

Ultra-low Current, Low-Noise Microphone with Analog Output

GENERAL DESCRIPTION

The ICS-40310* is a high-performance MEMS microphone with a combination of very low power consumption, high SNR, and a tiny package. Running from a 1 V supply, the ICS-40310 consumes only 16 μA of current while providing a 64 dB SNR with an analog 4.5 k Ω impedance output. These features, combined with the benefits of MEMS technology, reflow solder compatibility, and a highly stable response over time and temperature, make the ICS-40310 an ideal microphone choice for always-on power-sensitive mobile devices. The ICS-40310 is pin-compatible with the INMP504 and INMP510.

**Protected by U.S. Patents 7,449,356; 7,825,484; 7,885,423; and 7,961,897. Other patents are pending.*

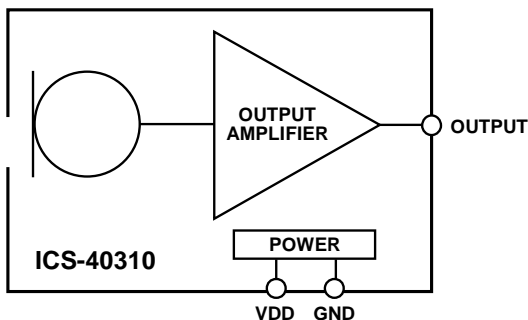
APPLICATIONS

- Dedicated “AlwaysOn” Microphone
- Smartphones
- Wearable Computing Devices
- Tablet Computers
- Bluetooth Headsets

FEATURES

- Low Current Consumption: 16 μA
- Small Surface-Mount Package: 3.35 \times 2.5 \times 0.98 mm
- High SNR of 64 dBA
- Sensitivity of -37 dBV
- 0.9 V to 1.3 V Supply
- Single-Ended Analog Output
- Compatible with Sn/Pb and Pb-Free Solder Processes
- RoHS/WEEE Compliant

FUNCTIONAL BLOCK DIAGRAM



ORDERING INFORMATION

| PART | TEMP RANGE | PACKAGING |
|-----------------|--------------|-------------------|
| ICS-40310 | 0°C to +70°C | 13" Tape and Reel |
| EV_IC3-40310-FX | — | |

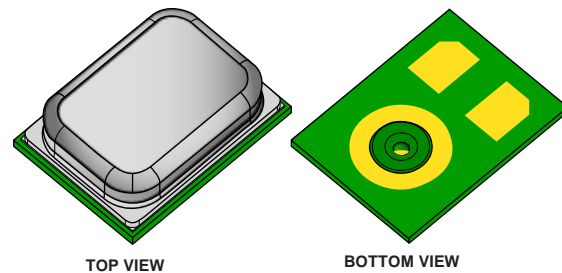


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SPECIFICATIONS

TABLE 1. ELECTRICAL CHARACTERISTICS

(T_A = 0 to 70°C, V_{DD} = 0.9 to 1.3 V, unless otherwise noted. All minimum and maximum specifications are guaranteed across temperature and voltage and are specified in Table 1, unless otherwise noted. Typical specifications are not guaranteed.)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS | NOTES |
|-------------------------------------|--|-----|------|------|---------|-------|
| PERFORMANCE | | | | | | |
| Directionality | | | Omni | | | |
| Sensitivity | 1 kHz, 94 dB SPL | -40 | -37 | -34 | dBV | |
| Signal-to-Noise Ratio (SNR) | 20 Hz to 20 kHz, A-weighted | | 64 | | dB | |
| Equivalent Input Noise (EIN) | 20 Hz to 20 kHz, A-weighted | | 30 | | dBA SPL | |
| Dynamic Range | Derived from EIN and maximum acoustic input | | 82 | | dB | |
| Frequency Response | Low frequency -3 dB point | | 90 | | Hz | 1 |
| | High frequency -3 dB point | | 16 | | kHz | |
| Total Harmonic Distortion (THD) | 105 dB SPL | | 1.3 | 2.5 | % | |
| Power Supply Rejection (PSR) | 217 Hz, 100 mVp-p square wave superimposed on V _{DD} = 1.0 V (A-weighted) | | -81 | | dBV | |
| Power-Supply Rejection Ratio (PSRR) | 1 kHz, 100 mVp-p sine wave superimposed on V _{DD} | | -53 | | dB | |
| Acoustic Overload Point | 10% THD | | 112 | | dB SPL | |
| POWER SUPPLY | | | | | | |
| Supply Voltage (V _{DD}) | | 0.9 | | 1.3 | V | |
| Supply Current (I _S) | V _{DD} = 0.9 V | | 16 | 23 | μA | |
| | V _{DD} = 1.3 V | | 19.5 | 25 | μA | |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Impedance | | 2.9 | 4.5 | 10.5 | kΩ | |
| Output DC Offset Voltage | | 500 | 570 | 650 | mV | |
| Startup Time | Output to within 0.2 dB of final sensitivity | | 0.8 | | sec | |
| Output Current Limit | | | 25 | | μA | |
| Maximum Output Voltage | 112 dB SPL input, RMS | | 112 | | mV | |
| Noise Floor | 20 Hz to 20 kHz, A-weighted, RMS | | -101 | | dBV | |

Note 1: See Figure 3 and Figure 4.

ABSOLUTE MAXIMUM RATINGS

Stress above those listed as Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to the absolute maximum ratings conditions for extended periods may affect device reliability.

TABLE 2. ABSOLUTE MAXIMUM RATINGS

| PARAMETER | RATING |
|-----------------------------|---|
| Supply Voltage (V_{DD}) | -0.3 V to +1.45 V |
| Sound Pressure Level | 160 dB SPL |
| Mechanical Shock | 10,000 <i>g</i> |
| Vibration | Per MIL-STD-883 Method 2007, Test Condition B |
| Temperature Range | |
| Biased | 0°C to +70°C |
| Storage | -55°C to +150°C |

ESD CAUTION



ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

SOLDERING PROFILE

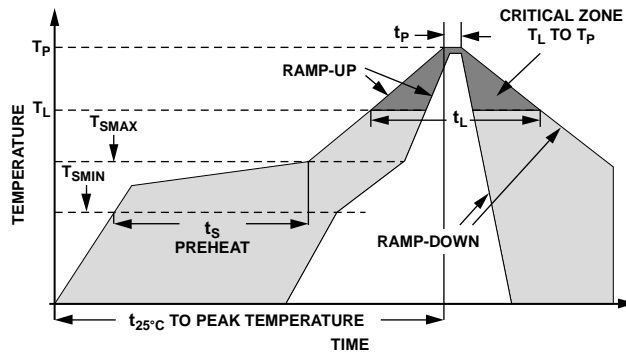


Figure 1. Recommended Soldering Profile Limits

TABLE 3. RECOMMENDED SOLDERING PROFILE*

| PROFILE FEATURE | | Sn63/Pb37 | Pb-Free |
|---|--|------------------|------------------|
| Average Ramp Rate (T_L to T_P) | | 1.25°C/sec max | 1.25°C/sec max |
| Preheat | Minimum Temperature (T_{SMIN}) | 100°C | 100°C |
| | Minimum Temperature (T_{SMIN}) | 150°C | 200°C |
| | Time (T_{SMIN} to T_{SMAX}), t_S | 60 sec to 75 sec | 60 sec to 75 sec |
| Ramp-Up Rate (T_{SMAX} to T_L) | | 1.25°C/sec | 1.25°C/sec |
| Time Maintained Above Liquidous (t_L) | | 45 sec to 75 sec | ~50 sec |
| Liquidous Temperature (T_L) | | 183°C | 217°C |
| Peak Temperature (T_P) | | 215°C +3°C/-3°C | 260°C +0°C/-5°C |
| Time Within +5°C of Actual Peak Temperature (t_P) | | 20 sec to 30 sec | 20 sec to 30 sec |
| Ramp-Down Rate | | 3°C/sec max | 3°C/sec max |
| Time +25°C ($t_{25^\circ\text{C}}$) to Peak Temperature | | 5 min max | 5 min max |

*The reflow profile in Table 3 is recommended for board manufacturing with InvenSense MEMS microphones. All microphones are also compatible with the J-STD-020 profile.

PIN CONFIGURATIONS AND FUNCTION DESCRIPTIONS

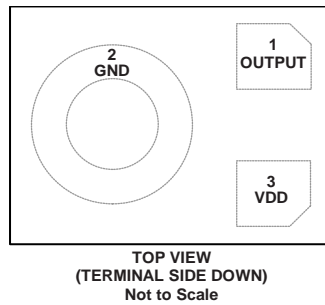


Figure 2. Pin Configuration

TABLE 4. PIN FUNCTION DESCRIPTIONS

| PIN | NAME | FUNCTION |
|-----|--------|---|
| 1 | OUTPUT | Analog Output Signal |
| 2 | GND | Ground |
| 3 | VDD | Power Supply. Bypass to GND with a 0.1 μ F capacitor. |

TYPICAL PERFORMANCE CHARACTERISTICS

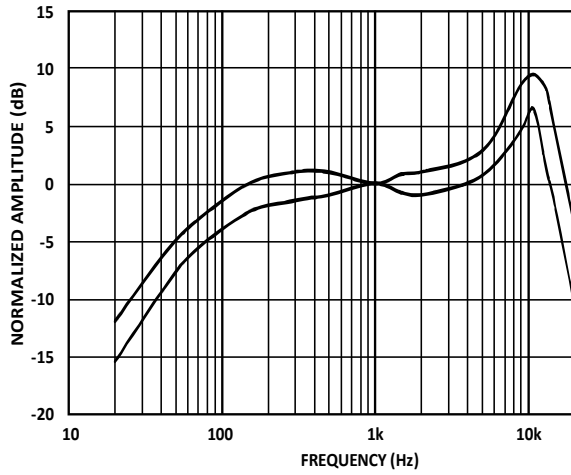


Figure 3. Frequency Response Mask

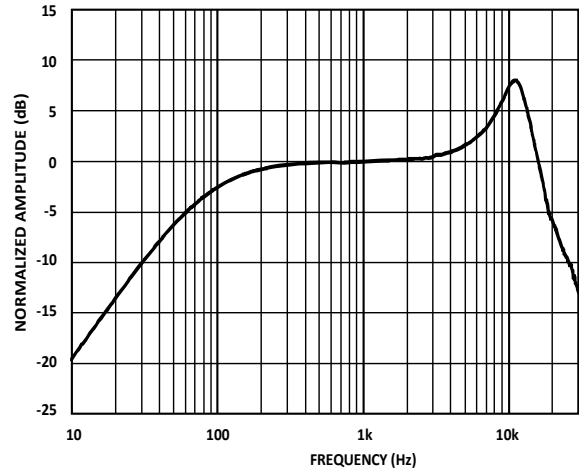


Figure 4. Typical Frequency Response (Measured)

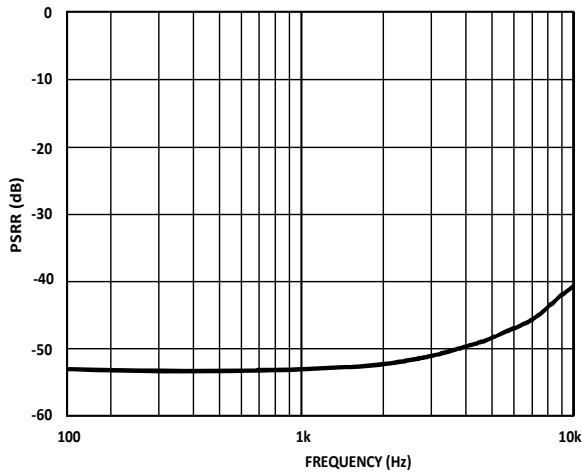


Figure 5. Power-Supply Rejection Ratio (PSRR) vs. Frequency

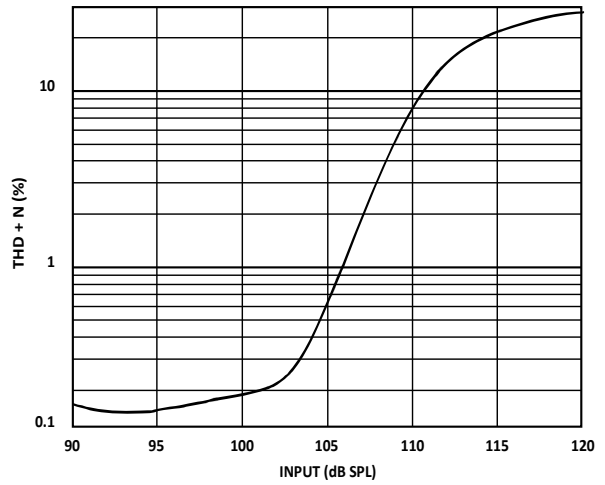


Figure 6. THD + N vs. Input Level

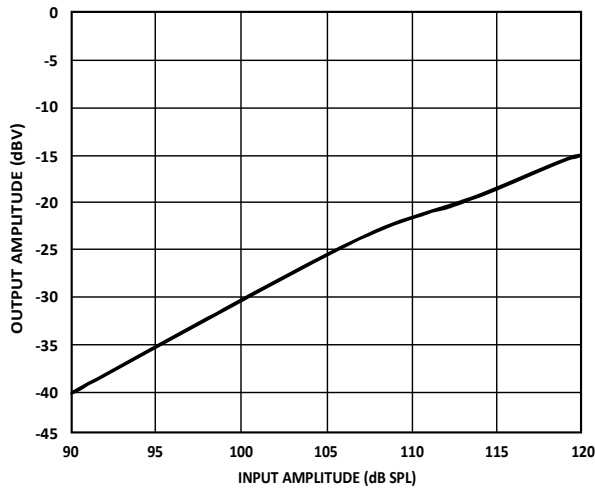


Figure 7. Linearity

APPLICATIONS INFORMATION

OUTPUT IMPEDANCE CONSIDERATION

The ICS-40310 has an output impedance of 4.5 kΩ, which is significantly higher than the impedance of many other MEMS microphones. This higher output impedance enables the microphone to operate with a very low supply current, but also needs to be considered in the design of the signal chain following the microphone. The input impedance of the device to which the microphone’s output is connected should be much higher than 4.5 kΩ to ensure no loss of signal amplitude through the signal chain. A minimum input impedance of 47 kΩ is recommended for the device connected to the ICS-40310’s output. An input with this impedance will reduce the microphone’s output signal level by only 0.8 dB.

CODEC AND AMPLIFIER CONNECTIONS

The ICS-40310 output can be connected to a dedicated codec microphone input (see Figure 8), or to a high input impedance gain stage (see Figure 9). A 0.1 μF ceramic capacitor placed close to the ICS-40310 supply pin is used for testing and is recommended to adequately decouple the microphone from noise on the power supply. An AC-coupling capacitor is required at the output of the microphone. This capacitor creates a high-pass filter with a corner frequency at

$$f_c = 1/(2\pi \times C \times R)$$

where *R* is the input impedance of the codec or amplifier.

A codec input connected to the ICS-40310’s output should be high impedance, as described above in the Output Impedance Consideration section. The size of the AC-coupling capacitor should be chosen such that the high-pass filter that it forms at the codec’s input does not affect the microphone’s low frequency performance. For high-impedance (>47 kΩ) inputs, a 100 nF or larger AC-coupling capacitor will be sufficient. See Figure 8 for a schematic of this connection.

Figure 9 shows the ICS-40310 connected to an op amp configured as a noninverting preamplifier.

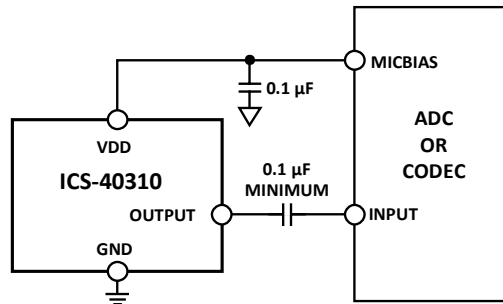


Figure 8. ICS-40310 Connected to an ADC or Codec

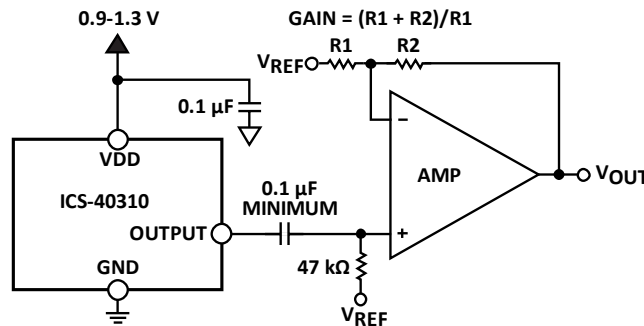


Figure 9. ICS-40310 Connected to an Op Amp

SUPPORTING DOCUMENTS

For additional information, see the following documents.

EVALUATION BOARD USER GUIDE

UG-325, *Analog Output MEMS Microphone Flex Evaluation Board*

APPLICATION NOTES

AN-1003, *Recommendations for Mounting and Connecting the InvenSense Bottom-Ported MEMS Microphones*

AN-1068, *Reflow Soldering of the MEMS Microphone*

AN-1112, *Microphone Specifications Explained*

AN-1124, *Recommendations for Sealing InvenSense Bottom-Port MEMS Microphones from Dust and Liquid Ingress*

AN-1140, *Microphone Array Beamforming*

AN-1165, *Op Amps for Microphone Preamp Circuits*

AN-1181, *Using a MEMS Microphone in a 2-Wire Microphone Circuit*

PCB DESIGN AND LAND PATTERN LAYOUT

It is recommended that the PCB land pattern for the ICS-40310 be laid out to a 1:1 ratio to the solder pads on the microphone package, as shown in Figure 10. Take care to avoid applying solder paste to the sound hole in the PCB. A suggested solder paste stencil pattern layout is shown in Figure 11. The diameter of the sound hole in the PCB should be larger than the diameter of the sound port of the microphone. A minimum diameter of 0.5 mm is recommended.

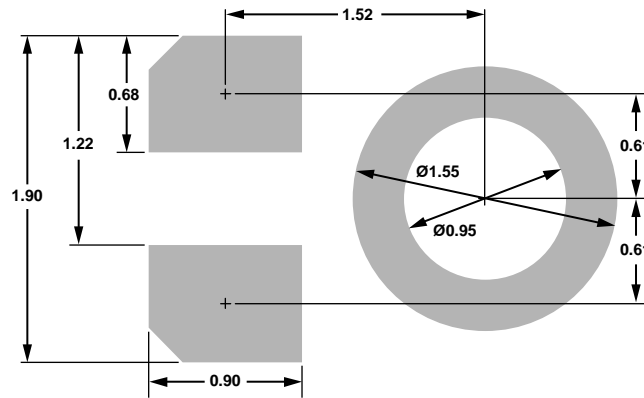


Figure 10. PCB Land Pattern Layout (Dimensions shown in millimeters)

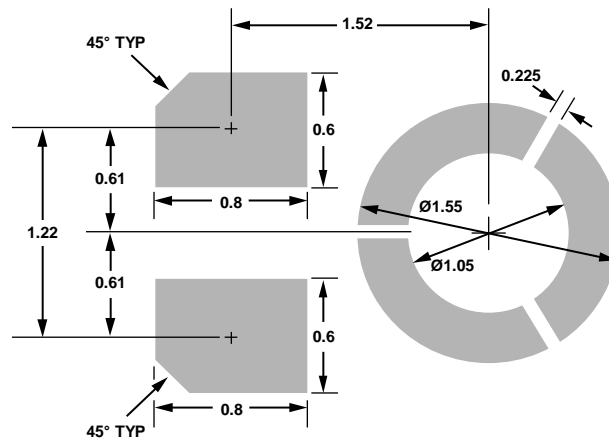


Figure 11. Suggested Solder Paste Stencil Pattern Layout (Dimensions shown in millimeters)

PCB MATERIAL AND THICKNESS

The performance of the ICS-40130 is not affected by PCB thickness. The ICS-40310 can be mounted on either a rigid or flexible PCB. A flexible PCB with the microphone can be attached directly to the device housing with an adhesive layer. This mounting method offers a reliable seal around the sound port while providing the shortest acoustic path for good sound quality.

HANDLING INSTRUCTIONS

PICK AND PLACE EQUIPMENT

The MEMS microphone can be handled using standard pick-and-place and chip shooting equipment. Take care to avoid damage to the MEMS microphone structure as follows:

- Use a standard pickup tool to handle the microphone. Because the microphone hole is on the bottom of the package, the pickup tool can make contact with any part of the lid surface.
- Do not pick up the microphone with a vacuum tool that makes contact with the bottom side of the microphone. Do not pull air out of or blow air into the microphone port.
- Do not use excessive force to place the microphone on the PCB.

REFLOW SOLDER

For best results, the soldering profile must be in accordance with the recommendations of the manufacturer of the solder paste used to attach the MEMS microphone to the PCB. It is recommended that the solder reflow profile not exceed the limit conditions specified in Figure 1 and Table 3.

BOARD WASH

When washing the PCB, ensure that water does not make contact with the microphone port. Do not use blow-off procedures or ultrasonic cleaning.

OUTLINE DIMENSIONS

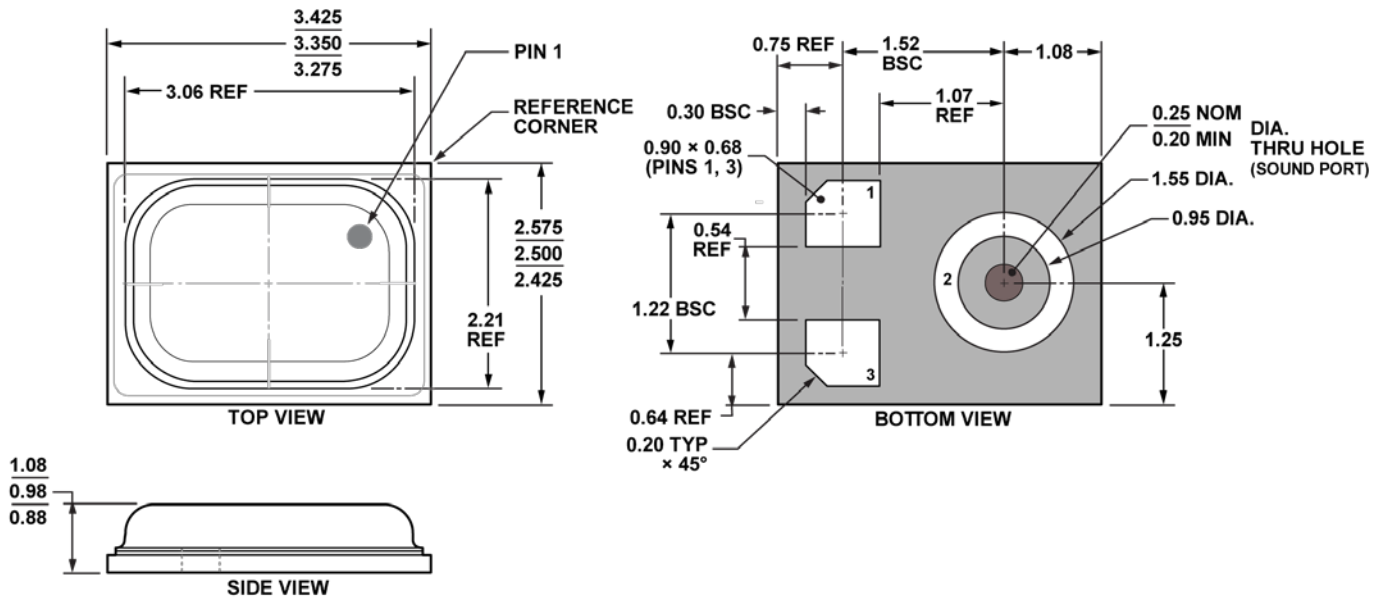


Figure 12. 3-Terminal Chip Array Small Outline No Lead Cavity
 3.35 mm × 2.5 mm × 0.98 mm Body
 Dimensions shown in millimeters

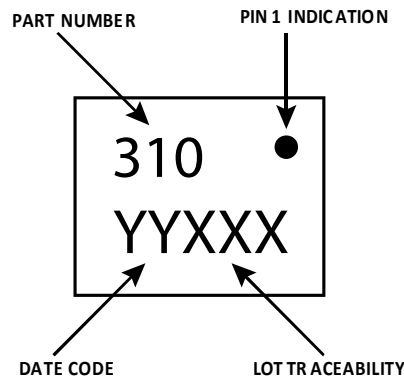


Figure 13. Package Marking Specification (Top View)

ORDERING GUIDE

| PART | TEMP RANGE | PACKAGE | QUANTITY | PACKAGING |
|-----------------|-------------------|-----------------------|-----------------|-------------------|
| ICS-40310 | 0°C to +70°C | 3-Terminal LGA_CAV | 10,000 | 13" Tape and Reel |
| EV_ICs-40310-FX | | Flex Evaluation Board | | |

REVISION HISTORY

| REVISION DATE | REVISION | DESCRIPTION |
|----------------------|-----------------|-------------------------|
| 05/15/2014 | 1.0 | Initial Release |
| 06/04/2014 | 1.1 | Replaced Figure 12 |
| 10/27/2014 | 1.2 | Updated Package Drawing |

COMPLIANCE DECLARATION DISCLAIMER

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