

DATA SHEET

SKY12355-337LF: 0.35 to 4.0 GHz Two-Bit Digital Attenuator

Applications

- Cellular infrastructure
- Wireless receivers

Features

- Positive voltage operation with integrated decoder
- Broadband operation: 0.35 to 4.0 GHz
- Attenuation: 18 dB with 6 dB LSB
- Low insertion loss: 0.6 dB @ 2 GHz
- Absorptive in 50 Ω systems
- Small QFN (12-pin, 3 x 3 mm) package (MSL1, 260 °C per JEDEC J-STD-020)



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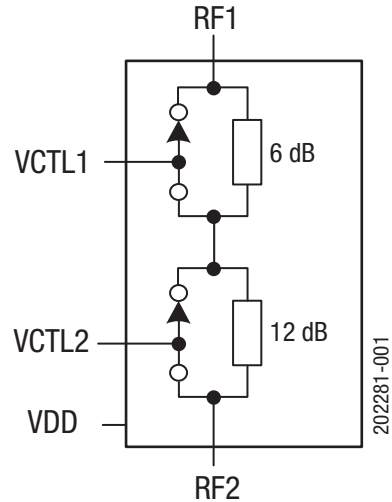


Figure 1. SKY12355-337LF Block Diagram

Description

The SKY12355-337LF is a GaAs pHEMT two-bit digital attenuator I/C. The device is provided in a 3 x 3 mm, 12-pin Quad Flat No-Lead (QFN) package.

The SKY12355-337LF is particularly suited for low-cost commercial applications for which high attenuation accuracy, low insertion loss, and low intermodulation products are required.

A functional block diagram is shown in Figure 1. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.

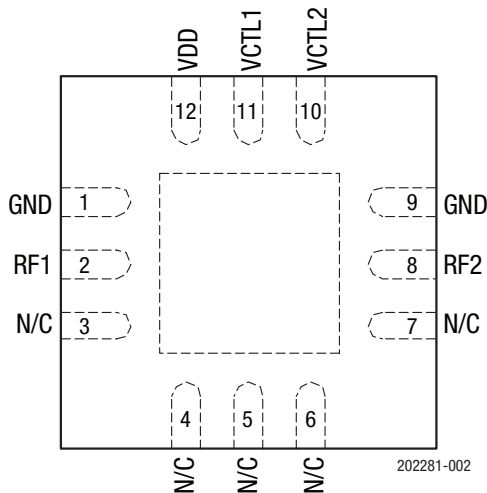


Figure 2. SKY12355-337LF Pinout (Top View)

Table 1. SKY12355-337LF Signal Descriptions¹

| Pin | Name | Description | Pin | Name | Description |
|-----|------|---|-----|-------|---|
| 1 | GND | Ground | 7 | N/C | No connection required. May be connected to ground with no change in performance. |
| 2 | RF1 | RF port. Must be DC blocked. | 8 | RF2 | RF port. Must be DC blocked. |
| 3 | N/C | No connection required. May be connected to ground with no change in performance. | 9 | GND | Ground |
| 4 | N/C | No connection required. May be connected to ground with no change in performance. | 10 | VCTL2 | DC control voltage. Controls 12 dB attenuation state. Refer to Table 4. |
| 5 | N/C | No connection required. May be connected to ground with no change in performance. | 11 | VCTL1 | DC control voltage. Controls 6 dB attenuation state. Refer to Table 4. |
| 6 | N/C | No connection required. May be connected to ground with no change in performance. | 12 | VDD | DC power supply. |

¹ Exposed pad must be grounded.

Functional Description

This attenuator has a least significant bit (LSB) of 6 dB and a most significant bit (MSB) of 12 dB for a total of 18 dB available attenuation. Pins 10 and 11 (VCTL2 and VCTL1) control the state of the 6 dB and 12 dB attenuation bits, respectively. For each bit, a logic high enables the attenuation state while a logic low enables a low insertion loss state.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY12355-337LF are provided in Table 2. Electrical specifications are provided in Table 3.

The state of the SKY12355-337LF is determined by the logic provided in Table 4. The VCTL1 and VCTL2 signals control the 6 dB and 12 dB attenuation bits, respectively. For each bit, a logic high enables the attenuation state, while a logic low enables the insertion loss state.

Typical performance characteristics are illustrated in Figures 3 to 6.

Table 2. SKY12355-337LF Absolute Maximum Ratings¹

| Parameter | Symbol | Minimum | Typical | Maximum | Units |
|--------------------------------|---------------------------------------|---------|---------|-----------------------|-------|
| Supply voltage | V _{DD} | | | 5.5 | V |
| Control voltage | V _{CTL1} , V _{CTL2} | | | V _{DD} + 0.1 | V |
| RF input power @ 3 V | P _{IN} | | | +28 | dBm |
| RF input power: | | | | | |
| T _{CASE} ≤ +85 °C | P _{IN} | | | +28 | dBm |
| T _{CASE} = +105 °C | P _{IN_105C} | | | +21 | dBm |
| Operating temperature | T _{OP} | -40 | | +105 | °C |
| Storage temperature | T _{STG} | -65 | | +150 | °C |
| Junction temperature | T _{JC} | -65 | | +150 | °C |
| Electrostatic discharge: | ESD | | | | |
| Charged-Device Model (Class 4) | | | | 1000 | V |
| Human Body Model (Class 1A) | | | | 250 | V |
| Machine Model (Class A) | | | | 100 | V |

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.

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. SKY12355-337LF Electrical Specifications¹ (1 of 2)

(V_{DD} = 3 V, V_{CTL} = 0 to 3 V, T_{OP} = +25 °C, P_{IN} = 0 dBm, Characteristic Impedance [Z₀] = 50 Ω, C1 and C2 = 1000 pF, Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|---|--------|--------------------|------|---------|------|-------|
| Insertion loss | IL | 350 MHz to 500 MHz | | 0.45 | 0.80 | dB |
| | | 500 MHz to 2 GHz | | 0.65 | 0.80 | dB |
| | | 2 GHz to 3 GHz | | 0.65 | 0.90 | dB |
| | | 3 GHz to 4 GHz | | 0.75 | 1.00 | dB |
| Attenuation accuracy (normalized to insertion loss) | Att | @ 6 dB: | | | | |
| | | 350 MHz to 500 MHz | 5.7 | 6.0 | 6.3 | dB |
| | | 500 MHz to 2 GHz | 5.9 | 6.2 | 6.5 | dB |
| | | 2 GHz to 3 GHz | 6.1 | 6.4 | 6.7 | dB |
| | | 3 GHz to 4 GHz | 6.1 | 6.4 | 6.7 | dB |
| | | @ 12 dB: | | | | |
| | | 350 MHz to 500 MHz | 11.9 | 12.2 | 12.5 | dB |
| | | 500 MHz to 2 GHz | 12.0 | 12.3 | 12.6 | dB |
| | | 2 GHz to 3 GHz | 11.9 | 12.2 | 12.5 | dB |
| | | 3 GHz to 4 GHz | 11.8 | 12.1 | 12.4 | dB |
| | | @ 18 dB: | | | | |
| | | 350 MHz to 500 MHz | 17.9 | 18.3 | 18.7 | dB |
| 500 MHz to 2 GHz | 18.3 | 18.6 | 18.9 | dB | | |
| 2 GHz to 3 GHz | 18.3 | 18.6 | 18.9 | dB | | |
| 3 GHz to 4 GHz | 18.3 | 18.6 | 18.9 | dB | | |

Table 3. SKY12355-337LF Electrical Specifications¹ (2 of 2)

(V_{DD} = 3 V, V_{CTL} = 0 to 3 V, T_{OP} = +25 °C, P_{IN} = 0 dBm, Characteristic Impedance [Z₀] = 50 Ω, C1 and C2 = 1000 pF, Unless Otherwise Noted)

| Parameter | Symbol | Test Condition | Min | Typical | Max | Units |
|--|-----------------|--|-----------------------|---------|-----------------------|-------|
| Return loss | IS11l | 350 to 500 MHz | 10 | 20 | | dB |
| | | 500 MHz to 2 GHz | 14 | 22 | | dB |
| | | 2 GHz to 3 GHz | 12 | 19 | | dB |
| | | 3 GHz to 4 GHz | 12 | 19 | | dB |
| Switching characteristics: Rise/fall time | | 10% RF to 90% RF or 90% RF to 10% RF | | 8 | | ns |
| On/off time | | 50% V _{CTL} to 90% RF or 50% V _{CTL} to 10% RF | | 37 | | ns |
| Attenuation amplitude settling | | 500 ns to 5 ms | | | 0.25 | dB |
| Phase settling (by design) | | 500 ns to 5 ms | -2 | | +2 | deg |
| 1 dB input compression point | IP1dB | V _{CTL} = 3 V, 500 MHz to 4 GHz, insertion state | | +28 | | dBm |
| 0.1 dB input compression point | IPO.1dB | V _{CTL} = 3 V, 500 MHz to 4 GHz, all states | | +19 | | dBm |
| Third order input intercept point | IIP3 | Tone spacing = 20 MHz, power/tone = +18 dBm, V _{DD} = V _{CTL1} = V _{CTL2} = 3.3 V, 500 MHz to 4 GHz: | | | | |
| | | Insertion loss state | +48 | +50 | | dBm |
| | | All attenuation states | +44 | +47 | | dBm |
| Supply voltage | V _{DD} | | 3 | | 5 | V |
| Control voltage | | V _{DD} | 3 | | 5 | V |
| | | V _{CTL} = low | 0 | | 0.3 × V _{DD} | V |
| | | V _{CTL} = high | 0.7 × V _{DD} | | V _{DD} | V |
| Control current | | V _{CTL} = low and V _{CTL} = high | | 10 | | μA |
| Supply current | I _{DD} | | | 20 | 50 | μA |

¹ Performance is guaranteed only under the conditions listed in this table.

Table 4. SKY12355-337LF Truth Table

| State | V _{DD} | V _{CTL1} | V _{CTL2} |
|----------------|-----------------|-------------------|-------------------|
| Insertion loss | High | Low | Low |
| 6 dB | High | High | Low |
| 12 dB | High | Low | High |
| 18 dB | High | High | High |

¹ High = 0.7 × V_{DD} to V_{DD}

Low = 0 to 0.3 × V_{DD}

Any state other than described in this table places the attenuator into an undefined state.

Typical Performance Characteristics

(VDD = 3 V, VCTL = 0 to 3 V, TOP = +25 °C, PIN = 0 dBm, Characteristic Impedance [Zo] = 50 Ω, C1 and C2 = 1000 pF, Unless Otherwise Noted)

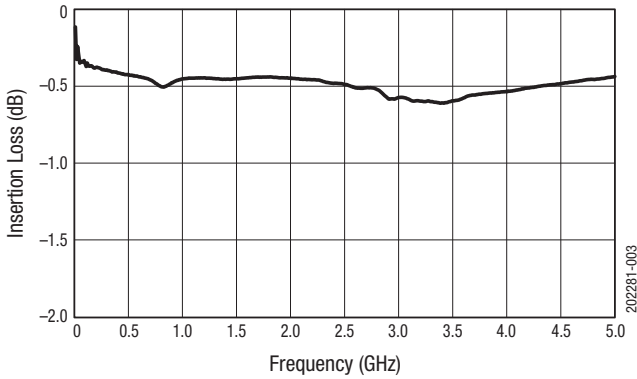


Figure 3. Insertion Loss vs Frequency

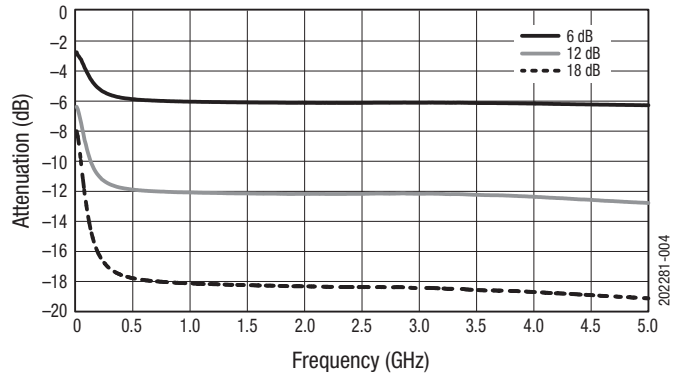


Figure 4. Attenuation vs Frequency (Normalized to Insertion Loss)

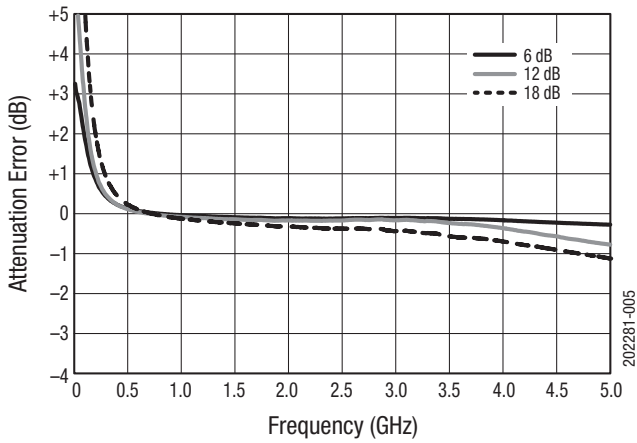


Figure 5. Attenuation Error vs Frequency (Normalized to Insertion Loss)

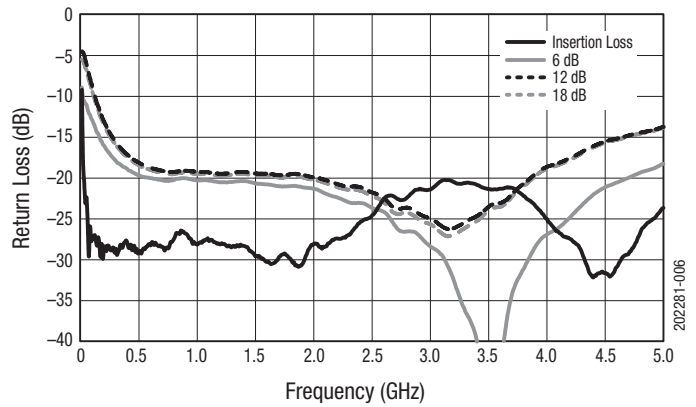


Figure 6. Return Loss vs Frequency

Evaluation Board Description

The SKY12355-337LF Evaluation Board is used to test the performance of the SKY12355-337LF digital attenuator. An Evaluation Board schematic diagram is shown in Figure 7. Table 5 provides the Bill of Materials (BOM) list for Evaluation Board components. An assembly drawing for the Evaluation Board is shown in Figure 8.

Package Dimensions

The PCB layout footprint for the SKY12355-337LF is shown in Figure 9. Typical part markings are noted in Figure 10. Package dimensions are shown in Figure 11, and tape and reel dimensions are provided in Figure 12.

Package and Handling Information

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 SKY12355-337LF is rated to Moisture Sensitivity Level 1 (MSL1) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to the Skyworks Application Note, *Solder Reflow Information*, document number 200164.

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.

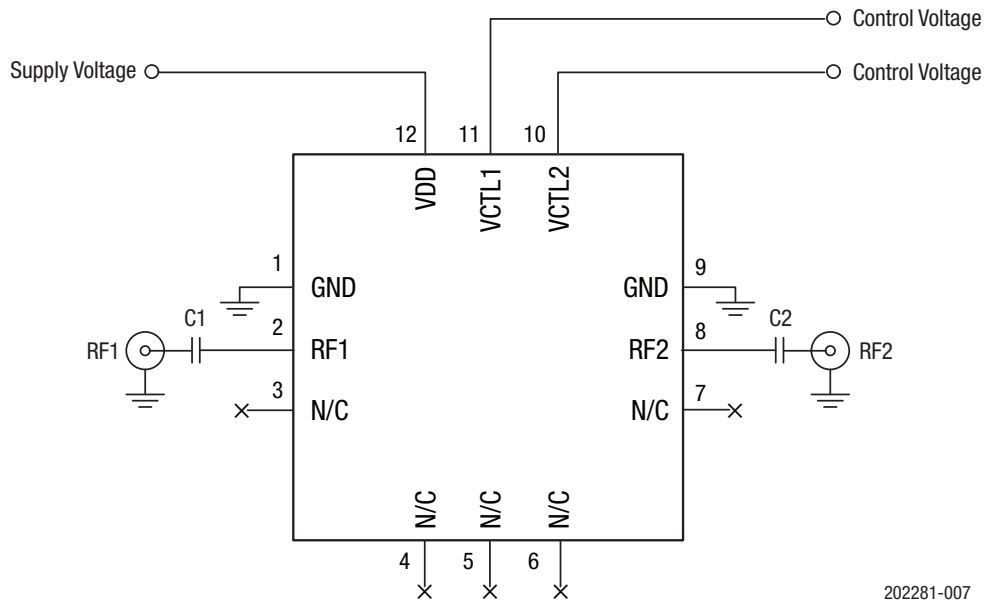


Figure 7. SKY12355-337LF Evaluation Board Schematic Diagram

Table 5. SKY12355-337LF Evaluation Board Bill of Materials¹

| Component | Value | Size | Manufacturer/Part Series |
|-----------|---------|------|--------------------------|
| C1, C2 | 1000 pF | 0402 | Murata GRM Series |

¹ Blocking capacitors are required on both RF ports for proper functionality. Value of DC blocking capacitor determines lower frequency operation.

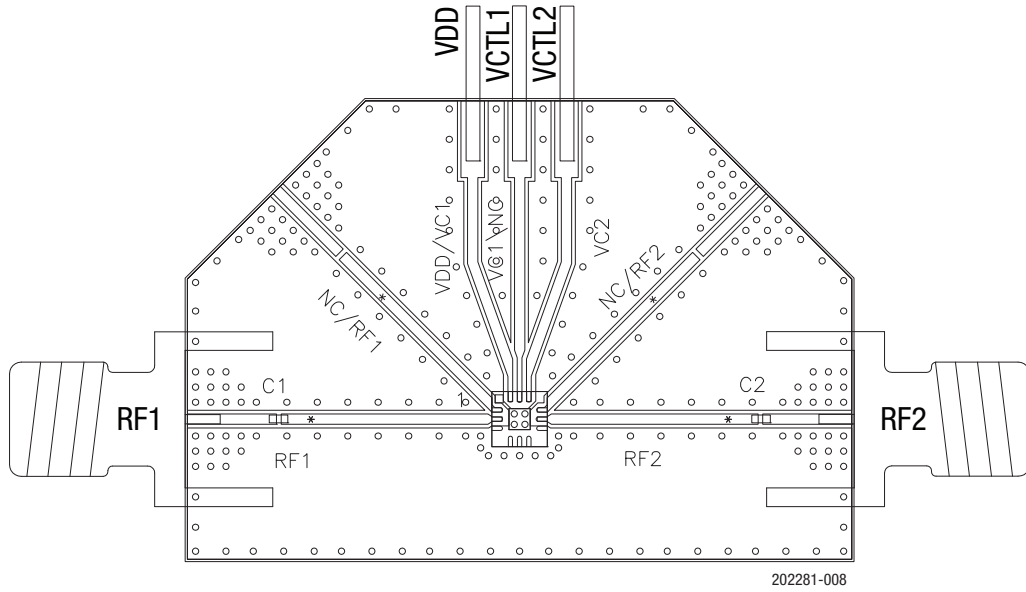
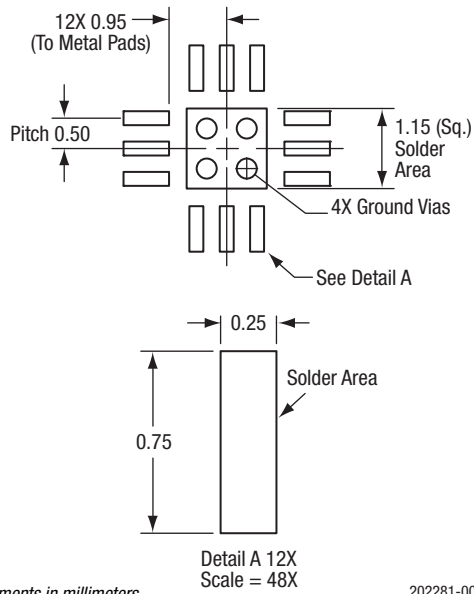


Figure 8. SKY12355-337LF Evaluation Board Assembly Diagram



All measurements in millimeters

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Figure 9. SKY12355-337LF PCB Layout Footprint

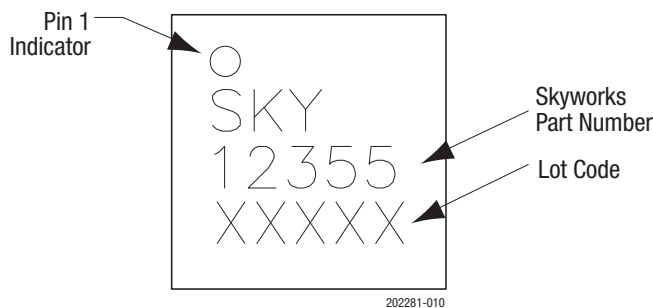
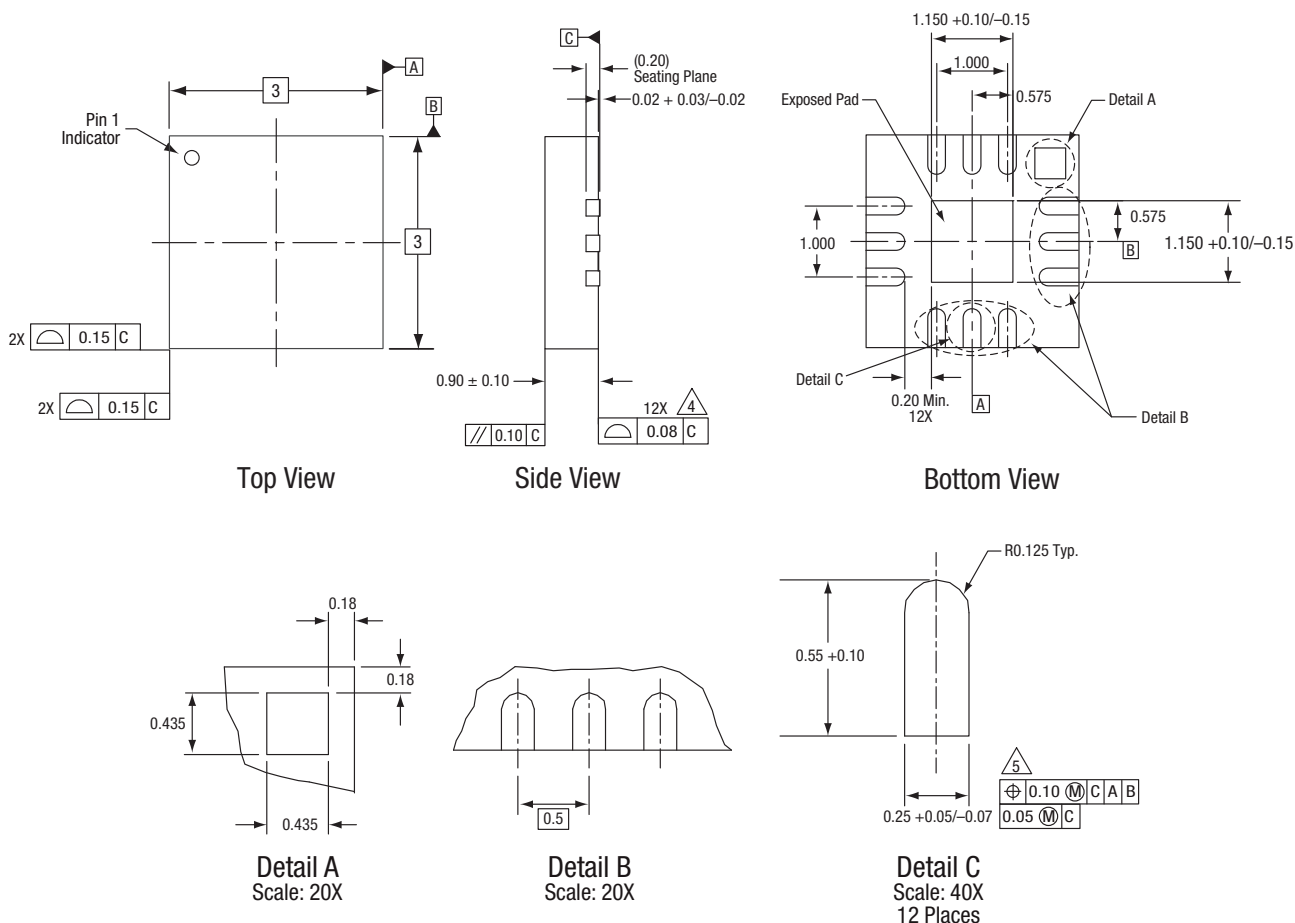


Figure 10. Typical Part Markings

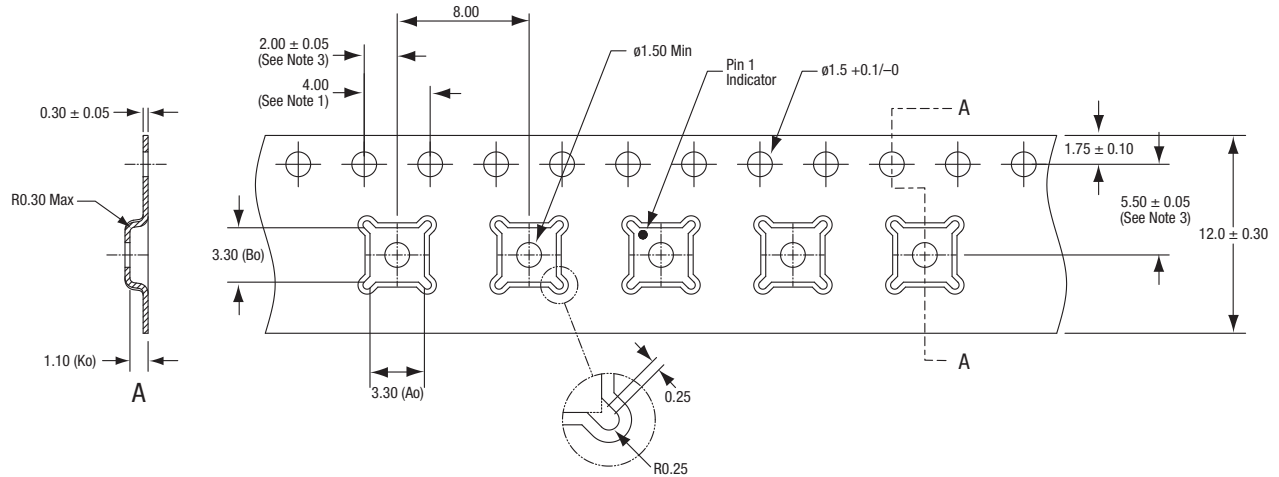


Notes:

1. All measurements are in millimeters.
2. Dimensions and tolerances according to ASME Y14.5M-1994.
3. Unilateral coplanarity applies to the exposed heat sink pad as well as the terminals.
4. Plating requirement per source control drawing (SCD) 2504.
5. Dimension applies to metallized terminal and is measured between 0.15 and 0.30 mm from the terminal tip. Do not measure at radius area.

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Figure 11. SKY12355-337LF Package Dimensions



Notes:

1. Sprocket hole pitch cumulative tolerance: ± 0.2 .
2. Carrier tape: black conductive polystyrene.
3. Pocket position relative to sprocket hole, measure as true position of pocket, not pocket hole.
4. Cover tape material: transparent conductive PSA, 9.30 mm wide.
5. All dimensions are in millimeters.

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Figure 12. SKY12355-337LF Tape and Reel Dimensions

Ordering Information

| Model Name | Manufacturing Part Number | Evaluation Board Part Numbers |
|------------------------------------|---------------------------|-------------------------------|
| SKY12355-337LF: Digital Attenuator | SKY12355-337LF | SKY12355-337LF-EK1 |

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