

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  $\pm 1$  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  $\times$  3.00 mm  $\times$  1.20 mm surface-mount package.

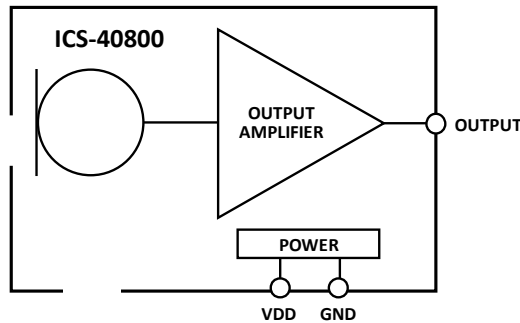
**APPLICATIONS**

- 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
- $\pm 1$  dB Sensitivity Tolerance
- Small 4  $\times$  3  $\times$  1.2 mm Surface-Mount Package
- Inverted Signal Output
- Extended Frequency Response from 80 Hz to 20 kHz
- 155  $\mu$ A 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_IC3-40800-FX	—	—

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## SPECIFICATIONS

**TABLE 1. ELECTRICAL CHARACTERISTICS**

T<sub>A</sub> = 25°C, V<sub>DD</sub> = 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
<b>PERFORMANCE</b>						
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 <sub>DD</sub> = 1.8 V, A-weighted		-86		dBV	
Power Supply Rejection Ratio (PSRR)	1 kHz, 100 mV p-p sine wave superimposed on V <sub>DD</sub> = 1.8 V		-55		dB	
Acoustic Overload Point	10% THD		128		dB SPL	
<b>POWER SUPPLY</b>						
Supply Voltage (V <sub>DD</sub> )		1.62		3.63	V	
Supply Current (I <sub>S</sub> )						
	V <sub>DD</sub> = 1.8 V		155		μA	
	V <sub>DD</sub> = 2.75 V		155		μA	
<b>OUTPUT CHARACTERISTICS</b>						
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**

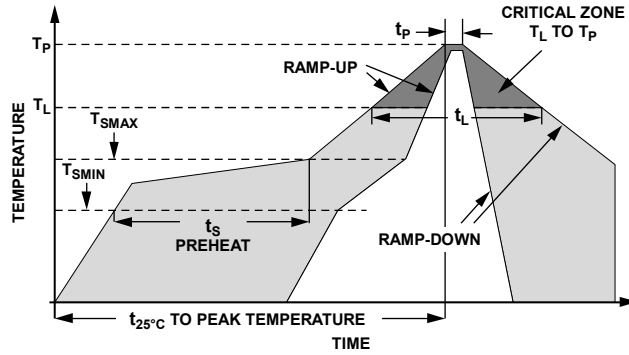
PARAMETER	RATING
Supply Voltage (V <sub>DD</sub> )	-0.3 V to +3.63 V
Mechanical Shock	10,000 g
Vibration	Per MIL-STD-883 Method 2007, Test Condition B
Temperature Range	
Biased	-40°C to +85°C
Storage	-55°C to +150°C

**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**



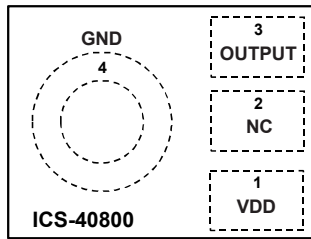
**Figure 1. Recommended Soldering Profile Limits**

**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 ( $T_{S_{MIN}}$ )	100°C	100°C
	Maximum Temperature ( $T_{S_{MAX}}$ )	150°C	200°C
	Time ( $T_{S_{MIN}}$ to $T_{S_{MAX}}$ ), $t_s$	60 sec to 75 sec	60 sec to 75 sec
Ramp-Up Rate ( $T_{S_{MAX}}$ 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

**\*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**



TOP VIEW  
(TERMINAL SIDE DOWN)  
Not to Scale

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)**

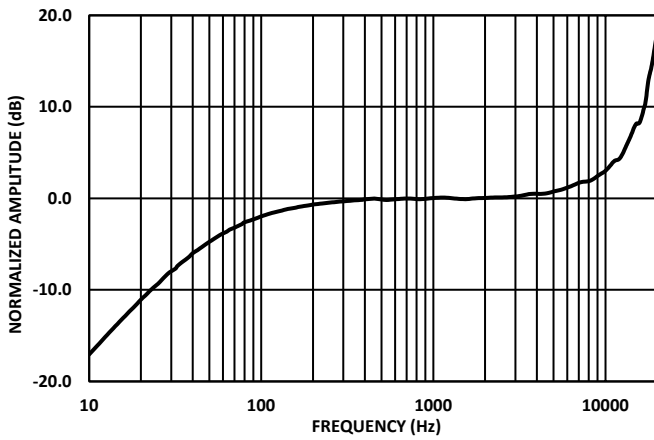


Figure 3. Typical Omnidirectional Frequency Response (Measured)

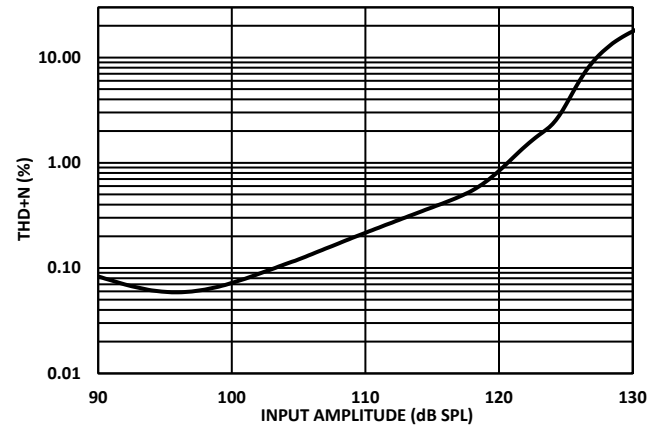


Figure 4. THD + N vs. Input Level

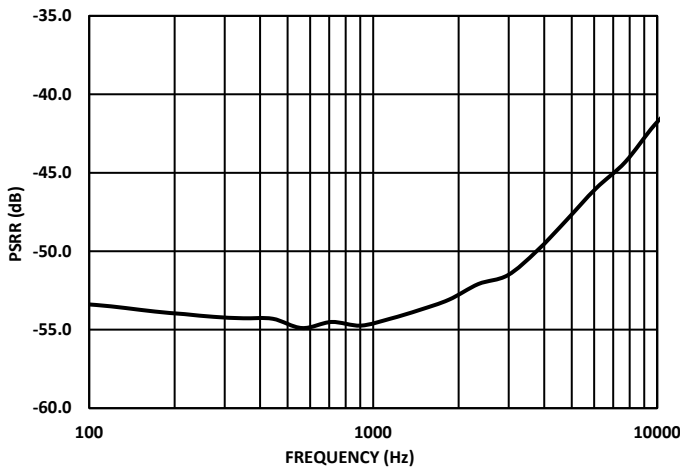
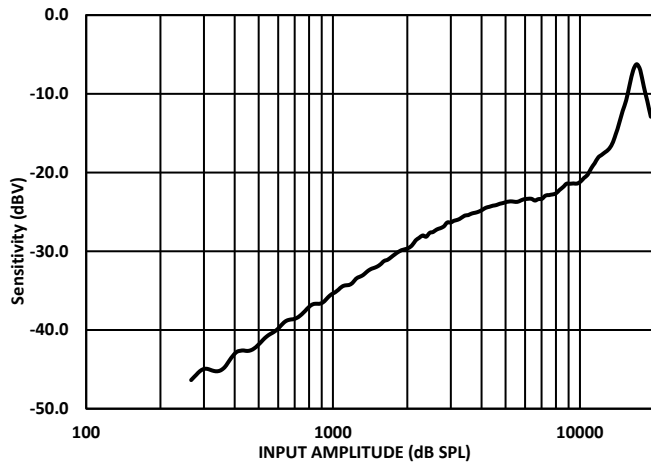
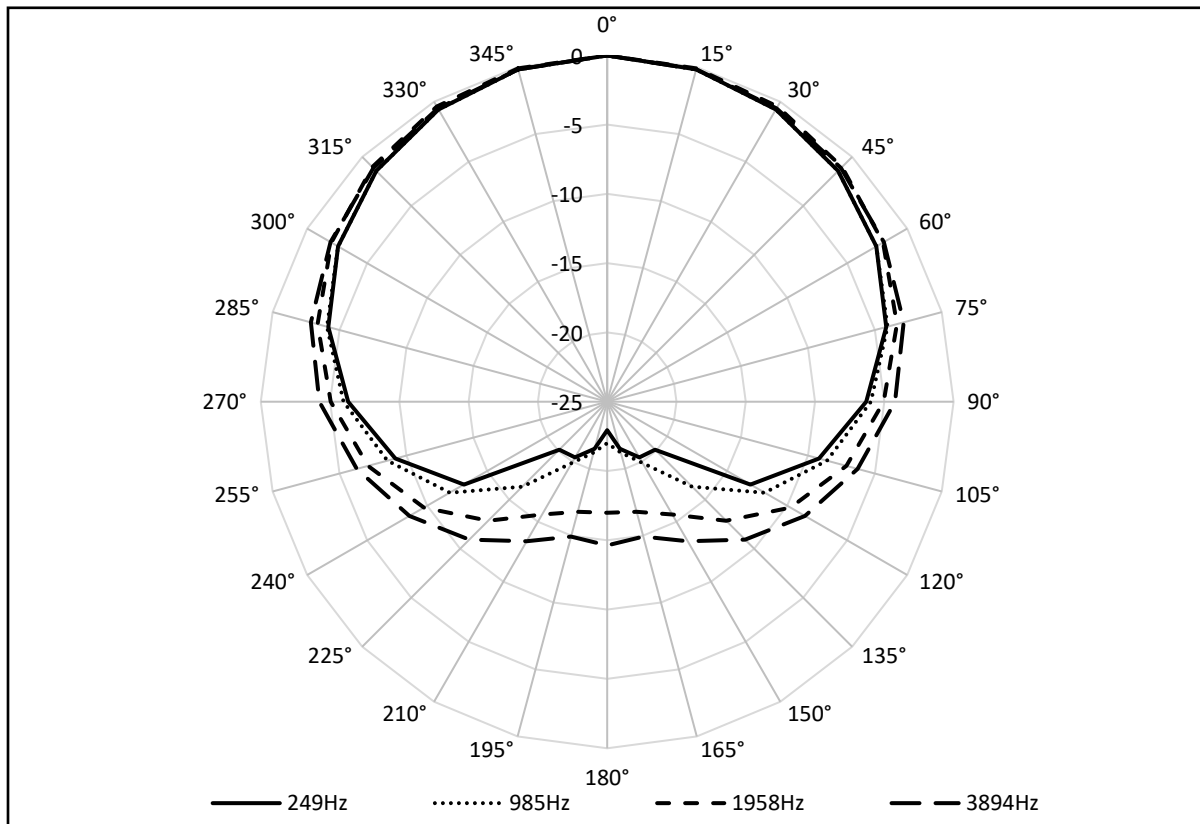


Figure 5. Power-Supply Rejection Ratio (PSRR) vs. Frequency

**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.

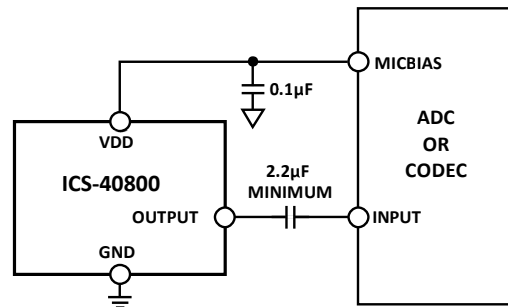


Figure 8. ICS-40800 Connected to a Codec

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**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*

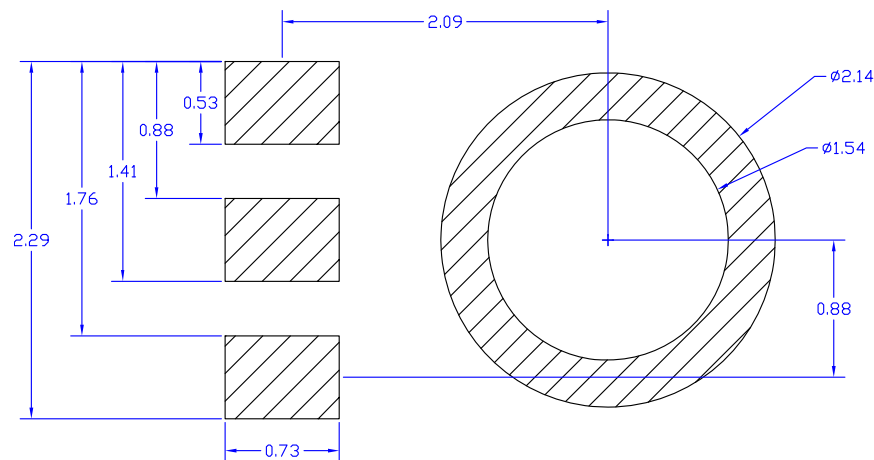
AN-1181, *Using a MEMS Microphone in a 2-Wire Microphone Circuit*

AN-000172, *Using MEMS Microphones in Directional Applications*

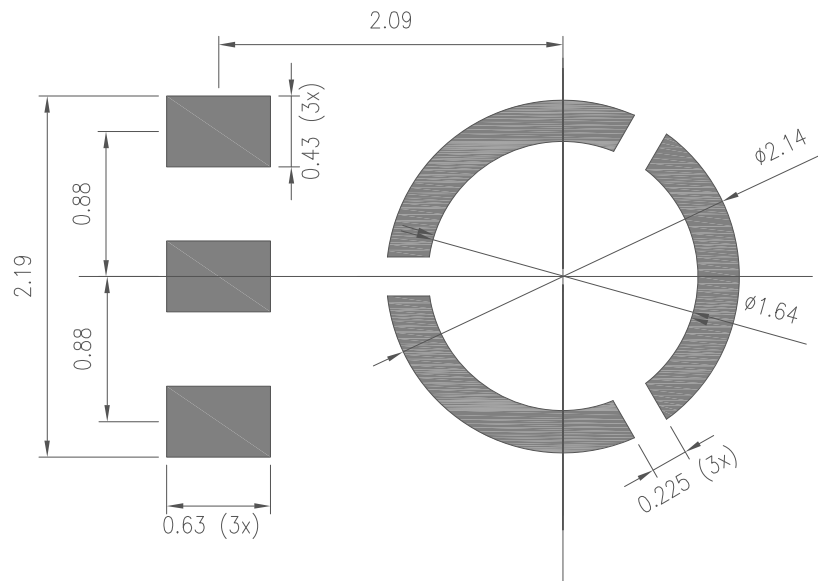
**PCB DESIGN AND LAND PATTERN LAYOUT**

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.

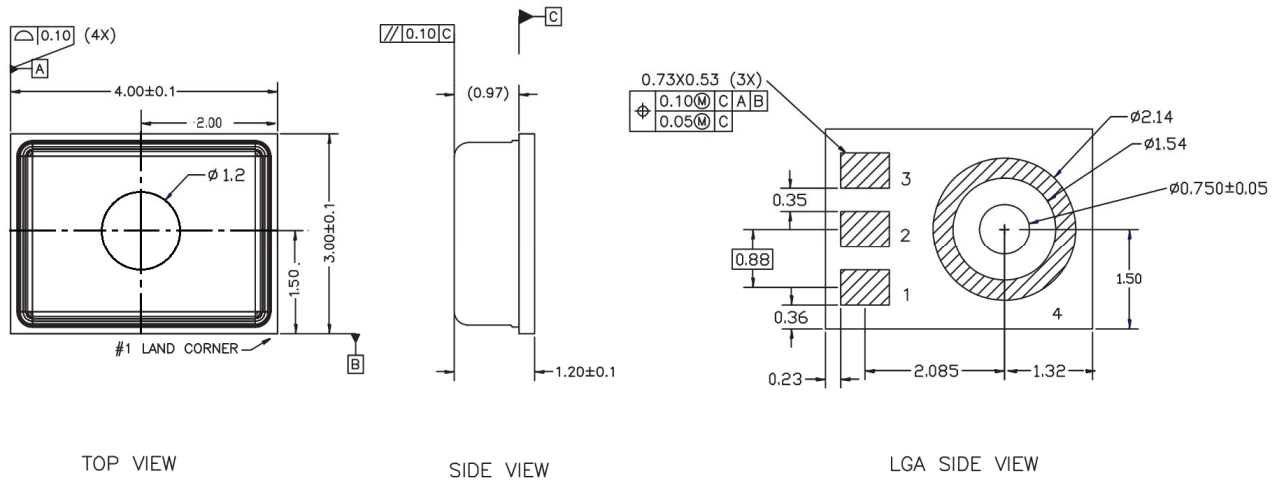
### **BOARD WASH**

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

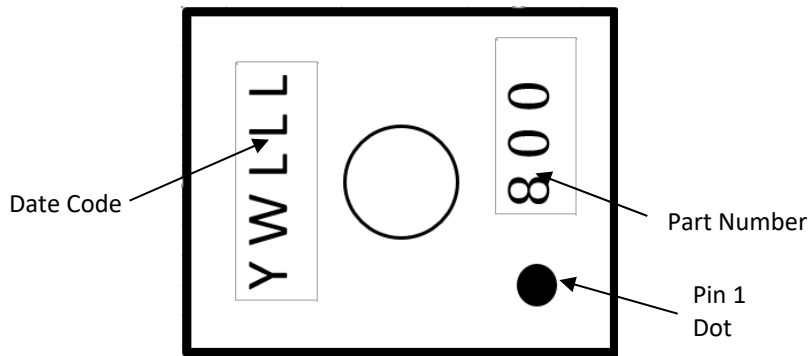
### **TOP PORT TAPE REMOVAL**

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		