

SKY65233-11: WLAN 802.11n Single-Band 2.4 GHz 2 x 2 MIMO Intera™ Front-End Module with 3 Antenna Ports

Features

- Single-band 2.4–2.5 GHz 2 x 2 MIMO architecture
- Two full 2.4–2.5 GHz transmit/receive chains
- 3rd antenna provides switch diversity on both chains
- Backward-compatible with 802.11 b/g standards
- P_{OUT} @ 2.5% EVM: 19 dBm (-11b); 19 dBm (-11g)
- Gain matching: <1.5 dB @ 2 GHz
- Single 3.0–3.6 V power supply, internal voltage regulation
- Temperature-compensated PA bias networks and directional power detection
- Separate digital controls for each PA
- Package size: 10 x 14 x 0.9 mm
- Lead (Pb)-free and RoHS-compliant MSL-3 @ 250 °C per JEDEC J-STD-020

NEW

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



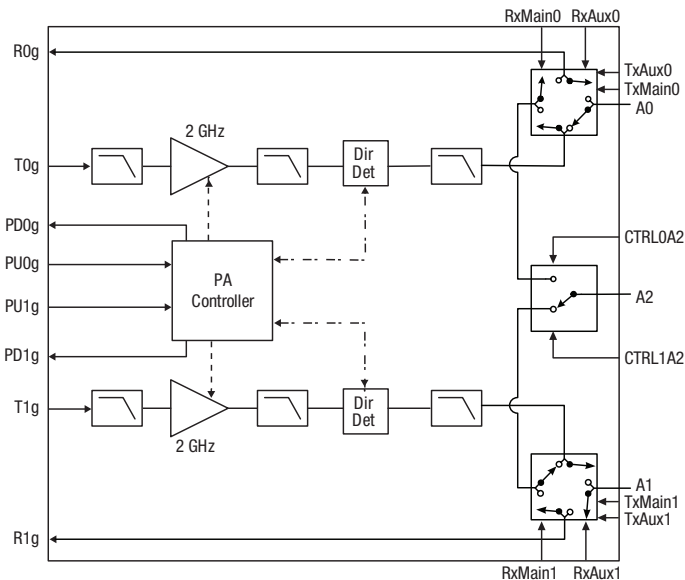
Description

The SKY65233-11 Intera nFEM combines two complete 2.4 GHz transmit/receive chains in one compact RF front end module optimized for 2 x 2 MIMO (multiple in—multiple out) operation, in compliance with the 802.11n draft standard. The SKY65233-11 includes two 2 GHz PAs, each with integrated input filtering for 3–4 GHz rejection, and two temperature-compensated, directional power detectors with 20 dB dynamic range. Also included are low loss, high rejection GaAs filters and diversity switches which provide high linearity in all transmit paths and low loss in all receive paths. Additionally, a third antenna port is added to provide switch diversity capability on both chains. All RF ports are matched to 50 Ω.

The SKY65233-11 Intera nFEM achieves outstanding gain matching which is a critical requirement for MIMO operation. This is accomplished through mirrored layout symmetry.

The SKY65233-11 is packaged in a lead (Pb)-free, RoHS-compliant laminate package, which measures 140 mm². It is designed as a pin-to-pin compatible version of SKY65230-11 for 2.4 GHz only.

Functional Block Diagram



Innovation to Go™
Now available for purchase online.

Absolute Maximum Ratings

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|-----------------------------|------------------|-----------|------|------|------|------|
| V _{CC} | V _{CC} | | -0.3 | | 5.5 | V |
| PU0g, PU1g | PU | | -0.3 | | 5.5 | V |
| T0g, T1g | RFin | | | | 10 | dBm |
| Operating temperature range | T _{OP} | | 0 | | 85 | °C |
| Storage temperature range | T _{STO} | | -65 | | 125 | °C |
| Moisture sensitivity level | MSL-3 | | | | 250 | °C |
| Thermal resistance | θ _{JC} | | | | 55 | °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 _{CC} | | 3 | 3.3 | 3.6 | V |
| Operating Temperature | T _{OP} | | 0 | 25 | 85 | °C |

DC Characteristics

Conditions: V_{CC} = 3.3 V, T_{OP} = 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 802.11g Tx supply current, T0g or T1g | I _{CC-g} | P _{OUT} = 18 dBm, 54 Mbps OFDM, PU0g or PU1g = 3.3 V | | 190 | | mA |
| Total 802.11g Tx quiescent current, T0g or T1g | I _{CC-g} | No RF | | 95 | | mA |
| Total 802.11b Tx supply current, T0g or T1g | I _{CC-b} | P _{OUT} = 18 dBm, 11 Mbps CCK, PU0g or PU1g = 3.3 V | | 190 | | mA |

PA Logic Characteristics

Conditions: V_{CC} = 3.3 V, T_{OP} = 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 PU0g, PU1g, (Tx On) | | | 2 | | V _{CC} | V |
| Logic low voltage for PU0g, PU1g, (Tx Off) | | | 0 | | 0.5 | V |
| Input current logic high voltage for PU0g, PU1g | | | | 100 | 200 | µA |
| Input current logic low voltage for PU0g, PU1g | | | | 0.2 | | µA |

PA Bias Control Line Truth Table

| Control Pin | Logic Level = 1 (3 V) | Logic Level = 0 (0 V) |
|-------------|-----------------------|-----------------------|
| PU0g | g Band PA0 On | g Band PA0 Off |
| PU1g | g Band PA1 On | g Band PA1 Off |

Switch Control Line Truth Tables**H = 3 V, L = 0 V, X = Don't Care**

| Path | RxMain0 | TxMain0 | RxAux0 | TxAux0 | Ctrl0A2 | Ctrl1A2 |
|--------|---------|---------|--------|--------|---------|---------|
| A0-R0g | H | L | L | L | X | X |
| A2-R0g | L | L | H | L | H | L |
| A0-T0g | L | H | L | L | X | X |
| A2-T0g | L | L | L | H | H | L |

| Path | RxMain1 | TxMain1 | RxAux1 | TxAux1 | Ctrl0A2 | Ctrl1A2 |
|--------|---------|---------|--------|--------|---------|---------|
| A1-R1g | H | L | L | L | X | X |
| A2-R1g | L | L | H | L | L | H |
| A1-T1g | L | H | L | L | X | X |
| A2-T1g | L | L | L | H | L | H |

CAUTION: Although this device is designed to be as robust as possible, ESD (Electrostatic Discharge) 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 must be employed at all times.

802.11b,g 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 switch control voltages set according to Truth Tables in this document. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into 50 Ω .

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|----------------------------|---|--|------|------|---------|
| Frequency range | F | | 2.4 | | 2.5 | GHz |
| Linear output power - g | P _{lin_g} | 54 Mbps OFDM, 64 QAM, EVM = 2.5 % | | 19 | | dBm |
| Compliant output power - b | P _{OUT_b} | 11 Mbps CCK | | 19 | | dBm |
| Backed off EVM | BEVM | 54 Mbps OFDM, 64 QAM, Pin = 8 dBm | | 1.5 | | % |
| 1 dB compression point | P _{1 dB} | | 22.5 | 25 | | dBm |
| Small signal gain | IS _{21l} | | | 25 | | dB |
| Small signal gain variation over frequency band | Δ IS _{21l} | | | 1 | 2.5 | dB |
| Gain matching, T0g to A0 vs. T1g to A1 | IS _{21l} - M | Compared frequency by frequency | | 1 | | dB |
| Gain, 3.2–3.3 GHz | IS _{21l} - 3.2 | | | -2 | | dB |
| Harmonics | 2f, 3f | P _{OUT} = 18 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 | IS _{11l} | T0g or T1g | | -10 | | dB |
| Output return loss | IS _{22l} | A0 or A1 | | -8 | | dB |
| Isolation between T0g and A1 | ISO-A1 | CW power into T0g and measure ratio of power at A0 to A1 | | | -25 | dBc |
| Isolation between T1g and A0 | ISO-A0 | CW power into T1g and measure ratio of power at A1 to A0 | | | -25 | dBc |
| Stability | STAB | P _{OUT} ≤ 18 dBm, load VSWR = 3:1 | All non-harmonically related outputs less than -50 dBc/1 MHz | | | |

802.11b,g Receive Specifications (Rx Chain 0, Rx Chain 1)

Conditions: $V_{CC} = 3.3\text{ V}$, $T_{OP} = 25\text{ }^{\circ}\text{C}$. PA enables and switch control voltages set according to Truth Tables in this document. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into 50 Ω .

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|----------------------|----------------------------|-------------------------|------|------|------|------|
| Frequency range | F | | 2.4 | | 2.5 | GHz |
| Insertion loss | IS _{21l} | | | 1.5 | 2.0 | dB |
| Input return loss | IS _{11l} | R0g or R1g | | -20 | | dB |
| Output return loss | IS _{22l} | A0 or A1 | | -15 | | dB |
| Insertion loss delta | Δ IS _{21l} | A0 to R0g and A1 to R1g | | | 0.5 | dB |

802.11b,g Power Detector Specification

Conditions: $V_{CC} = 3.3\text{ V}$, $T_{OP} = 25\text{ }^{\circ}\text{C}$. PA enables and switch control voltages set according to Truth Tables in this document. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into 50 Ω .

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---------------------------------------|----------|--------------------|------|------|------|------|
| Frequency range | F | | 2.4 | | 2.5 | GHz |
| Power detect range | PDR | A0 or A1 | 0 | | 20 | dBm |
| Power detector accuracy | PDacc2 | Over 3:1 VSWR | | 1 | | dB |
| DC load impedance | Zload | | | | 3 | kohm |
| Output voltage, no RF | | | 0.80 | | 0.95 | V |
| Output voltage, 20 dBm | | | | 0.35 | | V |
| Power detector -3 dB corner frequency | LPF-3 dB | 10 k Ω load | 270 | 300 | 400 | kHz |

802.11b,g Transmit Specifications (Tx Chain 2)

Conditions: $V_{CC} = 3.3\text{ V}$, $T_{OP} = 25\text{ }^{\circ}\text{C}$. PA enables and switch control voltages set according to Truth Tables in this document. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into $50\ \Omega$.

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---|-------------------------|---|--|------|------|---------|
| Frequency range | F | | 2.4 | | 2.5 | GHz |
| Linear output power - g | P _{lin_g} | 54 Mbps OFDM, 64 QAM, EVM = 2.5 % | | 18.5 | | dBm |
| Compliant output power - b | P _{OUT_b} | 11 Mbps CCK | | 18.5 | | dBm |
| Backed off EVM | BEVM | 54 Mbps OFDM, 64 QAM, Pin = 8 dBm | | 1.5 | | % |
| 1 dB compression point | P _{1 dB} | | 22 | 25 | | dBm |
| Small signal gain | IS _{21l} | | | 25 | | dB |
| Small signal gain variation over frequency band | ΔIS _{21l} | | | 1 | 2.5 | dB |
| Gain matching, T0g to A0 vs. T1g to A1 | IS _{21l} - M | Compared frequency by frequency | | 1 | | dB |
| Gain, 3.2–3.3 GHz | IS _{21l} - 3.2 | | | -2 | | dB |
| Harmonics | 2f, 3f | P _{OUT} = 18 dBm, 1 Mbps, CCK, 802.11b | | -48 | -42 | dBm/MHz |
| Tx switching time | t _{sw} | 50 % of V _{CTL} to 90/10 % RF output power level | | | 500 | nS |
| Input return loss | IS _{11l} | T0g or T1g | | -10 | | dB |
| Output return loss | IS _{22l} | A2 | | -8 | | dB |
| Isolation between T0g and A1 | ISO-A1 | CW power into T0g and measure ratio of power at A0 to A1 | | | -25 | dBc |
| Isolation between T1g and A0 | ISO-A0 | CW power into T1g and measure ratio of power at A1 to A0 | | | -25 | dBc |
| Stability | STAB | P _{OUT} ≤ 18 dBm, load VSWR = 3:1 | All non-harmonically related outputs less than -50 dBc/1 MHz | | | |

802.11b,g Receive Specifications (Rx Chain 2)

Conditions: $V_{CC} = 3.3\text{ V}$, $T_{OP} = 25\text{ }^{\circ}\text{C}$. PA enables and switch control voltages set according to Truth Tables in this document. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into $50\ \Omega$.

| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|----------------------|--------------------|-------------------------|------|------|------|------|
| Frequency range | F | | 2.4 | | 2.5 | GHz |
| Insertion loss | IS _{21l} | | | 1.8 | 2.5 | dB |
| Input return loss | IS _{11l} | R0g or R1g | | -20 | | dB |
| Output return loss | IS _{22l} | A2 | | -15 | | dB |
| Insertion loss delta | ΔIS _{21l} | A2 to R0g and A2 to R1g | | | 0.5 | dB |

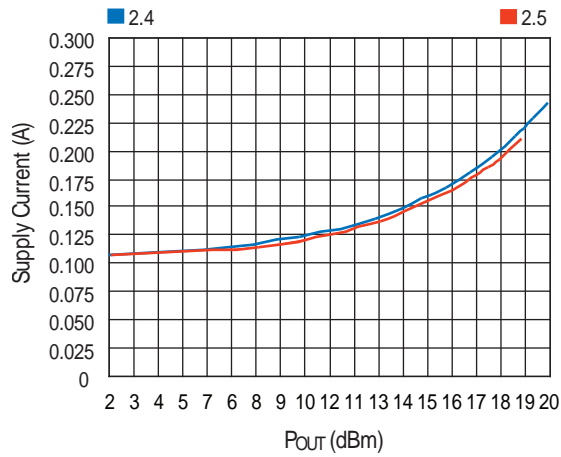
802.11b,g Power Detector Specification

Conditions: $V_{CC} = 3.3\text{ V}$, $T_{OP} = 25\text{ }^{\circ}\text{C}$. PA enables and switch control voltages set according to Truth Tables in this document. Measurements made on Skyworks EVB with all losses de-embedded. All unused ports terminated into $50\ \Omega$.

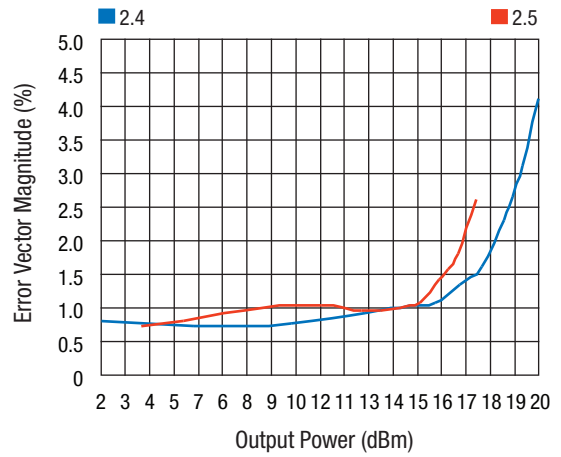
| Parameter | Symbol | Condition | Min. | Typ. | Max. | Unit |
|---------------------------------------|-------------------|---------------|------|------|------|------|
| Frequency range | F | | 2.4 | | 2.5 | GHz |
| Power detect range | PDR | A0 or A1 | 0 | | 20 | dBm |
| Power detector accuracy | PDacc2 | Over 3:1 VSWR | | 1 | | dB |
| DC load impedance | Z _{load} | | | | 3 | kohm |
| Output voltage, no RF | | | 0.80 | | 0.95 | V |
| Output voltage, 20 dBm | | | | 0.35 | | V |
| Power detector -3 dB corner frequency | LPF-3 dB | 10 kΩ load | 270 | 300 | 400 | kHz |

Typical Performance Data (2.4–2.5 GHz)

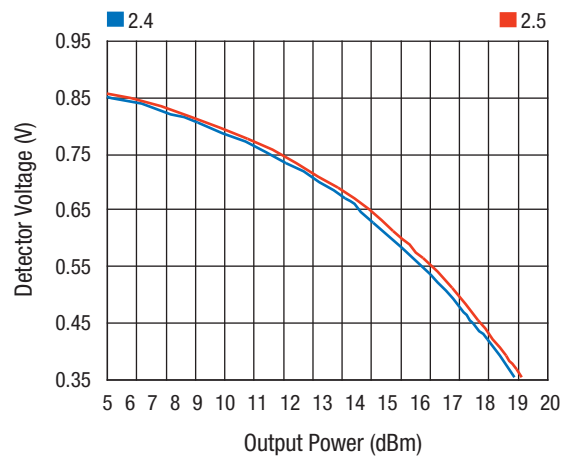
$V_{CC} = 3.3\text{ V}$, $T_A = 25\text{ }^\circ\text{C}$, OFDM 54 Mbps, $Z_0 = 50\ \Omega$, unless otherwise noted



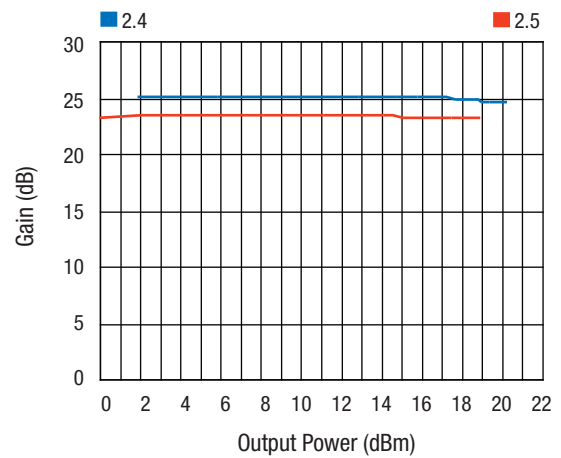
Supply Current vs. Output Power



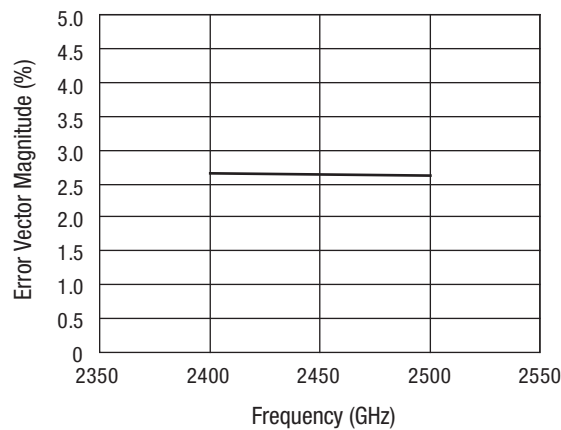
EVM vs. Output Power



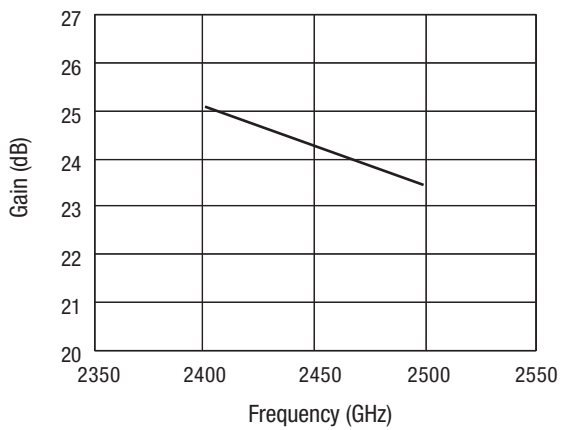
Detector Voltage vs. Output Power



Gain vs. Output Power

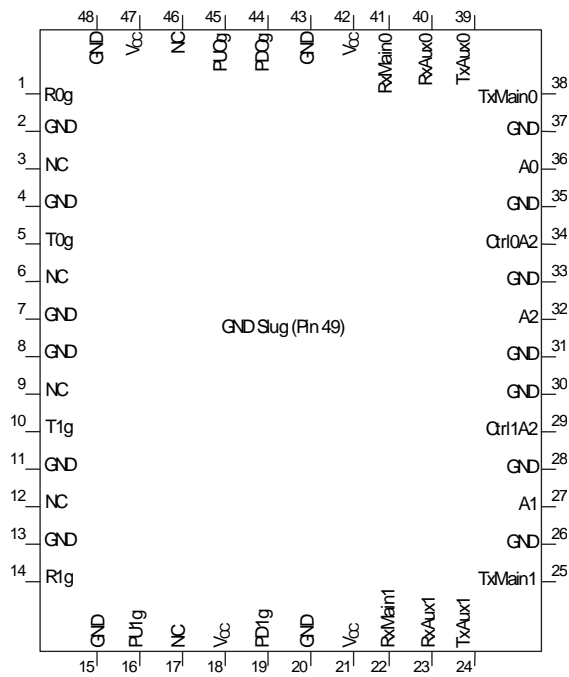


EVM vs. Frequency ($P_{OUT} = 18\text{ dBm}$)



Gain vs. Frequency

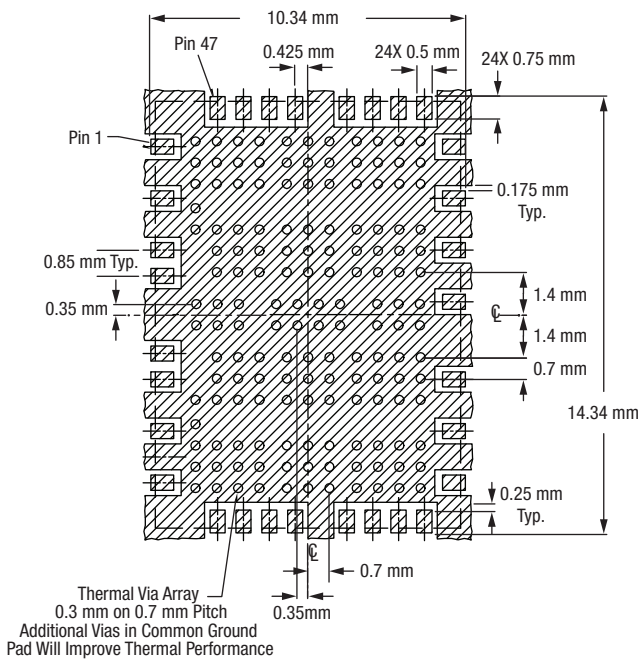
Module Pin Out



Pin Descriptions

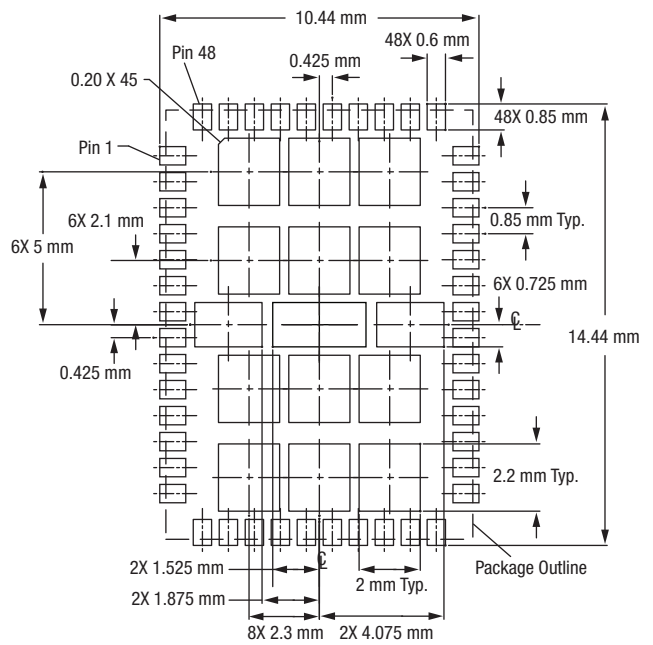
| Pin # | Name | Description |
|-------|---------|--------------------------------|
| 1 | R0g | Receiver output |
| 2 | GND | Ground |
| 3 | NC | No connection |
| 4 | GND | Ground |
| 5 | T0g | Transmitter input |
| 6 | NC | No connection |
| 7 | GND | Ground |
| 8 | GND | Ground |
| 9 | NC | No connection |
| 10 | T1g | Transmitter input |
| 11 | GND | Ground |
| 12 | NC | No connection |
| 13 | GND | Ground |
| 14 | R1g | Receiver output |
| 15 | GND | Ground |
| 16 | PU1g | Power amp enable input |
| 17 | NC | No connection |
| 18 | Vcc | 3.3 V |
| 19 | PD1g | Power detector 1 output |
| 20 | GND | Ground |
| 21 | Vcc | 3.3 V |
| 22 | RxMain1 | Diversity switch control input |
| 23 | RxAux1 | Diversity switch control input |
| 24 | TxAux1 | Diversity switch control input |
| 25 | TxMain1 | Diversity switch control input |
| 26 | GND | Ground |
| 27 | A1 | Antenna 1 |
| 28 | GND | Ground |
| 29 | Ctrl1A2 | TR switch control input |
| 30 | GND | Ground |
| 31 | GND | Ground |
| 32 | A2 | Antenna 2 |
| 33 | GND | Ground |
| 34 | Ctrl0A2 | TR switch control input |
| 35 | GND | Ground |
| 36 | A0 | Antenna 0 |
| 37 | GND | Ground |
| 38 | TxMain0 | Diversity switch control input |
| 39 | TxAux0 | Diversity switch control input |
| 40 | RxAux0 | Diversity switch control input |
| 41 | RxMain0 | Diversity switch control input |
| 42 | Vcc | 3.3 V |
| 43 | GND | Ground |
| 44 | PDOg | Power detector 0 output |
| 45 | PUOg | Power amp enable input |
| 46 | NC | No connection |
| 47 | Vcc | 3.3 V |
| 48 | GND | Ground |
| 49 | GND | Ground |

Recommended Footprint

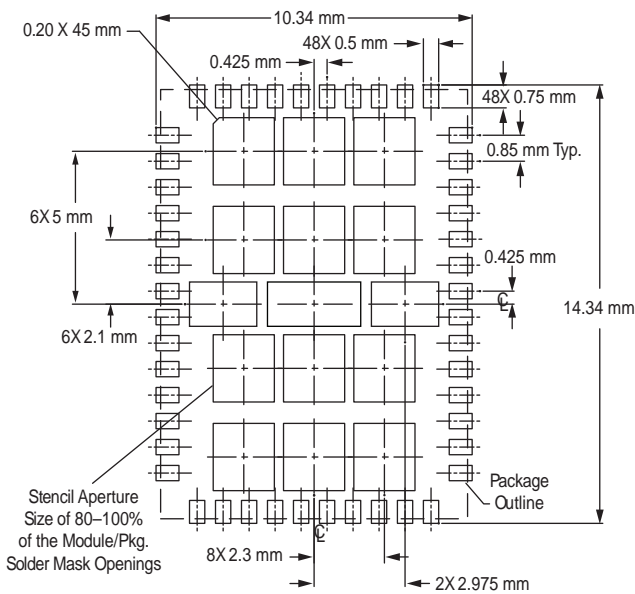


Thermal vias should be tented and filled with solder mask 30–35 µm copper plating recommended.

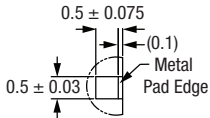
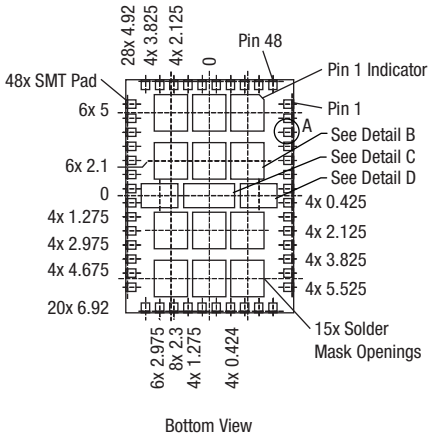
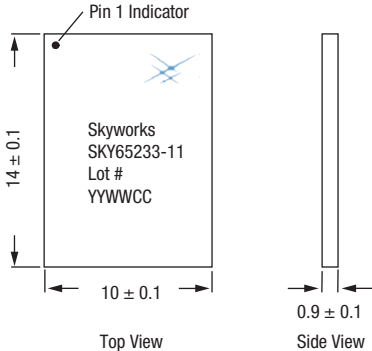
Solder Mask



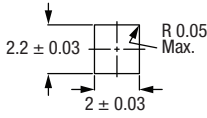
Stencil Pattern



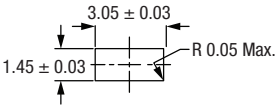
Package Outline



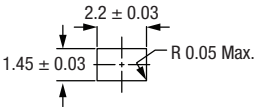
Detail A
Pad Scale: 2X
14X Rotated 180°
10X Rotated 90° CW
10X Rotated 90° CCW



Detail B
Scale: Full
12X



Detail C
Scale: Full



Detail D
Scale: Full
2X

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