# SKY65338: 450-470 MHz Transmit/Receive Front-End Module

## Applications

- Tetra radio
- Remote metering
- GSM
- WLL transmitters

## Features

- Transmit output power > +25 dBm
- High gain in transmit path: 32 dB
- High transmit/receive isolation > 30 dB
- Internal RF match and bias circuits
- All RF ports internally DC blocked
- Single DC supply = +3.6 V
- Small footprint, MCM (12-pin, 8 x 8 mm) Pb-free (MSL3, 260 °C per JEDEC J-STD-020) SMT package

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

## Description

Skyworks SKY65338 is a high-efficiency Front-End Module (FEM) that incorporates a transmit and receive path, and an antenna transmit/receive (T/R) switch.

The transmit path consists of a high efficiency Power Amplifier (PA) followed by an harmonic filter for rejection of harmonic frequencies.

The PA is implemented using Skyworks high reliability Heterojunction Bipolar Transistor (HBT) process and is Class AB biased to provide maximum efficiency with a low spurious output.

A high linearity and high isolation Single-Pole Double-Throw (SPDT) switch is used at the common antenna interface between the transmit and receive paths. The receive path is a low insertion loss through-path with input and output ports internally matched to 50 $\Omega$.

The device is mounted in a 12-pin, 8 x 8 mm Multi-Chip Module (MCM) Surface-Mounted Technology (SMT) package, which allows for a highly manufacturable low-cost solution.

A block diagram of the SKY65338 is shown in Figure 1. The device package and pinout for the 12-pin MCM are shown in Figure 2.
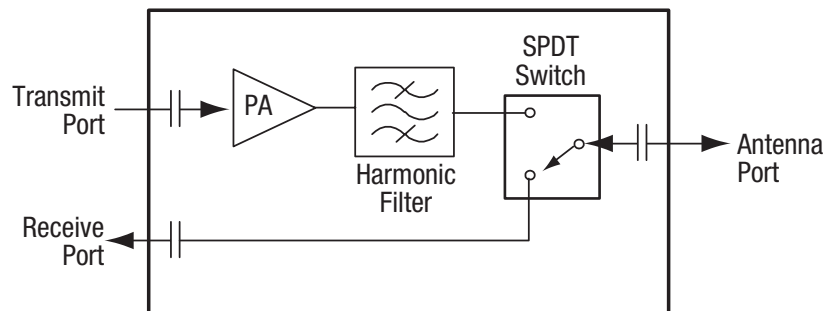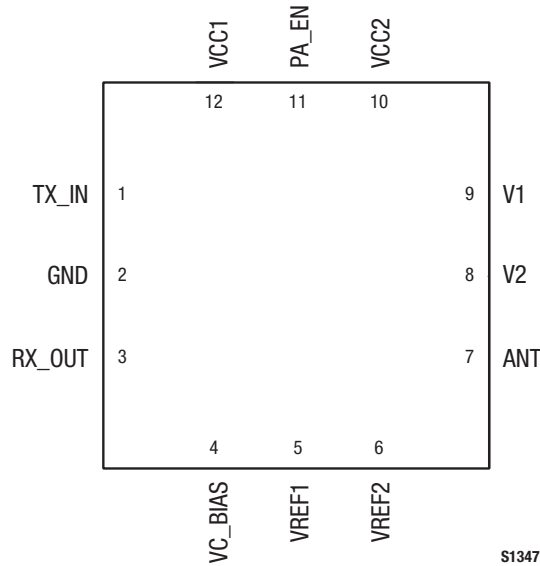


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**Figure 1. SKY65338 Block Diagram**

**Figure 2. SKY65338 Pinout – 12-Pin MCM
(Top View)**

**Table 1. SKY65338 SPDT Switch Control Logic**

| Mode | V1 Signal (Pin 9) | V2 Signal (Pin 8) |
|------|-------------------|-------------------|
| Transmit | 1 | 0 |
| Receive | 0 | 1 |

**Note**:  Logic level 0: 0 V to 0.2 V
Logic level 1: 2.0 V to 5.0 V

## Technical Description

The SKY65338 provides input and output amplifier stages, and is internally matched for optimum efficiency. An active bias circuit provides the input and output stages with excellent gain tracking over temperature and voltage variations. The module operates with positive DC voltages, and maintains high efficiency and good linearity. The nominal operating voltage is 3.6 V for maximum power, but the device can be operated at slightly lower voltages for other mobile applications.

The SKY65338 is internally matched for optimum linearity and efficiency. The input and output stages are independently supplied using the VCC1 and VCC2 supply lines (pins 12 and 10, respectively). The bias reference voltages for stages 1 and 2 are supplied using common lines VREF1 and VREF2 (pins 5 and 6, respectively). The DC control voltage that sets the bias for stages 1 and 2 is supplied by the VC_BIAS signal, pin 4.

### Operational Modes

The module's receive and transmit modes are configured using the V1 and V2 control signals (pins 9 and 8, respectively). The transmit path provides an harmonic filter and high efficiency PA.

The receive path provides a low loss <1 dB bypass between the antenna port and the receive port.

Table 1 provides the SPDT transmit/receive switch control logic.

## Electrical and Mechanical Specifications

Signal pin assignments and functional pin descriptions are described in Table 2. The absolute maximum ratings of the SKY65338 are provided in Table 3. The recommended operating conditions are specified in Table 4 and electrical specifications are provided in Table 5.

Typical performance characteristics of the SKY65338 are illustrated in Figures 3, 4, and 5.

## 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

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related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The SKY65338 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. For packaging details, refer to the Skyworks Application Note, *Tape and Reel*, document number 101568.

**Table 2. SKY65338 Signal Descriptions**

| Pin # | Name | Description | Pin # | Name | Description |
|---|---|---|---|---|---|
| 1 | TX_IN | Transmit RF input | 7 | ANT | Antenna |
| 2 | GND | Ground | 8 | V2 | Switch logic (see Table 1) |
| 3 | RX_OUT | Receive RF output | 9 | V1 | Switch logic (see Table 1) |
| 4 | VC_BIAS | +3.6 V DC supply | 10 | VCC2 | +3.6 V DC supply |
| 5 | VREF1 | +3.6 V DC supply | 11 | PA_EN | PA enable switch (On = 2.5-3.6 V; Off = 0-0.2 V) |
| 6 | VREF2 | +3.6 V DC supply | 12 | VCC1 | +3.6 V DC supply |

**Table 3. SKY65338 Absolute Maximum Ratings (Note 1)**

| Parameter | Symbol | Minimum | Maximum | Units |
|---|---|---|---|---|
| Supply voltage | VCC | | 4.4 | V |
| Input power | $P_{IN}$ | | +5 | dBm |
| Supply current | $I_{CC}$ | | 800 | mA |
| Case operating temperature | $T_C$ | −40 | +85 | °C |
| Storage temperature | $T_{ST}$ | −65 | +125 | °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.

**Table 4. SKY65338 Recommended Operating Conditions**

| Parameter | Symbol | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|
| Supply voltage | VCC1, VCC2, VREF1, VREF2, VC_BIAS | 3.0 | 3.6 | 4.0 | V |
| Case operating temperature | $T_C$ | −40 | | +85 | °C |
| Storage temperature | $T_{ST}$ | −55 | | +125 | °C |

**Table 5. SKY65338 Electrical Specifications**
**(Frequency = 460 MHz, VCC1 = VCC2 = VREF1 = VREF2 = VC_BIAS = 3.6 V, $T_C$ = +25 °C, Unless Otherwise Noted)**

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|---|---|---|---|---|---|---|
| Operating frequency range | f | | 450 | | 470 | MHz |
| Transmit path small signal gain | G | CW, $P_{IN}$ = −30 dBm | 30 | 32 | | dB |
| Transmit saturated output power | $P_{SAT}$ | CW, $P_{IN}$ = −4 dBm | +25 | +27 | | dBm |
| Transmit path Noise Figure | NF | | | 5.5 | 6.5 | dB |
| Transmit path harmonics ($2^{nd}$ to $10^{th}$) | Pf2 to Pf10 | CW, $P_{OUT}$ = +25 dBm | 55 | 59 | | dBc |
| Power Added Efficiency | PAE | CW, $P_{OUT}$ = +27 dBm | 30 | 36 | | % |
| Receive path insertion loss | $R_{X\_LOSS}$ | | | 0.8 | 1.0 | dB |
| Transmit/receive path isolation | $I_{SOL}$ | CW | 27 | 30 | | dB |
| Input return loss | S11 | | 15 | 17 | | dB |
| Output return loss | S22 | | 9 | 12 | | dB |
| | | | | | | |
| Quiescent current | $I_Q$ | No RF | | 50 | 55 | mA |
| Operating current | $I_{OP}$ | $P_{OUT}$ = +25 dBm | | 300 | 350 | mA |
| Leakage current | $I_{LEAK}$ | No RF input, module in standby mode | | 2 | | µA |
| Maximum VSWR for stable operation | $VSWR_{MAX}$ | CW | 6:1 | 8:1 | | − |

## Evaluation Board Description

The SKY65338 Evaluation Board is used to test the performance of the SKY65338 FEM. The Evaluation Board schematic diagram is shown in Figure 6. An assembly drawing for the Evaluation Board is shown in Figure 7 and the layer detail is provided in Figure 8. The layer detail physical characteristics are noted in Figure 9. Table 6 provides the Bill of Materials (BOM) list for Evaluation Board components.

### Circuit Design Considerations

The following design considerations are general in nature and must be followed regardless of final use or configuration:

1. Paths to ground should be made as short as possible.

2. The ground pad of the SKY65338 has special electrical and thermal grounding requirements. This pad is the main thermal conduit for heat dissipation. Since the circuit board acts as the heat sink, it must shunt as much heat as possible from the device. Therefore, design the connection to the ground pad to dissipate the maximum wattage produced by the circuit board. Multiple vias to the grounding layer are required.

*NOTE: A poor connection between the slug and ground increases junction temperature ($T_J$), which reduces the lifetime of the device.*

## Package Dimensions

The phone board layout footprint for the SKY65338 is shown in Figure 10. Package dimensions for the 12-pin MCM are shown in Figure 11, and tape and reel dimensions are provided in Figure 12.

## Electrostatic Discharge (ESD) Sensitivity

The SKY65338 is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.
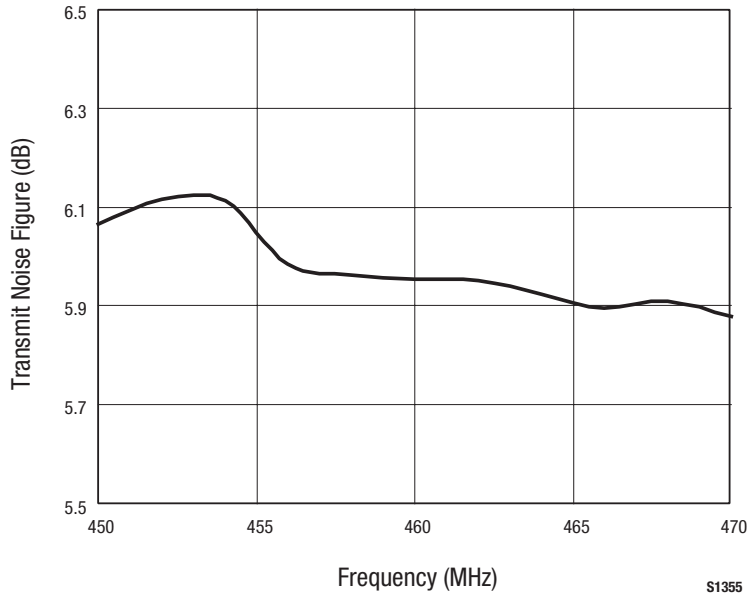
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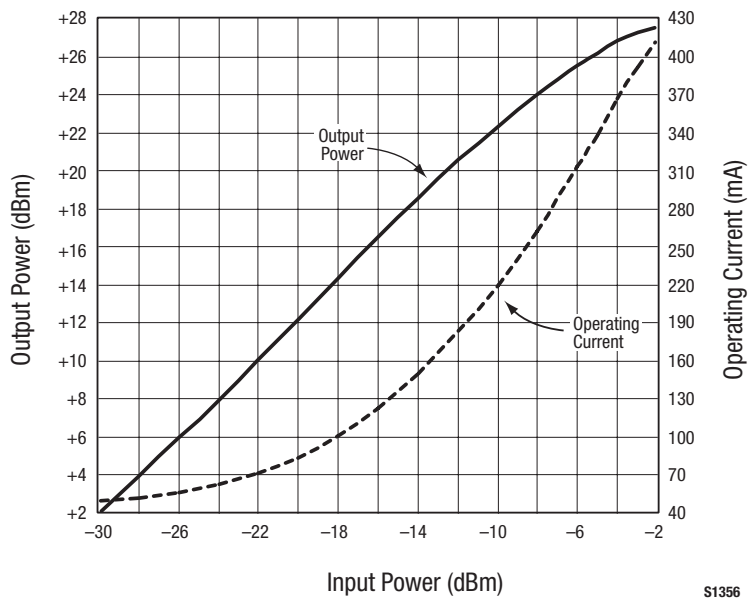**Figure 3. Noise Figure vs Frequency**



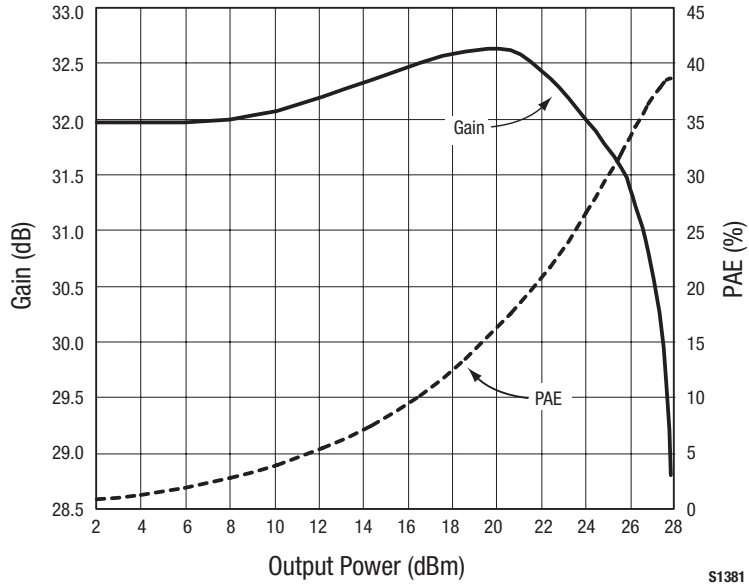**Figure 4. Output Power and Current Consumption vs Input Power**
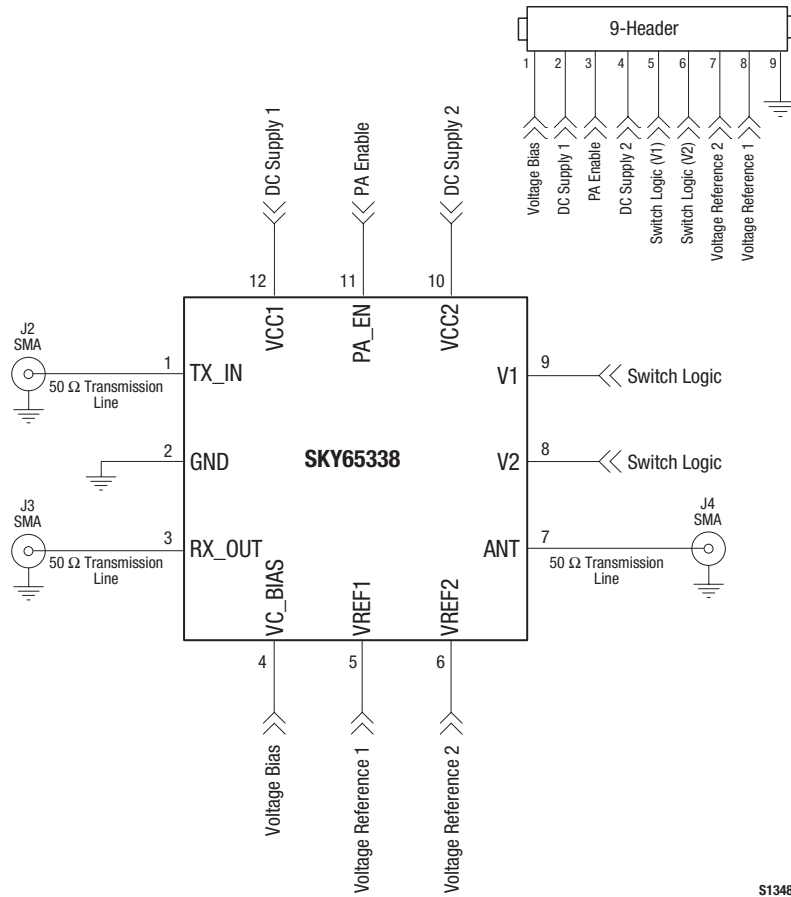
**Figure 5. Gain and PAE vs Output Power**



**Figure 6. SKY65338 Evaluation Board Schematic**
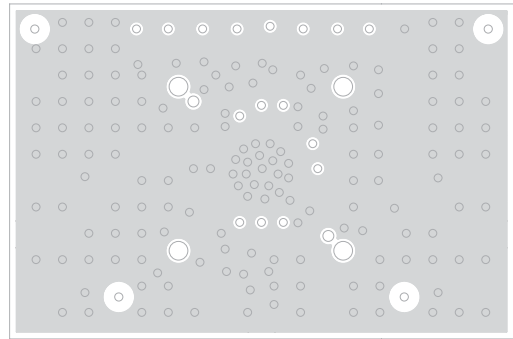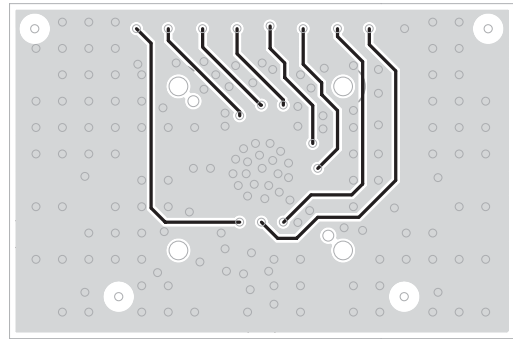
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**Figure 7. SKY65338 Evaluation Board Assembly Drawing**

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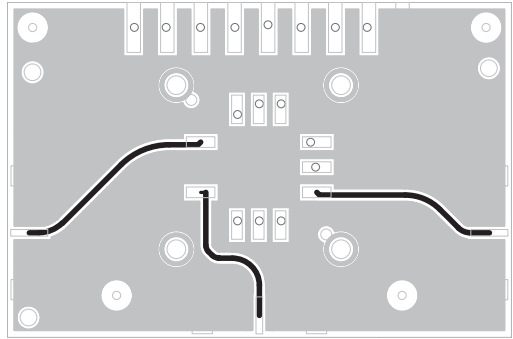
Layer 1: Top – Metal



Layer 2: Ground



Layer 3: Power Plane
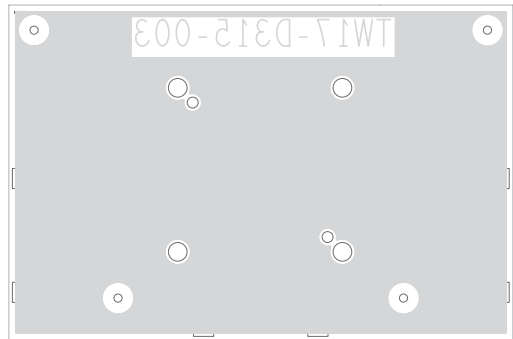


Layer 4: Solid Ground Plane

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**Figure 8. SKY65338 Evaluation Board Layer Detail**

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| Cross Section | Name | Thickness (mm) | Material |
|---|---|---|---|
| | Tmask | 0.010 | Solder Resist |
| | L1 | 0.035 | Cu, 1 oz. |
| | Dielectric | 0.300 | Rogers 4003 |
| | L2 | 0.035 | Cu, 1 oz |
| | Dielectric | 0.100 | FR4 |
| | L3 | 0.035 | Cu, 1 oz |
| | Dielectric | 0.300 | FR4 |
| | L4 | 0.035 | Cu, 1 oz |
| | Bmask | 0.010 | Solder resist |

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**Figure 9. Layer Detail Physical Characteristics**

**Table 6. SKY65338 Evaluation Board Bill of Materials**

| Component | Quantity | Size | Value | Vendor | Part Number |
|---|---|---|---|---|---|
| J2, J3, J4 | 3 | | | | 615R54-021 |
| SC1, SC2, SC3, SC4 | 4 | | | | 92196A052 |
| Backframe | 1 | | | | 1056-101 |

Stencil aperture 60-80% of module/pkg solder mask area

8.685

2X 1.65    12X 0.81

12X 1.043

2X 1.91

8.685

Component Outline

Stencil Aperture
Top View

8.685

6X 0.81

1.65 Typ

Pin 12

11X 1.043

Pin 1

8.685

1.91 Typ

0.25

Thermal Via Array ⌀0.3 mm on 1.0 mm pitch.
Additional vias in common ground pad
will improve thermal performance.
NOTE: It is recommended that thermal vias
should be filled with 30-35 μm Cu plating.

Metallization
Top View

Component Outline

Pin 12

⌀5.080 Solder
Mask Opening

8.785

1.65

12X 1.143

Pin 1

12X 0.91

8.785

1.91 Typ

Component Outline

Solder Mask Opening
Top View

*All measurements are in millimeters*

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**Figure 10. SKY65338 Phone Board Layout Footprint**
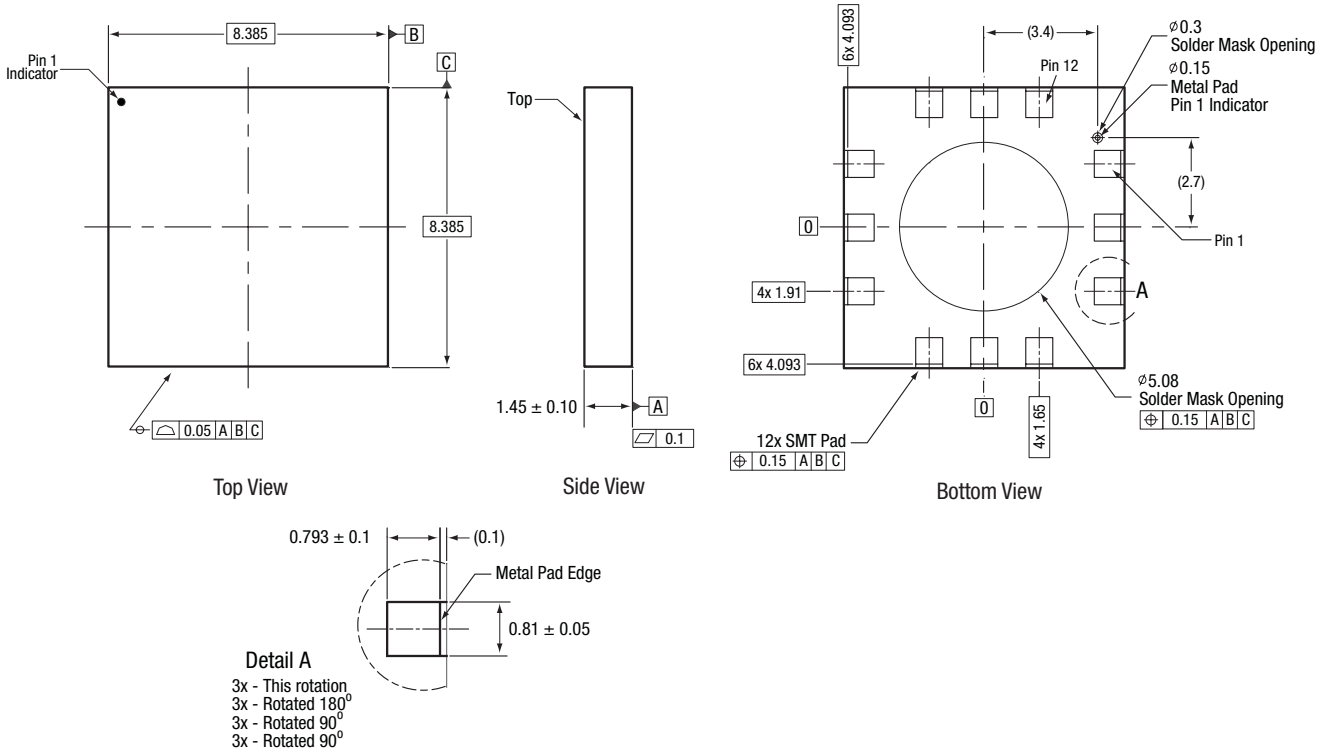
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**Figure 11. SKY65338 12-Pin MCM Package Dimensions**



Notes:
1. Carrier tape: black conductive poly carbonate or polystyrene.
2. Cover tape material: transparent conductive PSA.
3. Cover tape size: 13.3 mm width.
4. All measurements are in millimeters.
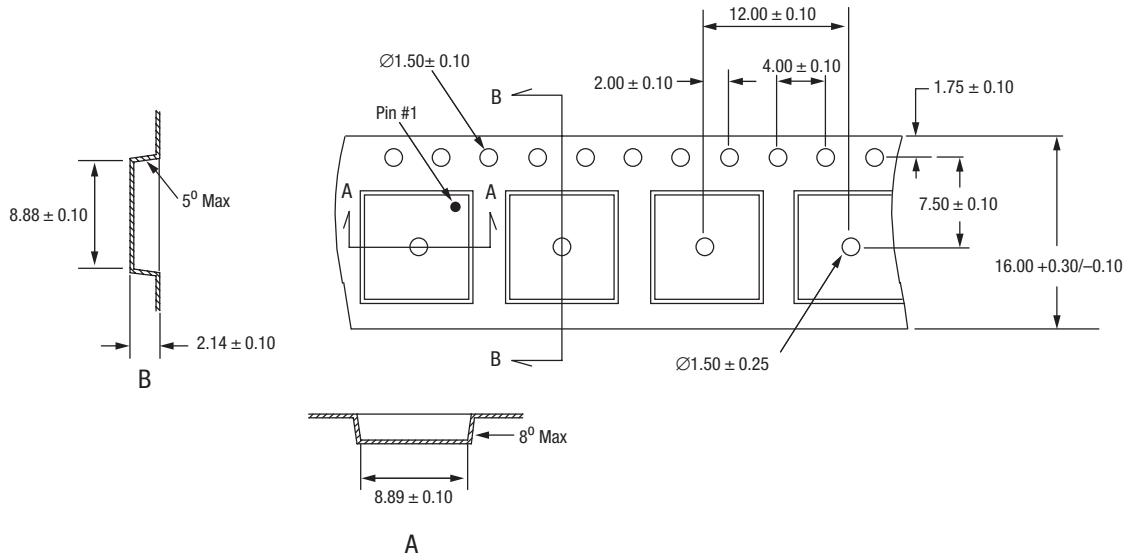
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**Figure 12. SKY65338 12-Pin MCM Tape and Reel Dimensions**

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## Ordering Information

| Model Name | Manufacturing Part Number | Evaluation Kit Part Number |
|---|---|---|
| SKY65338 450-470 MHz Front-End Module | SKY65338 (Pb-free package) | TW17-D315-003 |

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