

DATA SHEET

# SKY65336-11: 2.4 GHz Transmit/Receive Front-End Module with Integrated LNA

## Applications

- 2.4 GHz ISM band radios
- ZigBee® FEMs
- IEEE 802.15.4 applications

## Features

- Transmit output power > +20 dBm
- Receive NF < 3 dB
- High efficiency PA
- Programmable transmit power levels
- Configurable transmit/receive paths
- Internal switching and control circuits
- Internal RF match and bias circuits
- Single DC supply = 3.0 V
- Interfaces seamlessly with Ember EM250 and EM260 ZigBee transceivers
- All RF ports are internally DC blocked
- Small footprint, MCM (28-pin, 8 x 8 mm) SMT package (MSL3, 260 °C per JEDEC J-STD-020)



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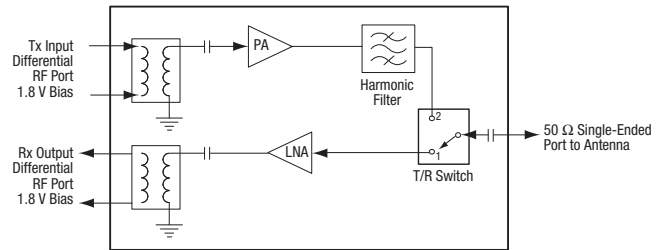


Figure 1. SKY65336-11 Block Diagram

## Description

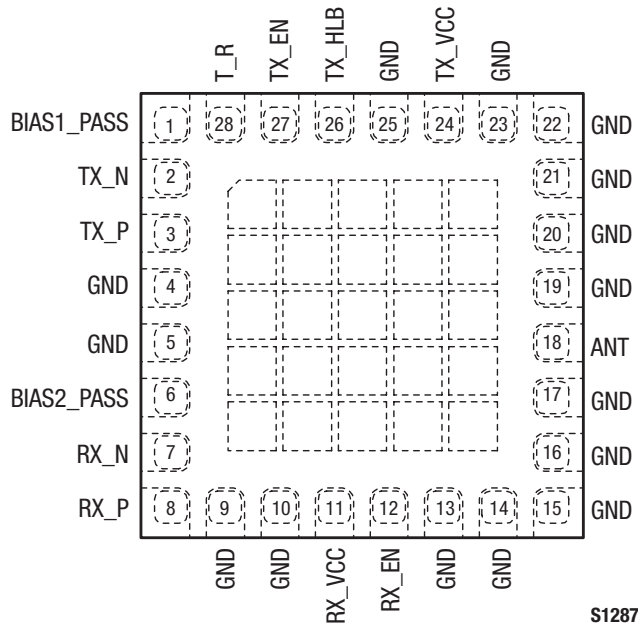
The Skyworks SKY65336-11 is a high-efficiency front-end module (FEM) for ZigBee and other 2.4 GHz ISM band applications. The small 8 x 8 mm Multi-Chip Module (MCM) contains a 2400 to 2500 MHz high-efficiency transmit path and a low-noise linear receive path.

The transmit path consists of an harmonic filter and high efficiency power amplifier (PA) capable of providing +20 dBm of power at the antenna port. Also included is an internal balun to allow use of differential input signals.

The receive path contains a high isolation transmit/receive (Tx/Rx) switch, low noise amplifier (LNA), and balun for low noise differential output.

The device is mounted in a 28-pin, 8 x 8 mm MCM surface-mount technology (SMT) package, which allows for a highly manufacturable low-cost solution.

A block diagram of the SKY65336-11 is shown in Figure 1. The device package and pinout for the 28-pin MCM are shown in Figure 2. Signal pin assignments and functional pin descriptions are described in Table 1.



**Figure 2. SKY65336-11 Pinout (Top View)**

**Table 1. SKY65336-11 Signal Descriptions<sup>1</sup>**

| Pin | Name       | Description                  | Pin | Name   | Description              |
|-----|------------|------------------------------|-----|--------|--------------------------|
| 1   | BIAS1_PASS | Transmit port bias supply    | 15  | GND    | Ground                   |
| 2   | TX_N       | Negative transmit input port | 16  | GND    | Ground                   |
| 3   | TX_P       | Positive transmit input port | 17  | GND    | Ground                   |
| 4   | GND        | Ground                       | 18  | ANT    | Antenna input            |
| 5   | GND        | Ground                       | 19  | GND    | Ground                   |
| 6   | BIAS2_PASS | Receive port bias supply     | 20  | GND    | Ground                   |
| 7   | RX_N       | Negative receive output port | 21  | GND    | Ground                   |
| 8   | RX_P       | Positive receive output port | 22  | GND    | Ground                   |
| 9   | GND        | Ground                       | 23  | GND    | Ground                   |
| 10  | GND        | Ground                       | 24  | TX_VCC | Transmit DC supply, +3 V |
| 11  | RX_VCC     | Receive DC supply, +3 V      | 25  | GND    | Ground                   |
| 12  | RX_EN      | Receive enable               | 26  | TX_HLB | Transmit power mode      |
| 13  | GND        | Ground                       | 27  | TX_EN  | Transmit enable          |
| 14  | GND        | Ground                       | 28  | T_R    | Transmit/receive switch  |

<sup>1</sup> The bottom ground pad **must be** connected to RF ground.

## Technical Description

### Transmit/Receive (Tx/Rx) Enable

Pin 27 (TX\_EN) and pin 12 (RX\_EN) are used to enable the transmit and receive port, respectively.

### Tx/Rx Switch

Pin 28 (T\_R) is used to control the Tx/Rx switch.

### Tx/Rx Enable and Tx/Rx Switch Mode Control

The following control logic is used to configure the transmit or receive mode of the SKY65336-11:

| TX_EN | RX_EN | T_R  | Mode          |
|-------|-------|------|---------------|
| High  | Low   | High | Transmit mode |
| Low   | High  | Low  | Receive mode  |

### High-Power and Low-Power Modes

High-power mode output is 20 dBm and low-power mode output is +10 dBm. Pin 26 (TX\_HLB) sets the transmit path in high-power or low-power mode according to the following logic:

| TX_HLB | State           |
|--------|-----------------|
| Low    | High-power mode |
| High   | Low-power mode  |

### Bottom Center Paddles

The bottom center paddles must be electrically grounded for proper RF performance. Customers should place adequate thermal vias under the ground paddles for optimum thermal performance. The Evaluation Board layout (see Figures 3 and 4) can be used as a guide for RF ground and thermal layout.

## Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY65336-11 are provided in Table 2. Recommended operating conditions are noted in Table 3 and electrical specifications are provided in Table 4.

Typical performance characteristics of the SKY65336-11 are shown in Figures 3 through 12.

**Table 2. SKY65336-11 Absolute Maximum Ratings<sup>1</sup>**

| Parameter                     | Symbol  | Minimum | Maximum | Units |
|-------------------------------|---|---------|---------|-------|
| Supply voltage                | RX_VCC, TX_VCC                                    | 2.1     | 4       | V     |
| Control voltage               | BIAS1_PASS, BIAS2_PASS, TX_EN, RX_EN, TX_HLB, T_R |         | 3.6     | V     |
| Bypass voltage                | BIAS1_PASS, BIAS2_PASS                            |         | 1.9     | V     |
| RF input power, antenna port  | P <sub>IN_ANT</sub>                               |         | 10      | dBm   |
| RF input power, transmit port | P <sub>IN_TX</sub>                                |         | +8      | dBm   |
| Case operating temperature    | T <sub>C</sub>                                    | -40     | +85     | °C    |
| Storage temperature           | T <sub>ST</sub>                                   | -55     | +125    | °C    |
| Junction temperature          | T <sub>J</sub>                                    |         | +150    | °C    |

<sup>1</sup> 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.

**ESD HANDLING:** *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 when handling or transporting. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD handling precautions should be used at all times.*

**Table 3. SKY65336-11 Recommended Operating Conditions**

| Parameter                       | Symbol                    | Min  | Typ  | Max       | Units |
|---------------------------------|---------------------------|------|------|-----------|-------|
| Supply voltage (TX_VCC, RX_VCC) | VCC                       | 2.7  | 3.0  | 3.6       | V     |
| Tx/Rx bias supply voltage       | BIAS1_PASS,<br>BIAS2_PASS | 1.7  | 1.8  | 1.9       | V     |
| Tx/Rx enable voltage:           |                           |      |      |           |       |
| Low                             | TX_ENL, RX_ENL            |      | 0    | 0.1       | V     |
| High                            | TX_ENH, RX_ENH            | 1.62 | 1.80 | VCC - 0.2 | V     |
| Tx/Rx control voltage:          |                           |      |      |           |       |
| Low                             | T_RL, TX_HLBL             |      | 0    | 0.1       | V     |
| High                            | T_RH, TX_HLBH             | 1.62 | 1.80 | VCC - 0.2 | V     |
| Frequency range                 | f                         | 2400 |      | 2500      | MHz   |

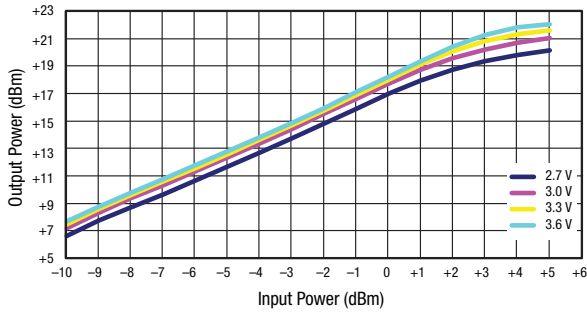
**Table 4. SKY65336-11 Electrical Specifications<sup>1</sup>**  
(VCC = 3.0 V, Tc = 25 °C, Unless Otherwise Noted)

| Parameter                                      | Symbol             | Test Condition  | Min   | Typ  | Max  | Units |
|--|--------------------|---|-------|------|------|-------|
| Frequency range                                | f                  |   | 2400  |      | 2500 | MHz   |
| Return loss                                    | RL                 | All RF ports  | 6     | 10   |      | dB    |
| <b>Transmitter Section</b>                     |                    |   |       |      |      |       |
| Input power range                              | P <sub>IN</sub>    | CW, high-power or low-power mode  |       | +3   | +5   | dBm   |
| Transmit saturated output power                | P <sub>SAT_H</sub> | High-power mode   | +19.5 | +20  |      | dBm   |
|  | P <sub>SAT_L</sub> | Low-power mode  | +8    | +10  |      | dBm   |
| Operating current                              | I <sub>OP_H</sub>  | P <sub>OUT</sub> = +20 dBm in high-power mode   |       | 145  | 160  | mA    |
|  | I <sub>OP_L</sub>  | P <sub>OUT</sub> = +10 dBm in low-power mode  |       | 70   | 80   | mA    |
| Harmonic levels <sup>2</sup>                   | P <sub>N</sub>     | CW, P <sub>OUT</sub> = +20 dBm in high-power mode, P <sub>OUT</sub> = +10 dBm in low-power mode |       | -44  | -39  | dBm   |
| Saturated gain                                 | G <sub>H</sub>     | CW, high-power mode   |       | 17   |      | dB    |
|  | G <sub>L</sub>     | CW, low-power mode  |       | 7    |      | dB    |
| Leakage current                                | I <sub>LEAK</sub>  | No RF input, VCC = 3.0 V, RX_EN = 0 V, TX_EN = 0 V  |       | 0.5  | 2.0  | μA    |
| <b>Receiver Section (Frequency = 2445 MHz)</b> |                    |   |       |      |      |       |
| Small signal gain                              | G                  | CW  | 9.5   | 10.5 |      | dB    |
| Noise figure                                   | NF                 |   |       | 2.0  | 3.0  | dB    |
| Input 1 dB compression                         | IP1dB              | CW  |       | -11  |      | dBm   |
| Input IP3                                      | IIP3               | Two CW tones spaced 1 MHz apart @ P <sub>IN</sub> = -9 dBm                                      | -1    | +3   |      | dBm   |
| Operating current                              | I <sub>CC</sub>    | CW  |       | 8    | 15   | mA    |
| Leakage current                                | I <sub>LEAK</sub>  | No RF input, VCC = 3.0 V, RX_EN = 0 V, TX_EN = 0 V  |       | 0.5  | 2.0  | μA    |

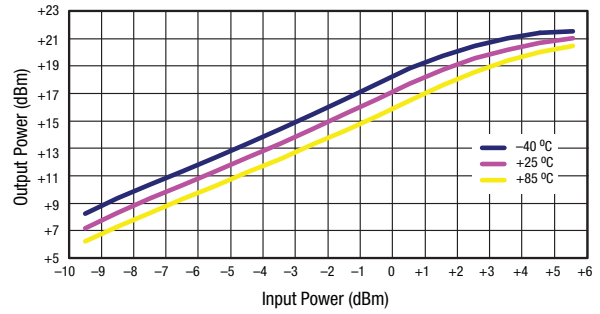
<sup>1</sup> Performance is guaranteed only under the conditions listed in this table.

<sup>2</sup> Harmonic levels using the Zigbee modulated signal are +6 dBm lower than the values shown here.

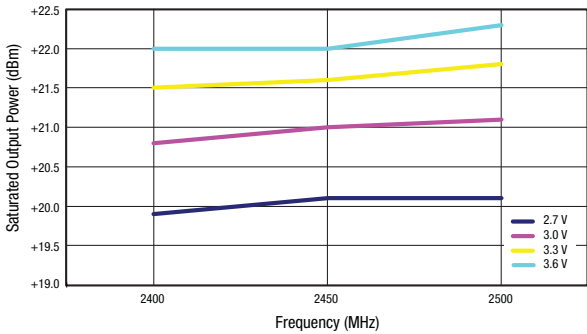
**Typical Performance Characteristics**  
 (VCC = 3.0 V, Tc = 25 °C, Unless Otherwise Noted)



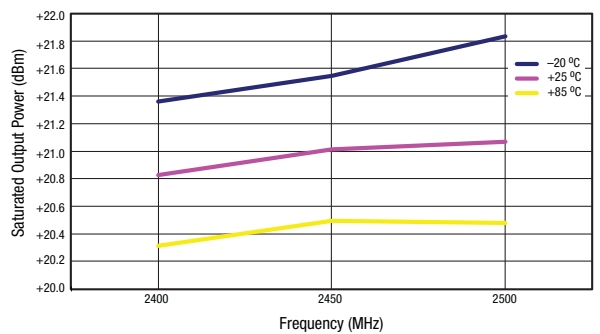
**Figure 3. Output Power vs Input Power Over Voltage @ 2450 MHz**



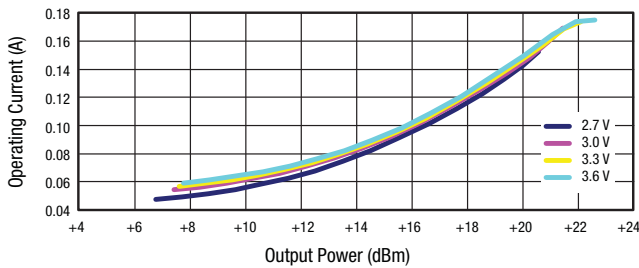
**Figure 4. Output Power vs Input Power Over Temperature @ 2450 MHz**



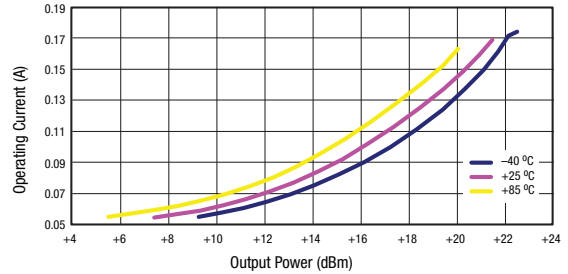
**Figure 5. Saturated Output Power vs Frequency Over Voltage**



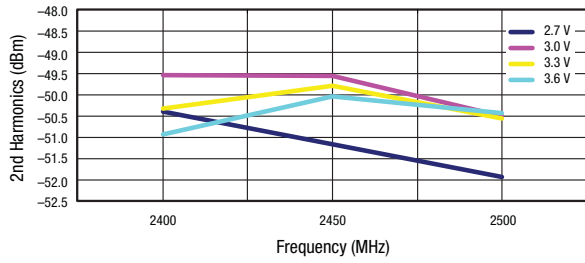
**Figure 6. Saturated Output Power vs Frequency Over Temperature**



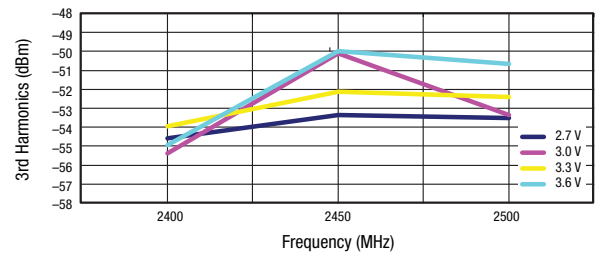
**Figure 7. Operating Current vs Output Power Over Voltage @ 2450 MHz**



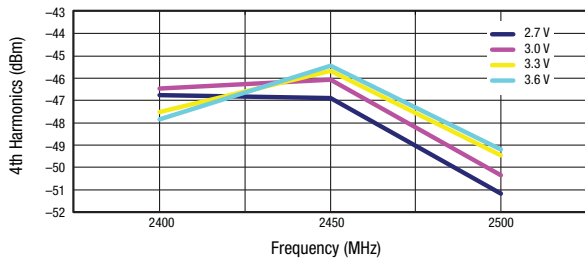
**Figure 8. Operating Current vs Output Power Over Temperature @ 2450 MHz**



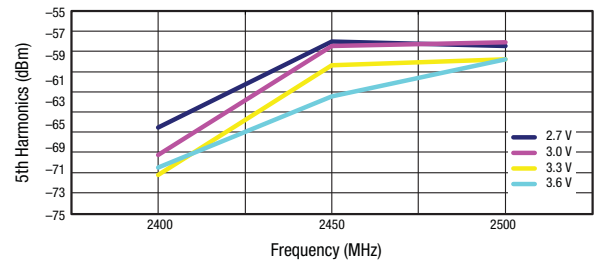
**Figure 9. Second Harmonics vs Frequency Over Voltage (High-power mode)**



**Figure 10. Third Harmonics vs Frequency Over Voltage (High-power mode)**



**Figure 11. Fourth Harmonics vs Frequency Over Voltage (High-power mode)**

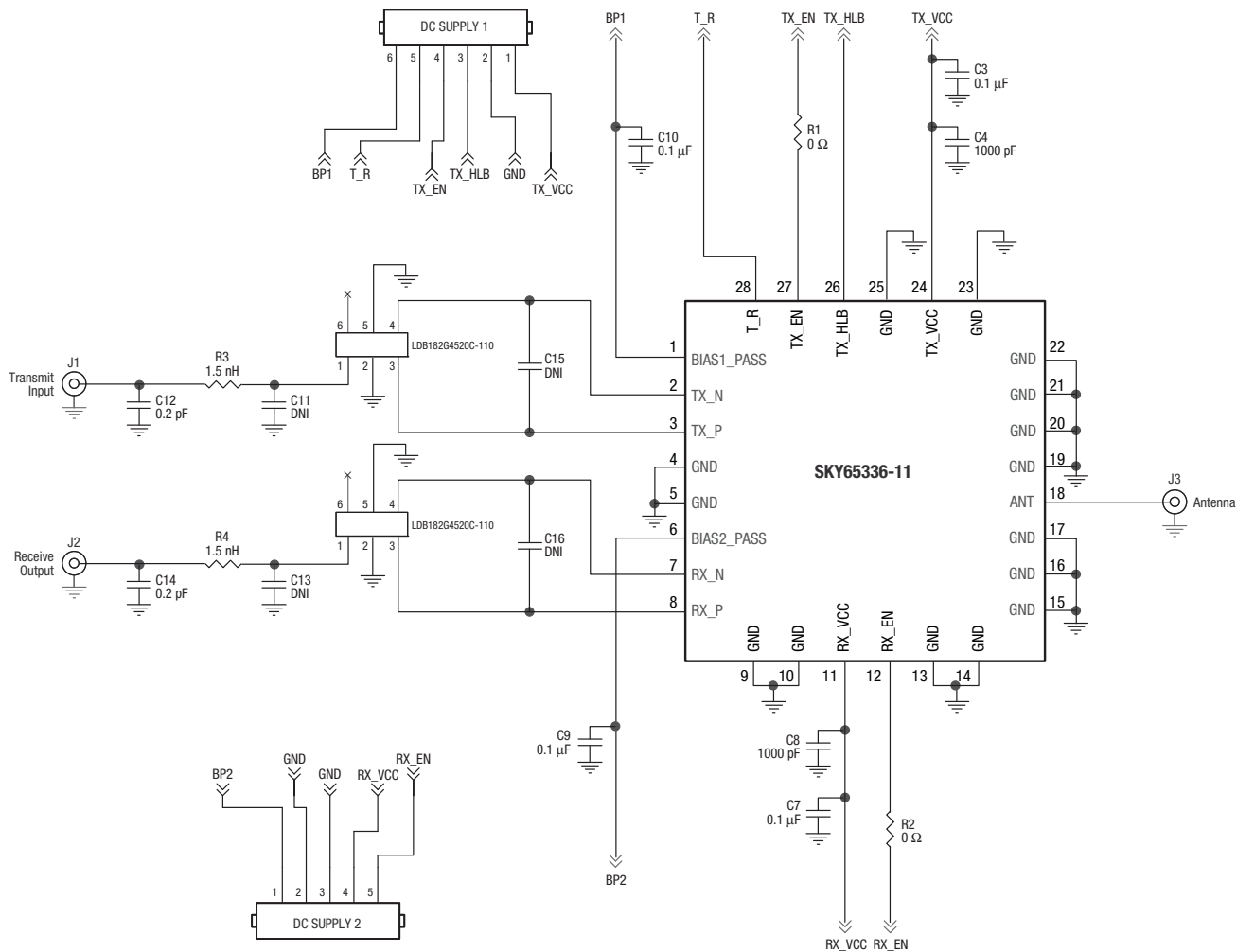


**Figure 12. Fifth Harmonics vs Frequency Over Voltage (High-power mode)**

### Evaluation Board Description

The SKY65336-11 Evaluation Board is used to test the performance of the SKY65336-11 FEM. The Evaluation Board schematic diagram is shown in Figure 13.

An assembly drawing for the Evaluation Board is shown in Figure 14.



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.

S1292

Figure 13. SKY65336-11 Evaluation Board Schematic

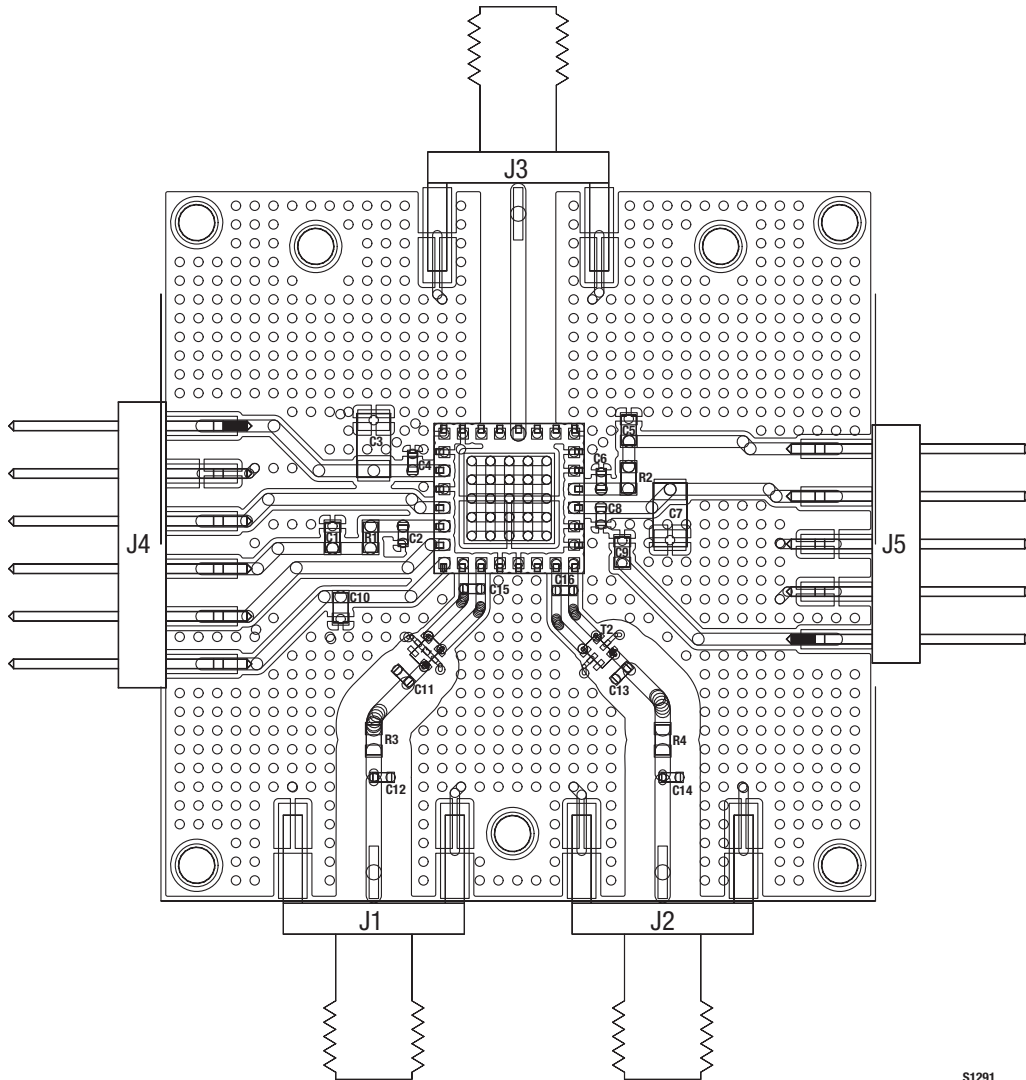


Figure 14. SKY65336-11 Evaluation Board Assembly Drawing

S1291



## Package Dimensions

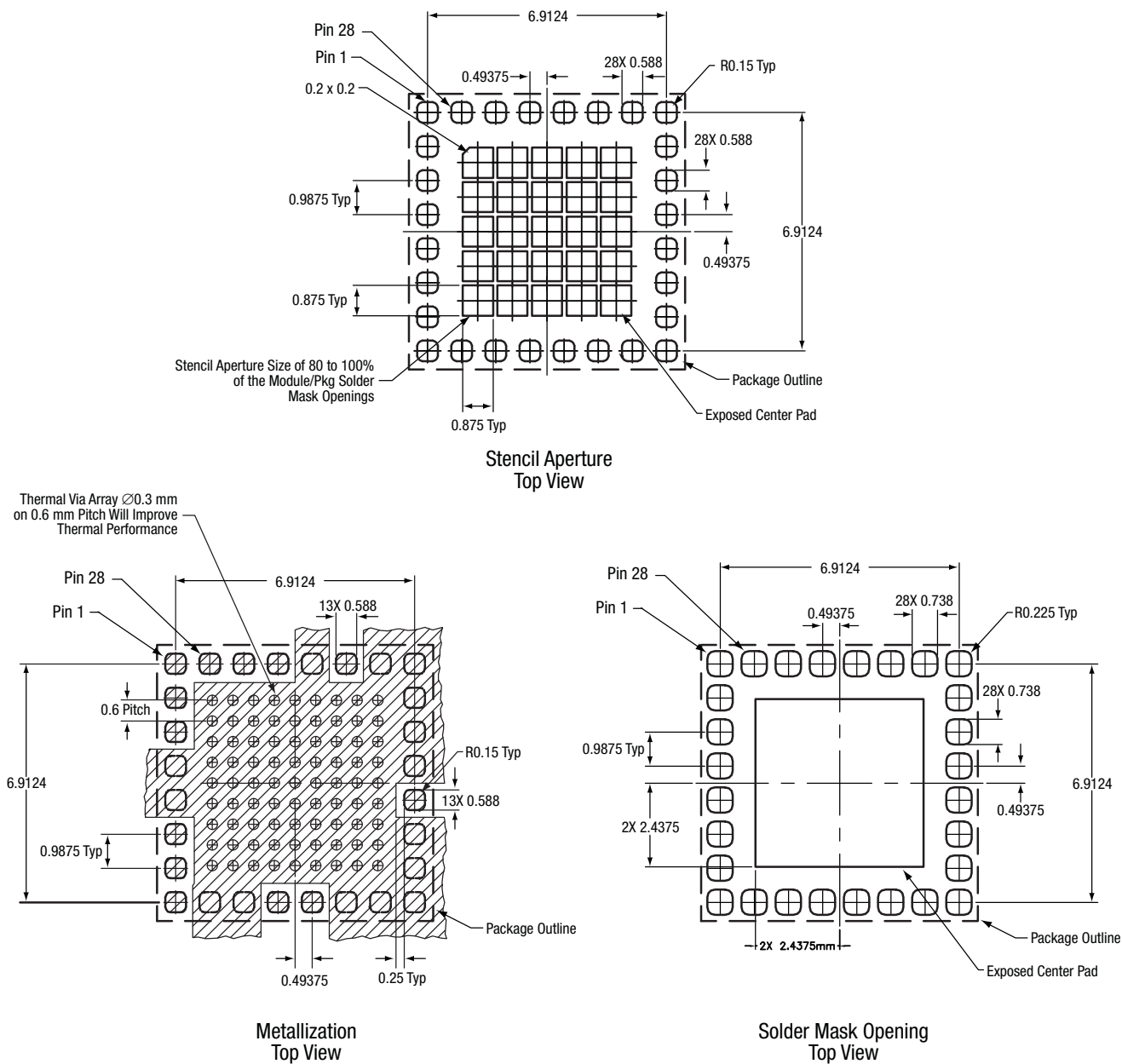
The PCB layout footprint for the SKY65336-11 is shown in Figure 15. Package dimensions are shown in Figure 16, and tape and reel dimensions are provided in Figure 17.

## 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 SKY65336-11 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.

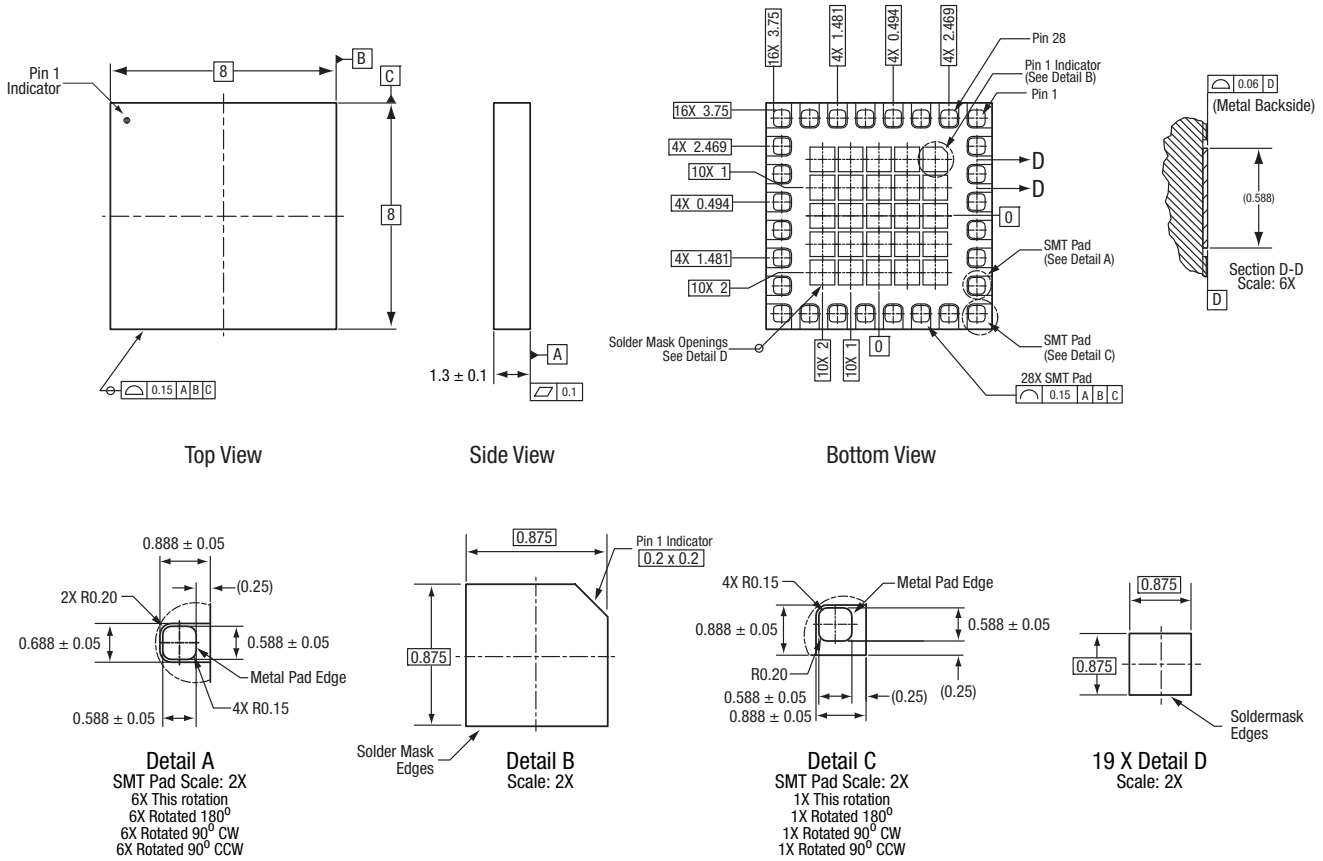
Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format.



All measurements are in millimeters

S1330

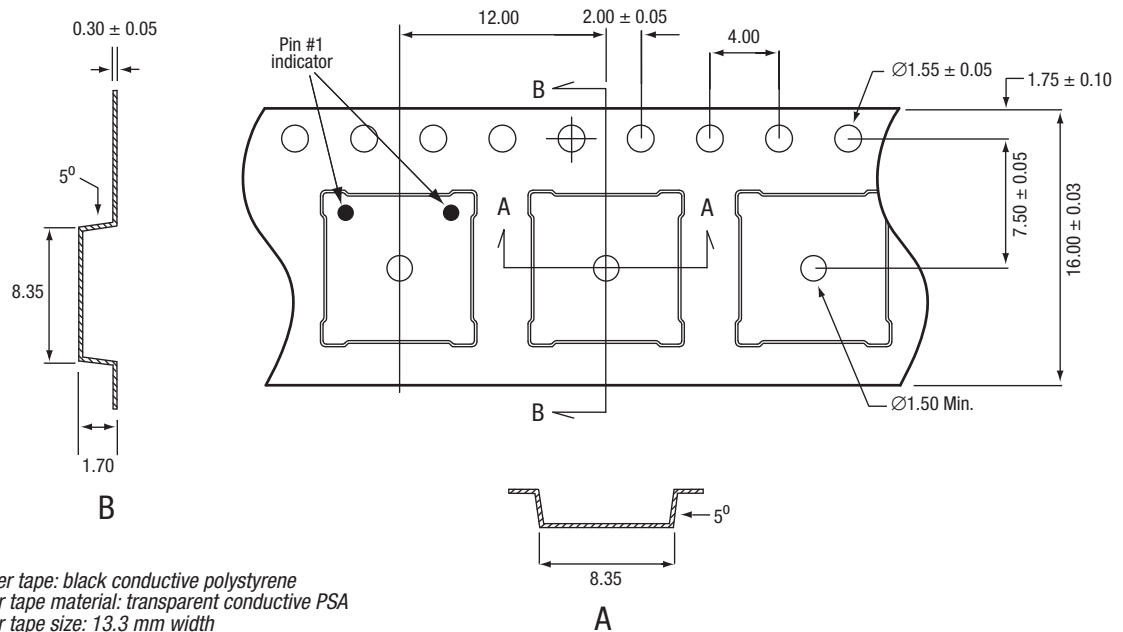
Figure 15. SKY65336-11 PCB Layout Footprint



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

S2649

Figure 16. SKY65336-11 Package Dimensions



Notes:

1. Carrier tape: black conductive polystyrene
2. Cover tape material: transparent conductive PSA
3. Cover tape size: 13.3 mm width
4. All dimensions are in millimeters
5. Pin 1 orientation is in top left corner for the following Skyworks products:

SKY74963-xx  
 CX74063-35  
 SKY77503-xx  
 SKY77506-xx  
 SKY77512-xx  
 SKY77526-xx  
 SKY77343-xx

For all other 8 x 8 mm MCM/RFLGA products, pin 1 orientation is in top right corner.

S1290

Figure 17. SKY65336-11 Tape and Reel Dimensions

## Ordering Information

| Model Name                  | Manufacturing Part Number | Evaluation Board Part Number |
|-----------------------------|---------------------------|------------------------------|
| SKY65336-11 Tx/Rx FEM w/LNA | SKY65336-11               | SKY65336-11-EVB              |

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