sub> | No RF                                                                                  |      | 135  |      | mA   |

### PA Logic Characteristics

**Conditions: V<sub>CC</sub> = 3.3 V, T<sub>OP</sub> = 25 °C. Measurements made on Skyworks EVB with all losses de-embedded.**

**All unused ports terminated into 50 Ω unless otherwise specified.**

| Parameter                                       | Symbol | Condition | Min. | Typ. | Max.            | Unit |
|-------------------------------------------------|--------|-----------|------|------|-----------------|------|
| Logic high voltage for PU0a, PU1a (Tx On)       |        |           | 2    |      | V <sub>CC</sub> | V    |
| Logic low voltage for PU0a, PU1a (Tx Off)       |        |           | 0    |      | 0.5             | V    |
| Input current logic high voltage for PU0a, PU1a |        |           |      | 100  | 200             | μA   |
| Input current logic low voltage for PU0a, PU1a  |        |           |      | 0.2  |                 | μA   |

## Switch Characteristics

Conditions:  $V_{CC} = 3.3\text{ V}$ ,  $T_{OP} = 25\text{ }^{\circ}\text{C}$ . Measurements made on Skyworks EVB with all losses de-embedded.  
All unused ports terminated into  $50\ \Omega$  unless otherwise specified.

| Parameter                   | Symbol         | Condition | Min. | Typ. | Max. | Unit          |
|-----------------------------|----------------|-----------|------|------|------|---------------|
| Control voltage - ON state  | $V_{CTL\_on}$  |           | 3    | 3.3  | 3.6  | V             |
| Control voltage - OFF state | $V_{CTL\_off}$ |           | 0    |      | 0.2  | V             |
| Control current - ON state  | $I_{CTL\_on}$  | RF ON     |      | 10   | 75   | $\mu\text{A}$ |
| Control current - ON state  | $I_{CTL\_on}$  | RF OFF    |      | 2    | 20   | $\mu\text{A}$ |

## Mode Control Voltage Table (V)

| Mode                     | $V_{CC}$ | PU0a | Rx0a | Tx0a | PU1a | Rx1a | Tx1a |
|--------------------------|----------|------|------|------|------|------|------|
| Sleep                    | 3.3      | 0    | 0    | 0    | 0    | 0    | 0    |
| T0a - ANT0               | 3.3      | 3.3  | 0    | 3.3  | 0    | 0    | 0    |
| R0a - ANT0               | 3.3      | 0    | 3.3  | 0    | 0    | 0    | 0    |
| T1a - ANT1               | 3.3      | 0    | 0    | 0    | 3.3  | 0    | 3.3  |
| R1a - ANT1               | 3.3      | 0    | 0    | 0    | 0    | 3.3  | 0    |
| <b>802.11n Operation</b> |          |      |      |      |      |      |      |
| T0a - ANT0 & T1a - ANT1  | 3.3      | 3.3  | 0    | 3.3  | 3.3  | 0    | 3.3  |
| R0a - ANT0 & R1a - ANT1  | 0 or 3.3 | 0    | 3.3  | 0    | 0    | 3.3  | 0    |

**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.

### 802.11a Transmit Specifications (Tx Chain 0, Tx Chain 1)

**Conditions:  $V_{CC} = 3.3\text{ V}$ ,  $T_{OP} = 25\text{ }^\circ\text{C}$ . PA enables and control voltages set according to Mode Control Voltage table. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into  $50\ \Omega$  unless otherwise specified.**

| Parameter                                        | Symbol            | Condition                                                | Min.                                                         | Typ. | Max. | Unit    |
|--------------------------------------------------|-------------------|----------------------------------------------------------|--------------------------------------------------------------|------|------|---------|
| Frequency range                                  | F                 |                                                          | 4.9                                                          |      | 5.85 | GHz     |
| Linear output power - a                          | Plin_a            | 54 Mbps OFDM, 64 QAM, EVM = 2.5 %                        |                                                              | 16   |      | dBm     |
| Backed off EVM                                   | BEVM              | 54 Mbps OFDM, 64 QAM, Pin = 7dBm                         |                                                              | 1.5  |      | %       |
| 1 dB compression point                           | $P_{1\text{ dB}}$ |                                                          | 21.5                                                         | 24   |      | dBm     |
| Small signal gain                                | $ S_{21} $        |                                                          |                                                              | 24   |      | dB      |
| Small signal gain variation over any 20 MHz band | $ \Delta S_{21} $ |                                                          |                                                              |      | 0.5  | dB      |
| Gain matching, T0g to A0 vs. T1g to A1           | $ S_{21}  - M$    | Compared frequency by frequency                          |                                                              | 2    |      | dB      |
| Gain, 3.2–3.9 GHz                                | $ S_{21}  - 3.9$  |                                                          |                                                              | 0    |      | dB      |
| Harmonics                                        | 2f, 3f            | $P_{OUT} = 18\text{ dBm}$ , 1 Mbps, CCK, 802.11b         |                                                              | -50  | -42  | dBm/MHz |
| Tx switching time                                | $t_{sw}$          | 50 % of $V_{CTL}$ to 90/10 % RF output power level       |                                                              |      | 500  | ns      |
| Input return loss                                | $ S_{11} $        | T0a or T1a                                               |                                                              | -6   |      | dB      |
| Output return loss                               | $ S_{22} $        | A0 or A1                                                 |                                                              | -10  |      | dB      |
| Isolation between T0g and A1                     | ISO-A1            | CW power into T0a and measure ratio of power at A0 to A1 |                                                              |      | -25  | dBc     |
| Isolation between T1g and A0                     | ISO-A0            | CW power into T1a and measure ratio of power at A1 to A0 |                                                              |      | -25  | dBc     |
| Stability                                        | STAB              | $P_{OUT} \leq 18\text{ dBm}$ , load VSWR = 3:1           | All non-harmonically related outputs less than -50 dBc/1 MHz |      |      |         |

### 802.11a Receive Specifications (Rx Chain 0, Rx Chain 1)

**Conditions:  $V_{CC} = 3.3\text{ V}$ ,  $T_{OP} = 25\text{ }^\circ\text{C}$ . PA enables & Tx control voltages = 0 V. Rx0ag or Rx1ag = 3.3 V. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into  $50\ \Omega$  unless otherwise specified.**

| Parameter            | Symbol            | Condition               | Min. | Typ. | Max. | Unit |
|----------------------|-------------------|-------------------------|------|------|------|------|
| Frequency range      | F                 |                         | 4.9  |      | 5.85 | GHz  |
| Insertion loss       | $ S_{21} $        |                         |      | 2.5  | 3    | dB   |
| Input return loss    | $ S_{11} $        | R0g or R1g              |      | -20  |      | dB   |
| Output return loss   | $ S_{22} $        | A0 or A1                |      | -15  |      | dB   |
| Insertion loss delta | $ \Delta S_{21} $ | A0 to R0g and A1 to R1g |      |      | 0.5  | dB   |

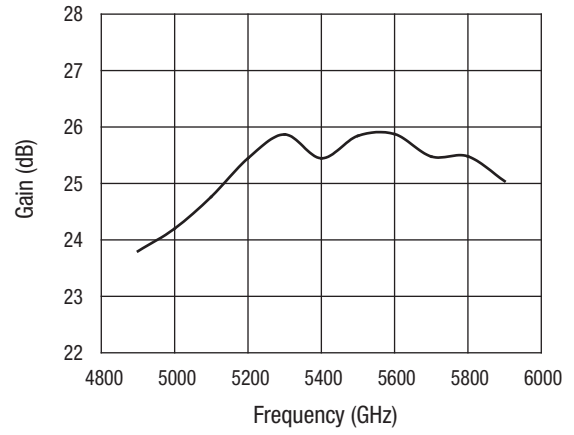
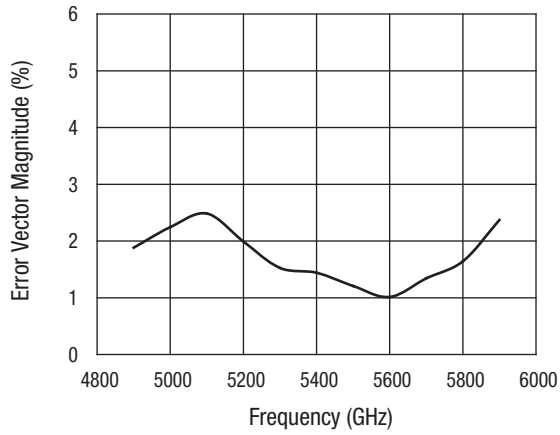
### 802.11a Power Detector Specification

**Conditions:  $V_{CC} = 3.3\text{ V}$ ,  $T_{OP} = 25\text{ }^\circ\text{C}$ . PU0a and Tx0ag or PU1a and Tx1ag = 3.3 V. RX0ag or RX1ag = 0 V. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into  $50\ \Omega$  unless otherwise specified.**

| Parameter                             | Symbol   | Condition         | Min. | Typ. | Max. | Unit      |
|---------------------------------------|----------|-------------------|------|------|------|-----------|
| Frequency range                       | F        |                   | 4.9  |      | 5.85 | GHz       |
| Power detect range                    | PDR      | A0 or A1          | 0    |      | 20   | dBm       |
| Power detector accuracy               | PDacc5   | Over 3:1 VSWR     |      | 0.7  |      | dB        |
| DC load impedance                     | Zload    |                   |      |      | 3    | $k\Omega$ |
| Output voltage, no RF                 |          |                   |      | 0.90 |      | V         |
| Output voltage, 18 dBm                |          |                   |      | 0.35 |      | V         |
| Power detector -3 dB corner frequency | LPF-3 dB | 10 $k\Omega$ load | 270  | 300  | 400  | kHz       |

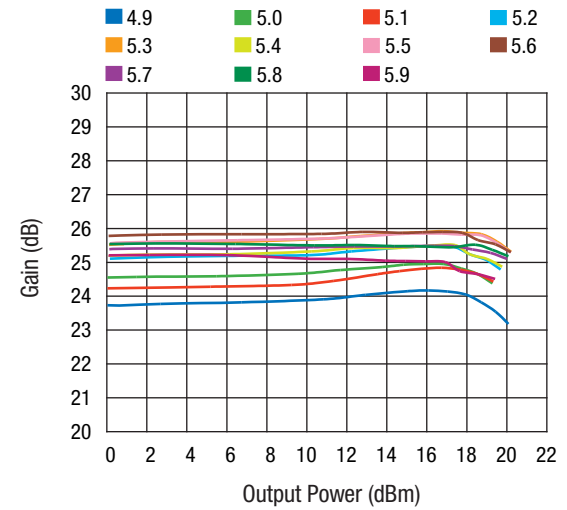
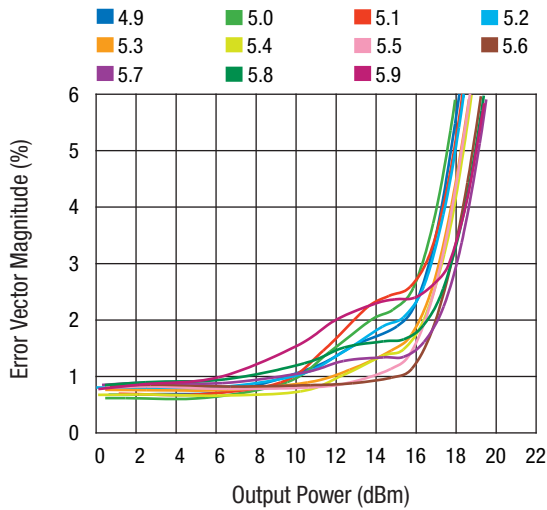
### Typical Performance Data (4.9–5.85 GHz)

$V_{CC} = 3.3\text{ V}$ ,  $T_A = 25\text{ }^\circ\text{C}$ , OFDM 54 Mbps,  $Z_0 = 50\ \Omega$ , unless otherwise noted



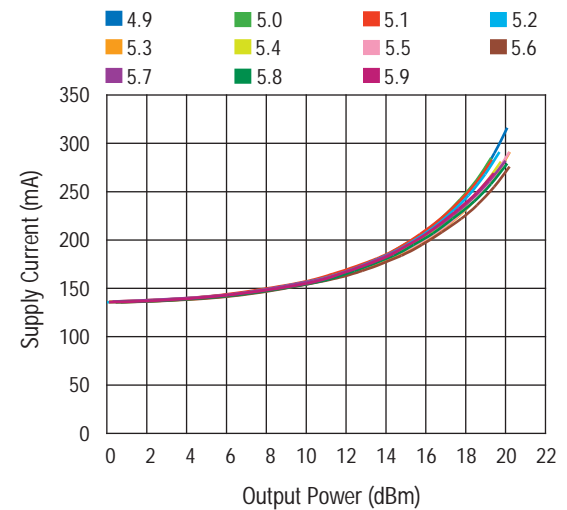
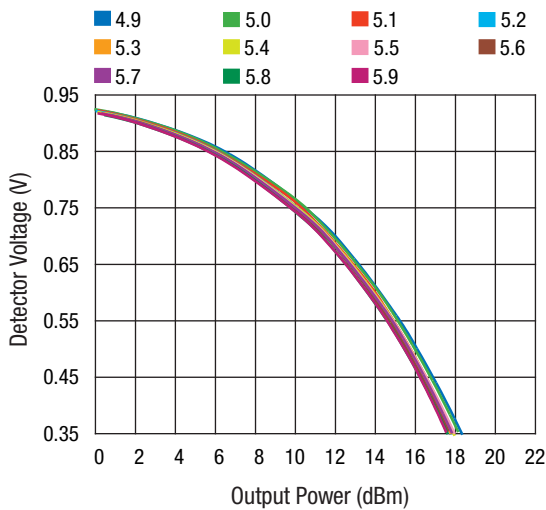
**EVM vs. Frequency ( $P_{OUT} = 15\text{ dBm}$ )**

**Gain vs. Frequency**



**EVM vs. Output Power**

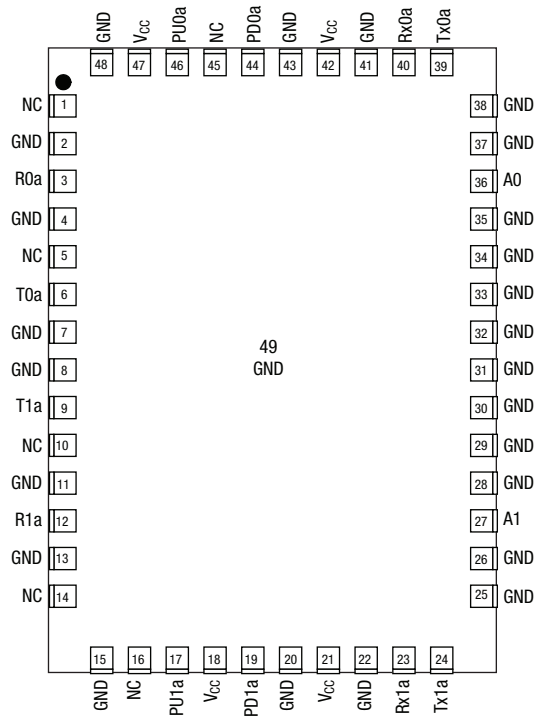
**Gain vs. Output Power**



**Detector Voltage vs. Output Power**

**Supply Current vs. Output Power**

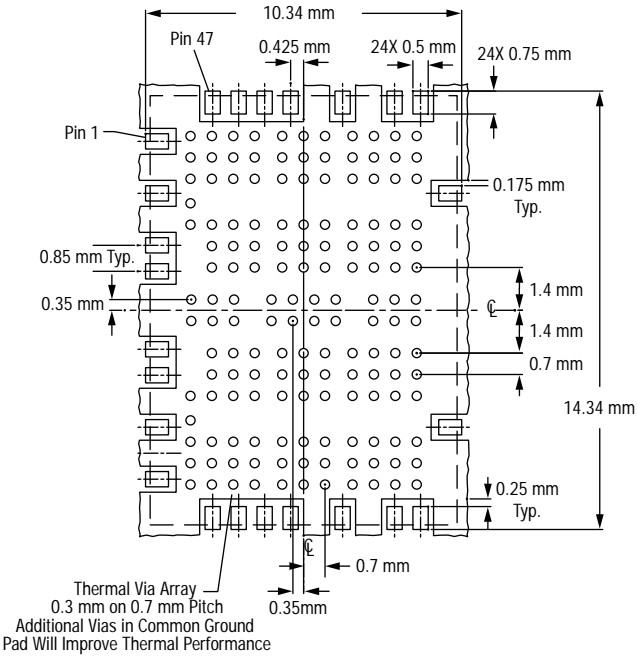
**Pin Out**



**Pin Descriptions**

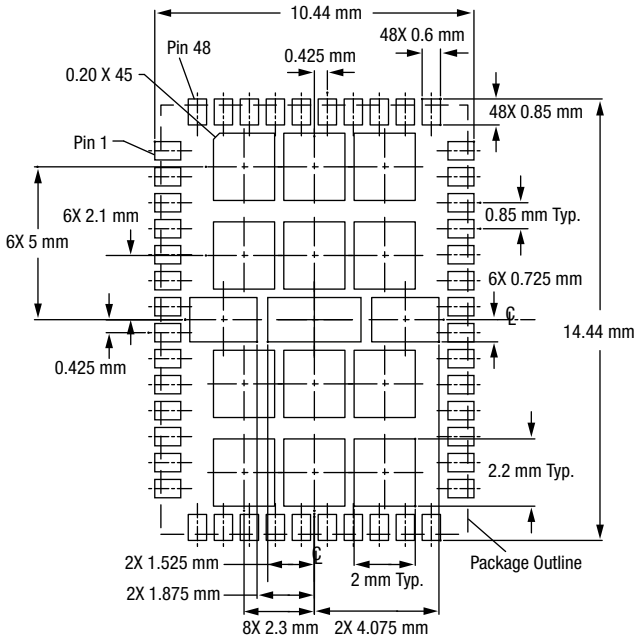
| Pin # | Pin Name        | Description                            | EVB Label               |
|-------|-----------------|----------------------------------------|-------------------------|
| 1     | NC              | No connection                          | NC                      |
| 2     | GND             | Ground                                 | GND                     |
| 3     | ROa             | Receiver output                        | ROa                     |
| 4     | GND             | Ground                                 | GND                     |
| 5     | NC              | No connection                          | NC                      |
| 6     | TOa             | Transmitter input                      | TOa                     |
| 7     | GND             | Ground                                 | GND                     |
| 8     | GND             | Ground                                 | GND                     |
| 9     | T1a             | Transmitter input                      | T1a                     |
| 10    | NC              | No connection                          | NC                      |
| 11    | GND             | Ground                                 | GND                     |
| 12    | R1a             | Receiver output                        | R1a                     |
| 13    | GND             | Ground                                 | GND                     |
| 14    | NC              | No connection                          | NC                      |
| 15    | GND             | Ground                                 | GND                     |
| 16    | NC              | No connection                          | NC                      |
| 17    | PU1a            | Power amplifier enable input           | VEN1a                   |
| 18    | V <sub>CC</sub> | 3.3 V                                  | None.<br>Tied to Pin 47 |
| 19    | PD1a            | Power detector output voltage from PA1 | VD1ag                   |
| 20    | GND             | Ground                                 | GND                     |
| 21    | V <sub>CC</sub> | 3.3 V                                  | None.<br>Tied to Pin 47 |
| 22    | GND             | Ground                                 | GND                     |
| 23    | Rx1a            | Switch control input                   | Rx1ag                   |
| 24    | Tx1a            | Switch control input                   | Tx1ag                   |
| 25    | GND             | Ground                                 | GND                     |
| 26    | GND             | Ground                                 | GND                     |
| 27    | A1              | Antenna 1                              | A1                      |
| 28    | GND             | Ground                                 | GND                     |
| 29    | GND             | Ground                                 | GND                     |
| 30    | GND             | Ground                                 | GND                     |
| 31    | GND             | Ground                                 | GND                     |
| 32    | GND             | Ground                                 | GND                     |
| 33    | GND             | Ground                                 | GND                     |
| 34    | GND             | Ground                                 | GND                     |
| 35    | GND             | Ground                                 | GND                     |
| 36    | AO              | Antenna 0                              | AO                      |
| 37    | GND             | Ground                                 | GND                     |
| 38    | GND             | Ground                                 | GND                     |
| 39    | Tx0a            | Switch control input                   | Tx0ag                   |
| 40    | Rx0a            | Switch control input                   | Rx0ag                   |
| 41    | GND             | Ground                                 | GND                     |
| 42    | V <sub>CC</sub> | 3.3 V                                  | None.<br>Tied to Pin 47 |
| 43    | GND             | Ground                                 | GND                     |
| 44    | PD0a            | Power detector output voltage from PA0 | VDOag                   |
| 45    | NC              | No connection                          | VEN0g                   |
| 46    | PU0a            | Power amplifier enable input           | VEN0a                   |
| 47    | V <sub>CC</sub> | 3.3 V                                  | V <sub>CC</sub>         |
| 48    | GND             | Ground                                 | GND                     |
| 49    | GND             | Ground                                 | GND                     |

**Recommended Footprint**

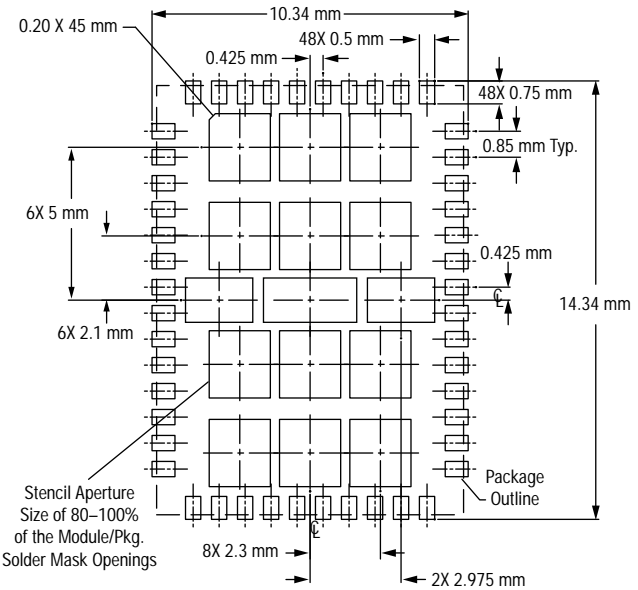


Thermal vias should be tented and filled with solder mask 30-35 µm copper plating recommended.

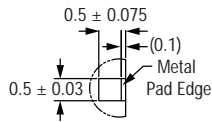
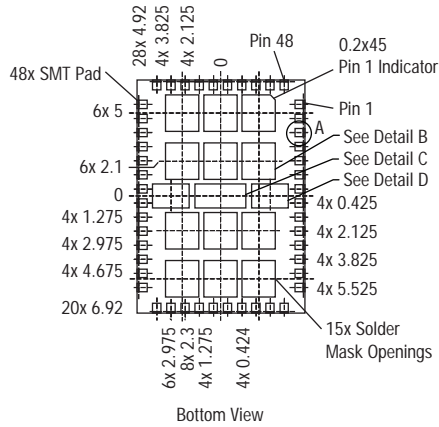
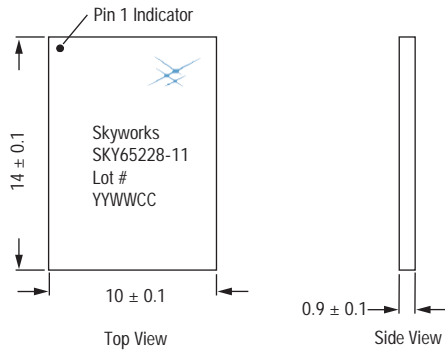
**Solder Mask**



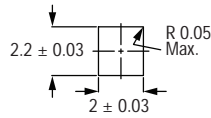
**Stencil Pattern**



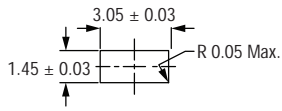
### Package Outline



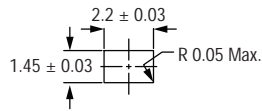
Detail A  
Pad Scale: 2X  
14X Rotated 180°  
10X Rotated 90° CW  
10X Rotated 90° CCW



Detail B  
Scale: Full  
12X



Detail C  
Scale: Full



Detail D  
Scale: Full  
2X



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