# ICS-40800

## Ultra-Low Noise Directional MEMS Microphone

## GENERAL DESCRIPTION

The ICS-40800 is an ultra-low noise, analog output, dual-ported MEMS microphone. The ICS-40800 includes a MEMS microphone element, an impedance converter, and an output amplifier.

The ICS-40800 is constructed from two sound ports, located on the bottom and top of the assembly. The dual port arrangement allows for the microphone to exhibit variable sensitivity to sound based on angle of arrival. The top port can also be sealed off resulting in a omni-directional sensitivity to sound.

The ICS-40800's 70 dB SNR and ±1 dB sensitivity tolerance make it an excellent choice for far field voice control and speech applications.

The ICS-40800 is available in a small 4.00 mm × 3.00 mm × 1.20 mm surface-mount package.

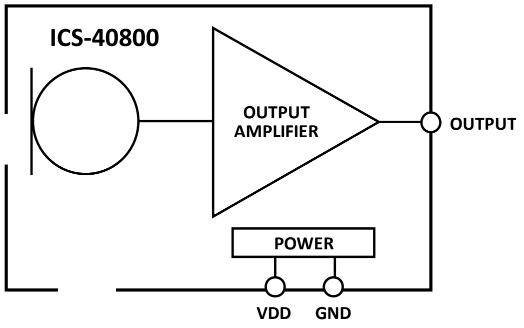
## APPLICATIONS

- Tablet Computers
- Teleconferencing Systems
- Digital Still and Video Cameras
- Communication Headsets
- Security and Surveillance
- Microphone Arrays
- Voice Control and Activation

## FEATURES

- Ultra-High 70 dBA SNR
- −38 dBV Sensitivity
- ±1 dB Sensitivity Tolerance
- Small 4 × 3 × 1.2 mm Surface-Mount Package
- Inverted Signal Output
- Extended Frequency Response from 80 Hz to 20 kHz
- 155 µA Current Consumption
- 128 dB SPL Acoustic Overload Point
- −86 dBV PSR
- Compatible with Sn/Pb and Pb-Free Solder Processes
- RoHS/WEEE Compliant

## FUNCTIONAL BLOCK DIAGRAM



## ORDERING INFORMATION

| PART | TEMP RANGE | PACKAGING |
|---|---|---|
| **ICS-40800** | −40°C to +85°C | 13” Tape and Reel |
| **EV_ICS-40800-FX** | — | — |

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# *SPECIFICATIONS*

## TABLE 1. ELECTRICAL CHARACTERISTICS

$T_A$ = 25°C, $V_{DD}$ = 1.62 to 3.63 V, omnidirectional configuration – top hole sealed, unless otherwise noted. Typical specifications are not guaranteed.

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS | NOTES |
|---|---|---|---|---|---|---|
| **PERFORMANCE** | | | | | | |
| Output Polarity | | Inverted | | | | |
| Sensitivity | 1 kHz, 94 dB SPL | −39 | −38 | −37 | dBV | |
| Signal-to-Noise Ratio (SNR) | 20 Hz to 20 kHz, A-weighted | | 70 | | dBA | |
| Equivalent Input Noise (EIN) | 20 Hz to 20 kHz, A-weighted | | 24 | | dBA SPL | |
| Dynamic Range | Derived from EIN and maximum acoustic input | | 104 | | dB | |
| Frequency Response | Low frequency −3 dB point | | 80 | | Hz | 1 |
| | High frequency −3 dB point | | >20 | | kHz | |
| Total Harmonic Distortion (THD) | 105 dB SPL | | | 0.6 | % | |
| Power-Supply Rejection (PSR) | 217 Hz, 100 mVp-p square wave superimposed on $V_{DD}$ = 1.8 V, A-weighted | | −86 | | dBV | |
| Power Supply Rejection Ratio (PSRR) | 1 kHz, 100 mV p-p sine wave superimposed on $V_{DD}$ = 1.8 V | | −55 | | dB | |
| Acoustic Overload Point | 10% THD | | 128 | | dB SPL | |
| **POWER SUPPLY** | | | | | | |
| Supply Voltage ($V_{DD}$) | | 1.62 | | 3.63 | V | |
| Supply Current ($I_S$) | | | | | | |
| | $V_{DD}$ = 1.8 V | | 155 | | µA | |
| | $V_{DD}$ = 2.75 V | | 155 | | µA | |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| Output Impedance | | | 338 | | Ω | |
| Maximum Output Voltage | 128 dB SPL input | | 0.531 | | V rms | |
| Noise Floor | 20 Hz to 20 kHz, A-weighted, rms | | -108 | | dBV | |

**Note 1:** See Figure 3.

# 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 +3.63 V |
| Mechanical Shock | 10,000 *g* |
| Vibration | Per MIL-STD-883 Method 2007, Test Condition B |
| Temperature Range | |
| Biased | −40°C to +85°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

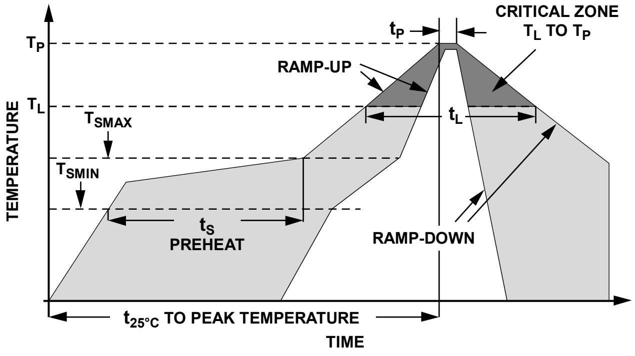


**Figure 1. Recommended Soldering Profile Limits**

## 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 ($T_{SMAX}$) | 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 ($t_{25°C}$) to Peak Temperature | | 5 min max | 5 min max |

***Note:** 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

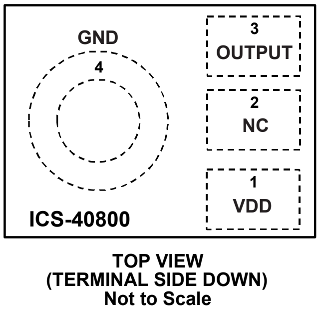


**Figure 2. Pin Configuration**

### TABLE 4. PIN FUNCTION DESCRIPTIONS

| PIN | NAME | FUNCTION |
|---|---|---|
| 1 | VDD | Power Supply |
| 2 | NC | No Connect – Leave pin floating |
| 3 | OUTPUT | Analog Output Signal |
| 4 | GND | Ground |

## TYPICAL PERFORMANCE CHARACTERISTICS (OMNIDIRECTIONAL)

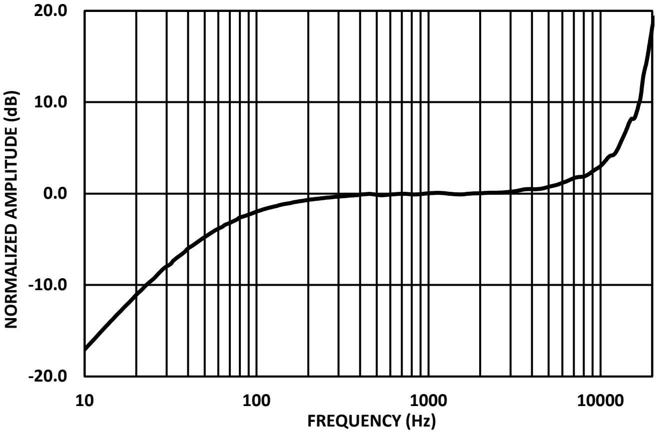


Figure 3. Typical Omnidirectional Frequency Response (Measured)

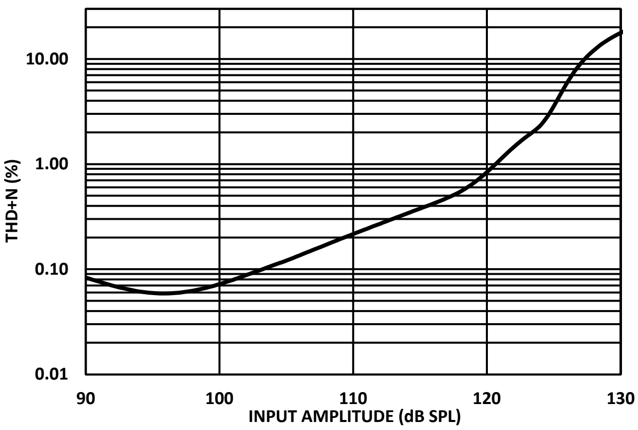


Figure 4. THD + N vs. Input Level

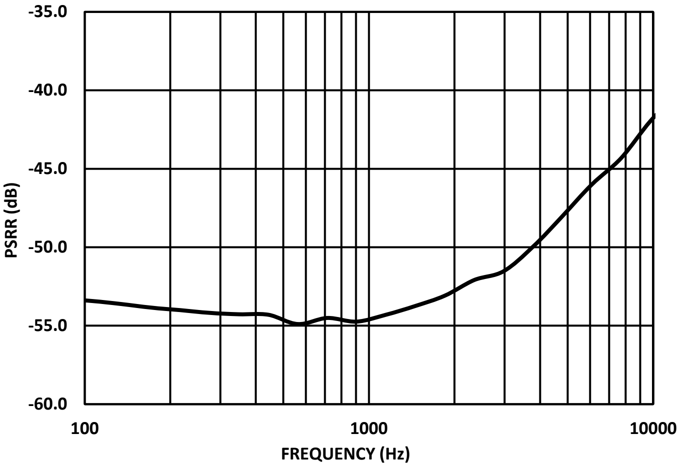


Figure 5. Power-Supply Rejection Ratio (PSRR) vs. Frequency

## TYPICAL PERFORMANCE CHARACTERISTICS (DIRECTIONAL)

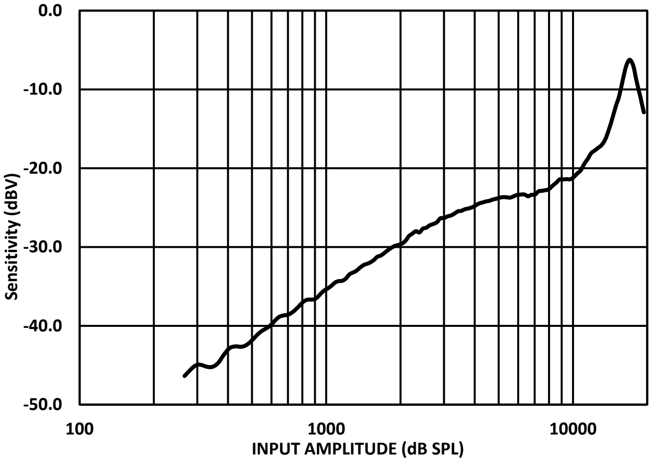


**Figure 6. On-axis (0° Normalized) Uncompensated Sensitivity vs. Frequency***

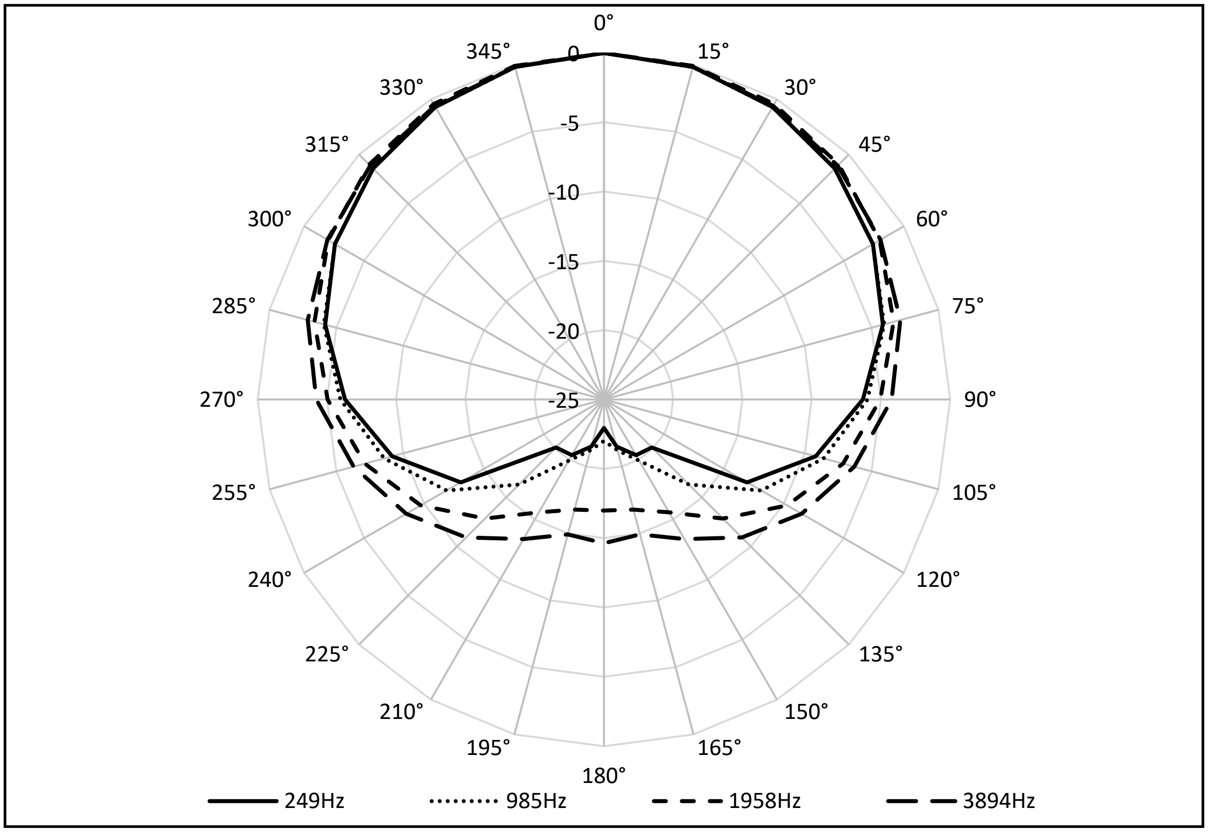


**Figure 7. On-axis (0° Normalized) Polar Response***

*Figures 6 and 7 refer to data from our specific reference design detailed in Application Note AN-000172. Actual results are heavily dependent on system level mechanical design as mentioned in the application note.

# APPLICATIONS INFORMATION

## CODEC CONNECTION

The ICS-40800 output can be connected to a dedicated codec microphone input (see Figure 8) or to a high input impedance gain stage. A 0.1 µF ceramic capacitor placed close to the ICS-40800 supply pin is used for testing and is recommended to adequately decouple the microphone from noise on the power supply. DC blocking capacitors are required at the outputs of the microphone. These capacitors create 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.

A minimum value of 2.2 µF is recommended in Figure 8 because the input impedance of some codecs can be as low as 2 kΩ at their highest PGA gain setting, which results in a high-pass filter corner frequency at 37 Hz.

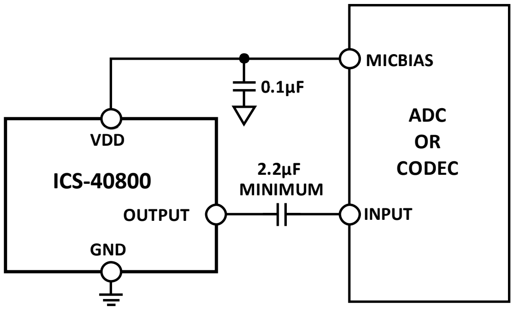


Figure 8. ICS-40800 Connected to a Codec

# SUPPORTING DOCUMENTS

For additional information, see the following documents.

## EVALUATION BOARD USER GUIDE

AN-000013, Analog Output MEMS Microphone Flex Evaluation Board User Guide

## APPLICATION NOTES

AN-100, *MEMS Microphone Handling and Assembly Guide*
AN-1003, *Recommendations for Mounting and Connecting the InvenSense Bottom-Ported MEMS Microphones*
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*
AN-000172, *Using MEMS Microphones in Directional Applications*

## PCB DESIGN AND LAND PATTERN LAYOUT

Lay out the PCB land pattern for the ICS-40800 at a 1:1 ratio to the solder pads on the microphone package (see Figure 9.) Take care to avoid applying solder paste to the sound hole in the PCB. Figure 10 shows a suggested solder paste stencil pattern layout.
The response of the ICS-40800 is not affected by the PCB hole size, as long as the hole is not smaller than the sound port of the microphone (0.75 mm, or 0.0295 inch, in diameter). A 1 mm (0.040 inch) diameter for the hole is recommended.

Align the hole in the microphone package with the hole in the PCB. The exact degree of the alignment does not affect the performance of the microphone as long as the holes are not partially or completely blocked.

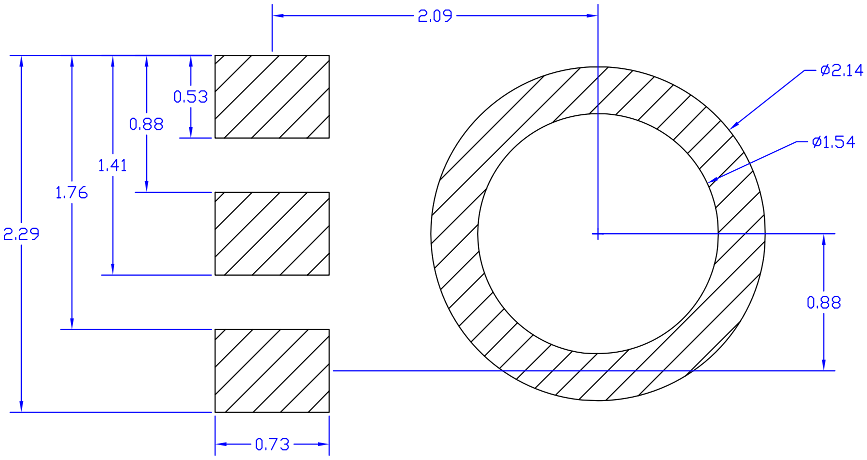
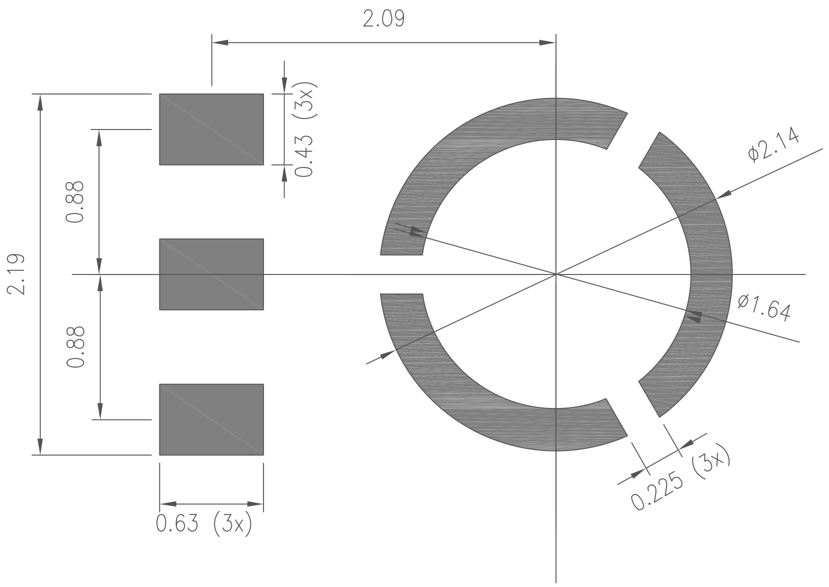


Figure 9. Suggested PCB Land Pattern Layout



Note : All units in mm

Figure 10. Suggested Solder Paste Stencil Pattern Layout

### PCB MATERIAL AND THICKNESS

The performance of the ICS-40800 is not affected by PCB thickness. The ICS-40800 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 top of the package, the pickup tool should not be placed over the microphone port.
- 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.

## TOP PORT TAPE REMOVAL

The ICS-40800 comes with a heat resistant pressure sensitive polyimide tape covering the top port to prevent particle contaminants during assembly and reflow.  The cover tape can be removed with tweezers or adhesive tape.

## OUTLINE DIMENSIONS

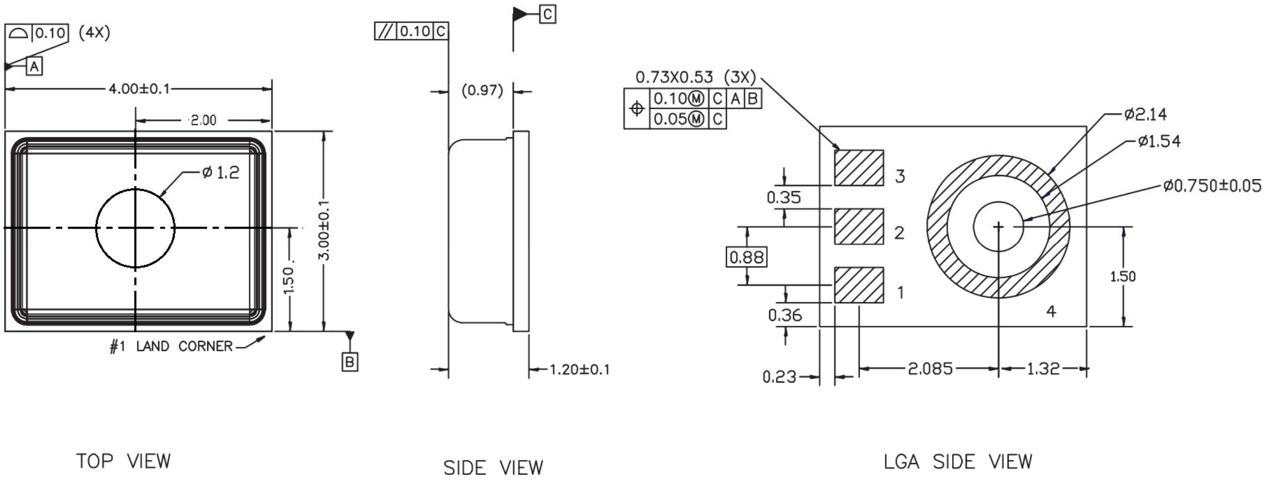


**Figure 11. 4-Terminal Chip Array Small Outline No Lead Cavity**
**4 mm × 3 mm × 1.2 mm**
**Dimensions shown in millimeters**

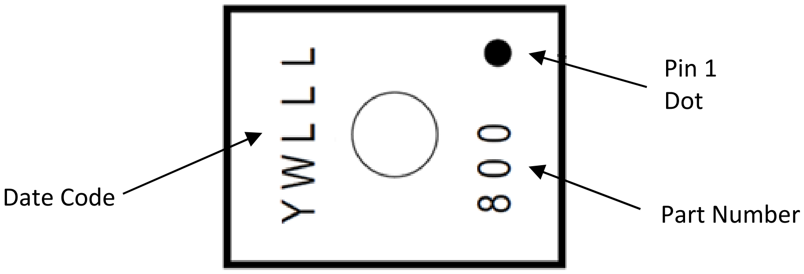


**Figure 12. Package Marking Specification (Top View)**

## ORDERING GUIDE

| PART | TEMP RANGE | PACKAGE | QUANTITY | PACKAGING |
|---|---|---|---|---|
| ICS-40800 | −40°C to +85°C | 4-Terminal LGA_CAV | 5000 | 13” Tape and Reel |
| EV_ICS-40800-FX | | Flex Evaluation Board | | |

## REVISION HISTORY

| REVISION DATE | REVISION | DESCRIPTION |
|---|---|---|
| 12/13/2017 | 0.1 | Preliminary |
| 2/22/2018 | 0.2 | Updated Polarity |
| 2/6/2020 | 1.0 | Initial Release |
| 4/15/2020 | 1.1 | Corrected typos |

## COMPLIANCE DECLARATION DISCLAIMER

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