

Ultra-Low Noise Microphone with Differential Output

**GENERAL DESCRIPTION**

The ICS-40720 is an ultra-low noise, differential analog output, bottom-ported MEMS microphone. The ICS-40720 includes a MEMS microphone element, an impedance converter, a differential output amplifier and an enhanced RF package. The ICS-40720's 70 dB SNR and  $\pm 2$  dB sensitivity tolerance make it an excellent choice for microphone arrays and far field voice control applications.

The ICS-40720 has a linear response up to 124 dB SPL with a differential output sensitivity specification of  $-32$  dBV. It can be used in a single-ended mode with  $-38$  dBV sensitivity and the same high SNR.

The ICS-40720 is available in a small 4.00 mm  $\times$  3.00 mm  $\times$  1.20 mm surface-mount package.

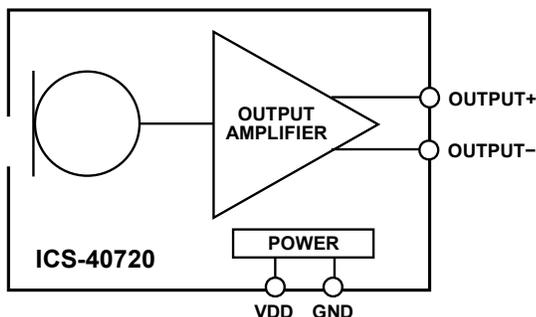
**APPLICATIONS**

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

**FEATURES**

- Ultra-High 70 dBA SNR
- $-32$  dBV Differential Sensitivity,  $-38$  dBV Single-Ended Sensitivity
- $\pm 2$  dB Sensitivity Tolerance
- Small 4  $\times$  3  $\times$  1.2 mm Surface-Mount Package
- Non-Inverted Signal Output
- Extended Frequency Response from 75 Hz to 20 kHz
- Enhanced RF Performance
- 285  $\mu$ A Current Consumption
- 124 dB SPL Acoustic Overload Point
- $-77$  dBV PSR
- Compatible with Sn/Pb and Pb-Free Solder Processes
- RoHS/WEEE Compliant

**FUNCTIONAL BLOCK DIAGRAM**



**ORDERING INFORMATION**

PART	TEMP RANGE	PACKAGING
ICS-40720	$-40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$	13" Tape and Reel
EV_IC3-40720-FX	—	—

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**SPECIFICATIONS**
**TABLE 1. ELECTRICAL CHARACTERISTICS**

 T<sub>A</sub> = 25°C, V<sub>DD</sub> = 1.5 to 3.63 V, unless otherwise noted. Typical specifications are not guaranteed.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
<b>PERFORMANCE</b>						
Directionality			Omni			
Sensitivity	1 kHz, 94 dB SPL, differential	-34	-32	-30	dBV	
	1 kHz, 94 dB SPL, single-ended	-40	-38	-36	dBV	
Signal-to-Noise Ratio (SNR)	20 Hz to 20 kHz, A-weighted, differential		70		dB	
	20 Hz to 20 kHz, A-weighted, single-ended		70		dB	
Equivalent Input Noise (EIN)	20 Hz to 20 kHz, A-weighted		24		dB SPL	
Dynamic Range	Derived from EIN and maximum acoustic input		100		dB	
Frequency Response	Low frequency -3 dB point		75		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		-77		dBV	
Power Supply Rejection Ratio (PSRR)	1 kHz, 100 mV p-p sine wave superimposed on V <sub>DD</sub> = 1.8 V		-45		dB	
Acoustic Overload Point	10% THD		124		dB SPL	
<b>POWER SUPPLY</b>						
Supply Voltage (V <sub>DD</sub> )		1.5		3.63	V	
Supply Current (I <sub>s</sub> )						
	V <sub>DD</sub> = 1.8 V		285	350	μA	
	V <sub>DD</sub> = 3.3 V			375	μA	
<b>OUTPUT CHARACTERISTICS</b>						
Output Impedance	Differential		750		Ω	
	Single-Ended, OUTPUT+		340		Ω	
	Single-Ended, OUTPUT-		410		Ω	
Output DC Offset	OUTPUT+		0.66		V	
	OUTPUT-		0.70		V	
Maximum Output Voltage	Differential, 124 dB SPL input		0.79		V rms	
	Single-Ended, 124 dB SPL input		0.40		V rms	
Noise Floor	20 Hz to 20 kHz, A-weighted, rms		-102		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**

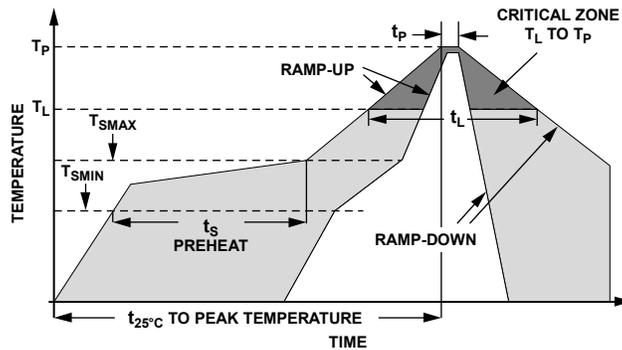
PARAMETER	RATING
Supply Voltage (V <sub>DD</sub> )	-0.3 V to +3.63 V
Sound Pressure Level	160 dB
Mechanical Shock	10,000 g
Vibration	Per MIL-STD-883 Method 2007, Test Condition B
Temperature Range	
Biased	-40°C to +85°C
Storage	-55°C to +150°C

**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**



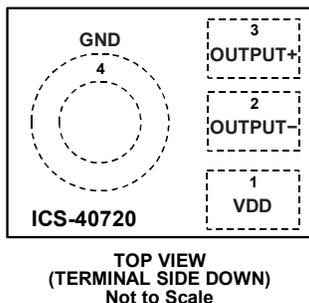
**Figure 1. Recommended Soldering Profile Limits**

**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
	Maximum 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**



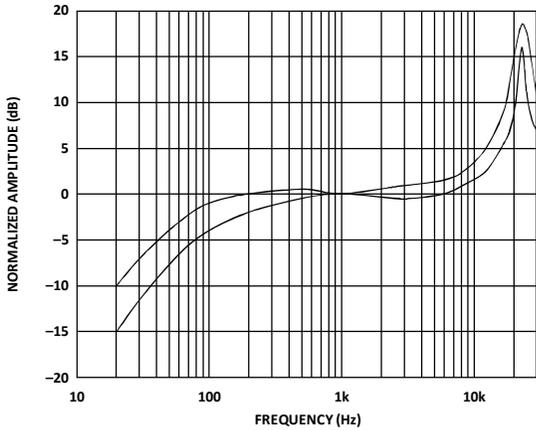
TOP VIEW  
(TERMINAL SIDE DOWN)  
Not to Scale

Figure 2. Pin Configuration

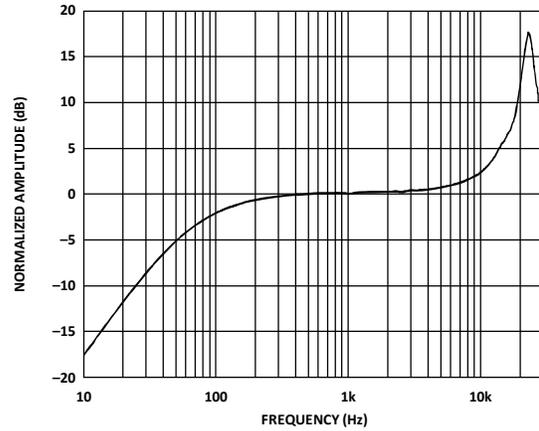
**TABLE 4. PIN FUNCTION DESCRIPTIONS**

PIN	NAME	FUNCTION
1	VDD	Power Supply
2	OUTPUT-	Analog Output Signal-
3	OUTPUT+	Analog Output Signal+
4	GND	Ground

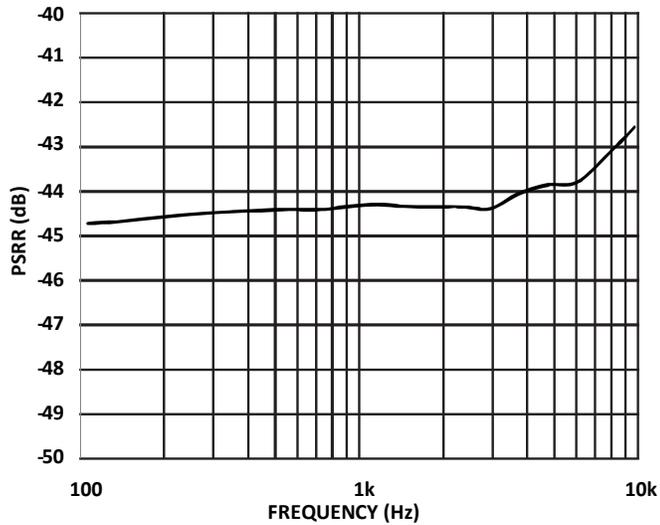
**TYPICAL PERFORMANCE CHARACTERISTICS**



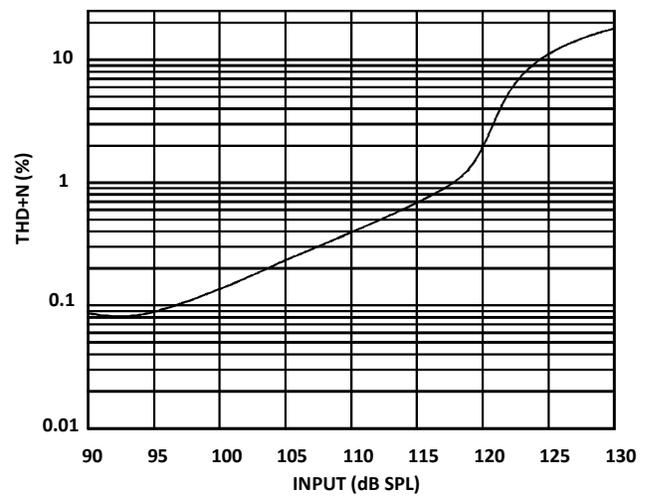
**Figure 3. Frequency Response Mask**



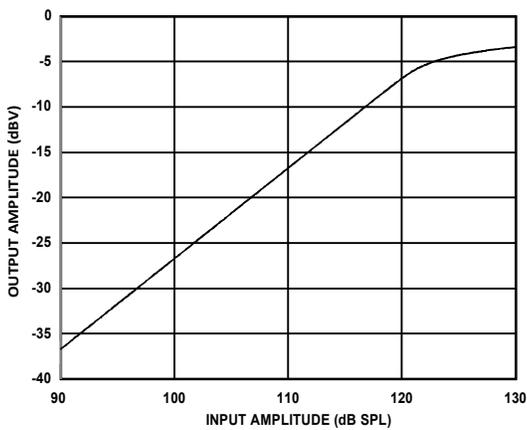
**Figure 4. Typical Frequency Response (Measured)**



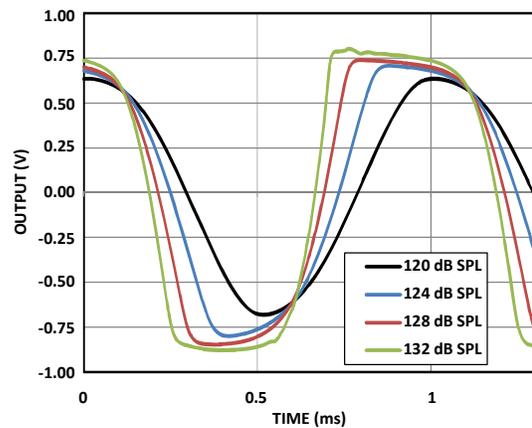
**Figure 5. Power-Supply Rejection Ratio (PSRR) vs. Frequency**



**Figure 6. THD + N vs. Input Level**



**Figure 7. Linearity**



**Figure 8 Clipping Characteristics**

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## **THEORY OF OPERATION**

### **BALANCED OUTPUT**

The ICS-40720 has a balanced differential output with 700  $\Omega$  output impedance. This configuration is compatible with a fully-differential codec input and provides the benefits of a balanced signal between the microphone and codec. A balanced analog audio signal provides rejection of common-mode noise that is present on both the positive and negative signals.

### **SINGLE-ENDED OPERATION**

The ICS-40720 can be used as a single-ended microphone by using the signal from only one of the two output pins. In this configuration, the sensitivity will be 6 dB lower than the differential output, but with the same high SNR performance. Pin OUTPUT+ will output the non-inverted signal, relative to the acoustic input, while the OUTPUT- pin will output an inverted signal. The unused output pin should be left disconnected when the mic is used in single-ended mode; do not connect the unused pin to ground.

**APPLICATIONS INFORMATION**

**CODEC CONNECTION**

The ICS-40720 output can be connected to a dedicated codec microphone input (see Figure 9) or to a high input impedance gain stage. A 0.1 μF ceramic capacitor placed close to the ICS-40720 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 9 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.

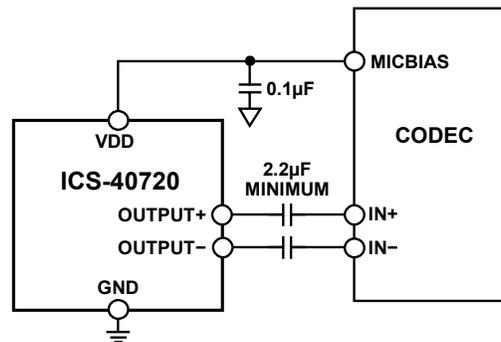


Figure 9. ICS-40720 Connected to a Differential-Input Codec

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**SUPPORTING DOCUMENTS**

For additional information, see the following documents.

**EVALUATION BOARD USER GUIDE**

AN-000012, *Differential Analog Output MEMS Microphone Flex Evaluation Board*

**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*

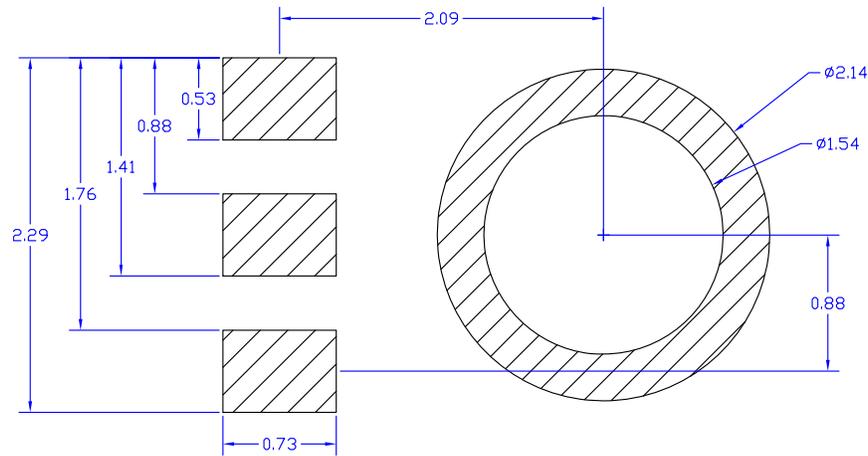
AN-1165, *Op Amps for Microphone Preamp Circuits*

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

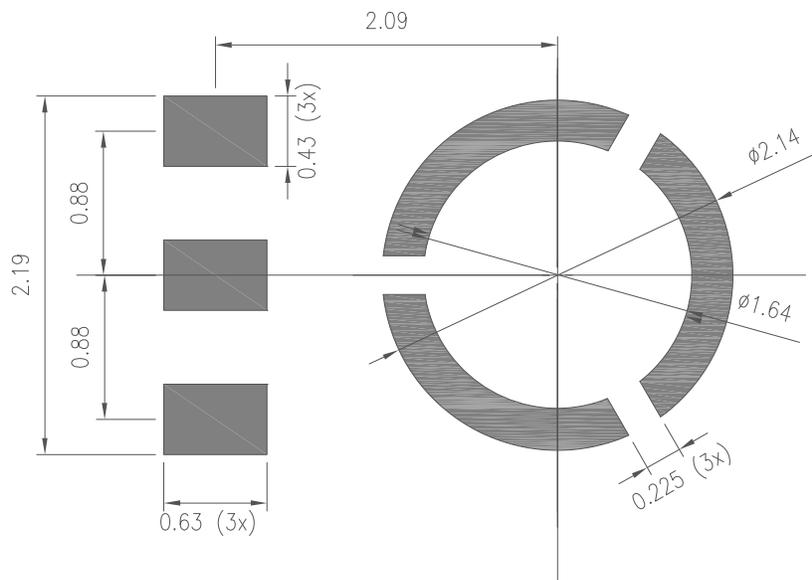
**PCB DESIGN AND LAND PATTERN LAYOUT**

Lay out the PCB land pattern for the ICS-40720 at a 1:1 ratio to the solder pads on the microphone package (see Figure 10.) Take care to avoid applying solder paste to the sound hole in the PCB. Figure 11 shows a suggested solder paste stencil pattern layout. The response of the ICS-40720 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 10. Suggested PCB Land Pattern Layout**



Note : All units in mm

**Figure 11. Suggested Solder Paste Stencil Pattern Layout**

**PCB MATERIAL AND THICKNESS**

The performance of the ICS-40720 is not affected by PCB thickness. The ICS-40720 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.

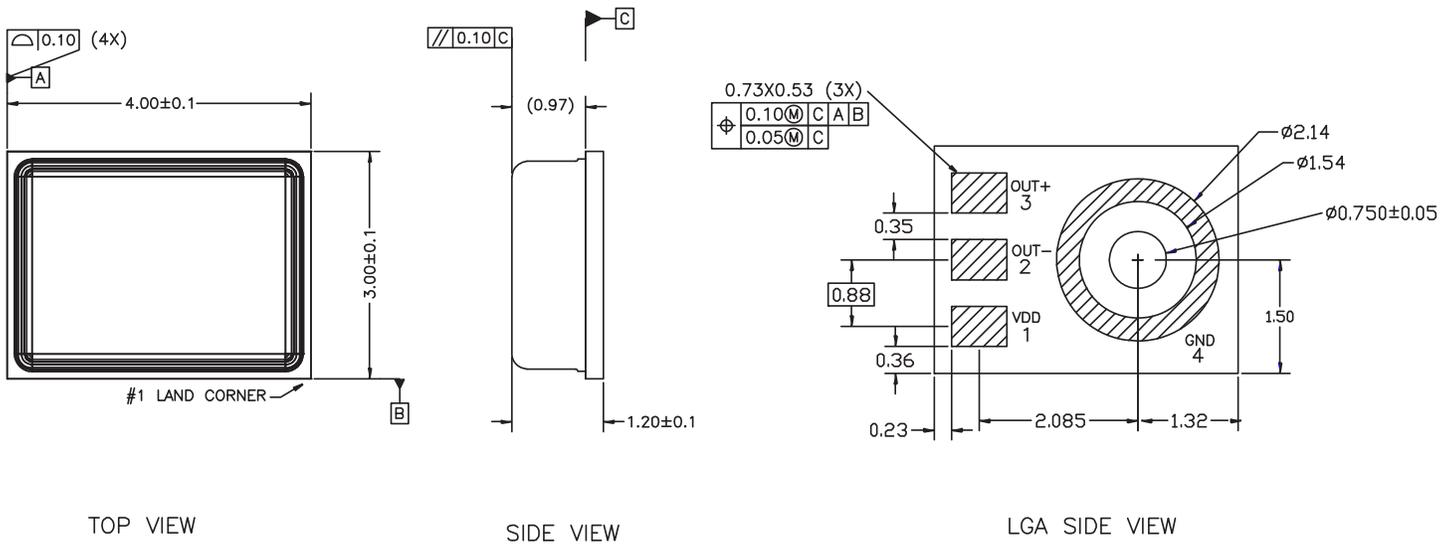
### **REFLOW SOLDER**

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.

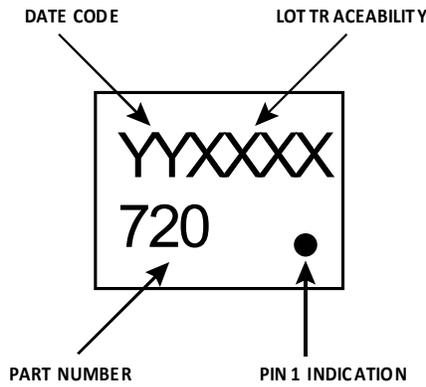
### **BOARD WASH**

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



**Figure 13. Package Marking Specification (Top View)**

**ORDERING GUIDE**

PART	TEMP RANGE	PACKAGE	QUANTITY	PACKAGING
ICS-40720	-40°C to +85°C	4-Terminal LGA_CAV	5000	13" Tape and Reel
EV_ICs-40720-FX		Flex Evaluation Board		

**REVISION HISTORY**

REVISION DATE	REVISION	DESCRIPTION
2/20/2015	1.0	Initial Version
05/07/2015	1.1	Removed <i>Preliminary Technical Data</i> from headers
5/26/2015	1.2	Corrected tape and reel quantities
1/20/2016	1.3	Corrected Package Marking Specification
07/03/2019	1.4	Table 3 and Formatting

## **COMPLIANCE DECLARATION DISCLAIMER**

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