TDK InvenSense

ICS-40638

High AOP Analog MEMS Microphone with Differential Output

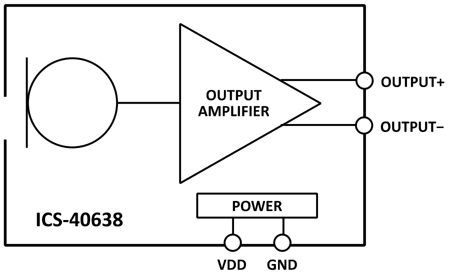
GENERAL DESCRIPTION

The ICS-40638 is an analog MEMS microphone with very high dynamic range and capable of operation up to 105°C. The ICS-40638 includes a MEMS microphone element, an impedance converter, and a differential output amplifier.

Other high-performance specifications include 138 dB SPL acoustic overload point, tight ±1 dB sensitivity tolerance and enhanced immunity to both radiated and conducted RF interference.

The ICS-40638 is available in a small 3.50 mm × 2.65 mm × 0.98 mm bottom port surface-mount package.

FUNCTIONAL BLOCK DIAGRAM



APPLICATIONS

- Automotive
- Still and video cameras
- IoT devices

FEATURES

SPEC	PERFORMANCE
SNR	63 dBA
Current	170 µA
AOP	138 SPL

- Differential non-inverting analog output
- −43 dBV sensitivity (differential)
- ±1 dB sensitivity tolerance
- Extended frequency response from 35 Hz to 20 kHz
- Enhanced RF immunity
- −81 dB PSRR
- 3.50 × 2.65 × 0.98 mm surface-mount package
- Compatible with Sn/Pb and Pb-free solder processes
- RoHS/WEEE compliant

ORDERING INFORMATION

PART	TEMP RANGE	PACKAGING
ICS-40638	−40°C to +105°C	13” Tape and Reel
EV_ICS-40638-FX	—	

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SPECIFICATIONS

TABLE 1. ELECTRICAL CHARACTERISTICS

T_A = 25°C, V_{DD} = 1.52 to 3.63 V, unless otherwise noted. Typical specifications are not guaranteed.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS	NOTES
PERFORMANCE						
Directionality			Omni			
Output Polarity			Non-Inverted			
Sensitivity	1 kHz, 94 dB SPL, differential	−44	−43	−42	dBV	
Signal-to-Noise Ratio (SNR)	20 kHz bandwidth, A-weighted		63		dBA	
Equivalent Input Noise (EIN)	20 kHz bandwidth, A-weighted		31		dBA SPL	
Dynamic Range	Derived from EIN and acoustic overload point		107		dB	
Total Harmonic Distortion (THD)	105 dB SPL		0.2		%	
Power Supply Rejection Ratio (PSRR)	1 kHz, 100 mV p-p sine wave superimposed on V_{DD} = 2.75 V		-81		dB	
Power Supply Rejection (PSR)	217 Hz, 100 mVp-p square wave superimposed on V_{DD} = 2.75 V		−111		dBV	
Acoustic Overload Point	10% THD		138		dB SPL	
POWER SUPPLY						
Supply Voltage (V_{DD})	Standard mode	1.52		3.63	V	
Supply Current (I_S)	V_{DD} = 1.8 V		170	190	µA	
OUTPUT CHARACTERISTICS						
Differential Output Impedance			355		Ω	
Output Common Mode Voltage	OUTPUT+ and OUTPUT-		1.0		V	
Output Differential Offset	Between OUTPUT+ and OUTPUT−		10		mV	
Startup Time	Output to within ±0.5 dB of stable sensitivity		15	20	ms	
Maximum Output Voltage	138 dB SPL input		1.0		V rms	
Noise Floor	20 Hz to 20 kHz, A-weighted, rms		−106		dBV	

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	
Operating	−40°C to +105°C *
Storage	−55°C to +150°C

*Operating range guarantees mic functionality. Some performance may be reduced near temperature limits.

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

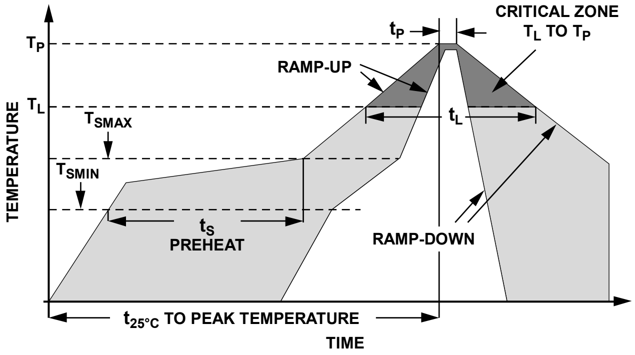


Figure 1. Recommended Soldering Profile Limits

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

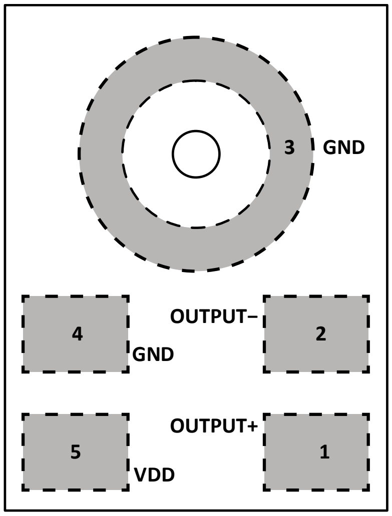


Figure 2. Pin Configuration (Top View, Terminal Side Down)

TABLE 4. PIN FUNCTION DESCRIPTIONS

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

TYPICAL PERFORMANCE CHARACTERISTICS

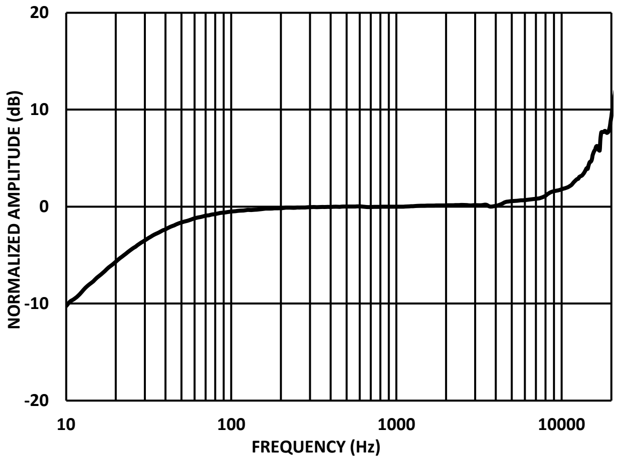


Figure 3. Typical Frequency Response (Measured)

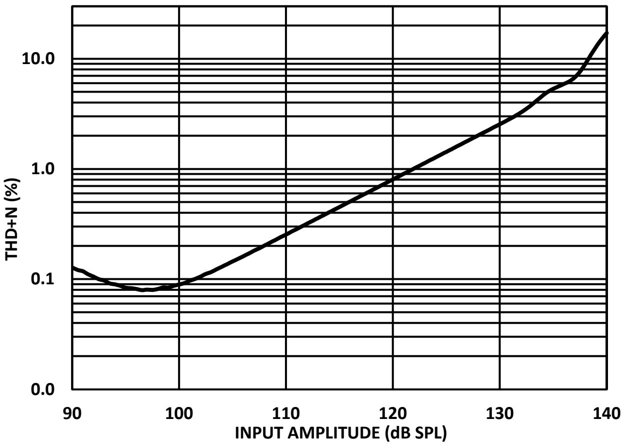


Figure 4. THD + N vs. Input Amplitude

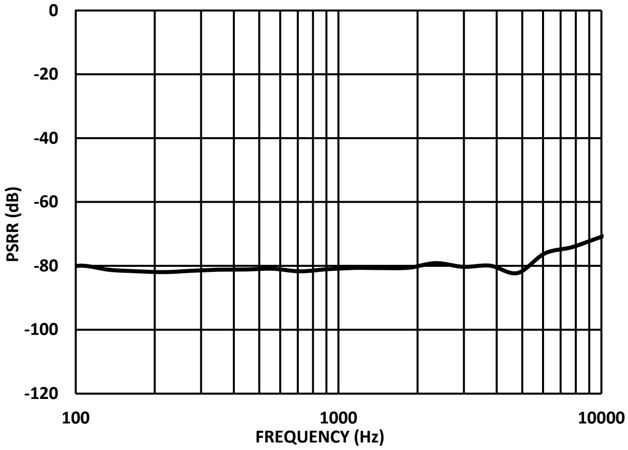


Figure 5. Power-Supply Rejection Ratio (PSRR) vs. Frequency

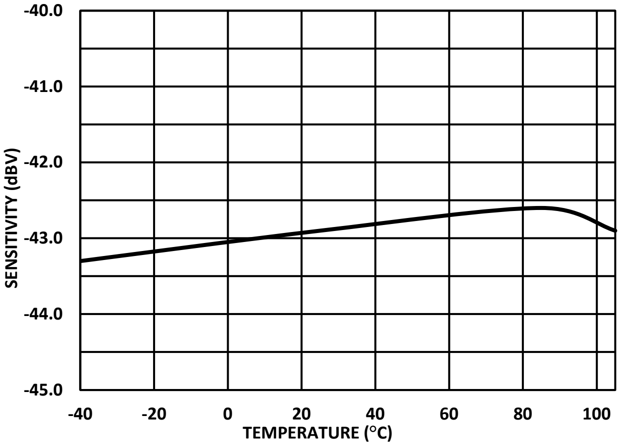


Figure 6. Sensitivity vs. Temperature

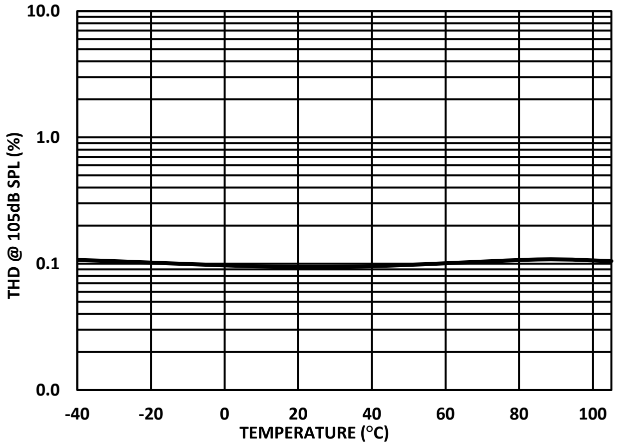


Figure 7. THD vs. Temperature

APPLICATIONS INFORMATION

CODEC CONNECTION

The ICS-40638 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-40638 supply pin is used for testing and is recommended to adequately decouple the microphone from noise on the power supply. A dc blocking 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.

A minimum value of 2.2 µF is recommended in Figure 8 for codecs, which may have a very low input impedance at some PGA gain settings.

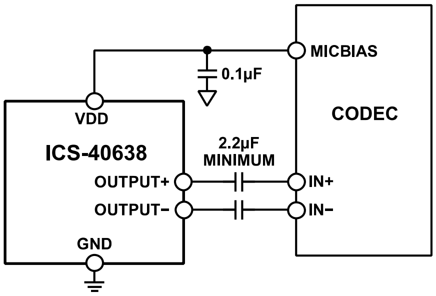


Figure 8. ICS-40638 Connected to a Differential-Input Codec

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-000161, *ESD Design and Test Guidelines for MEMS Microphones*

PCB DESIGN AND LAND PATTERN LAYOUT

Lay out the PCB land pattern for the ICS-40638 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-40638 is not affected by the PCB hole size, as long as the hole is not smaller than the sound port of the microphone (0.375 mm in diameter). A 0.5 mm to 1 mm 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.

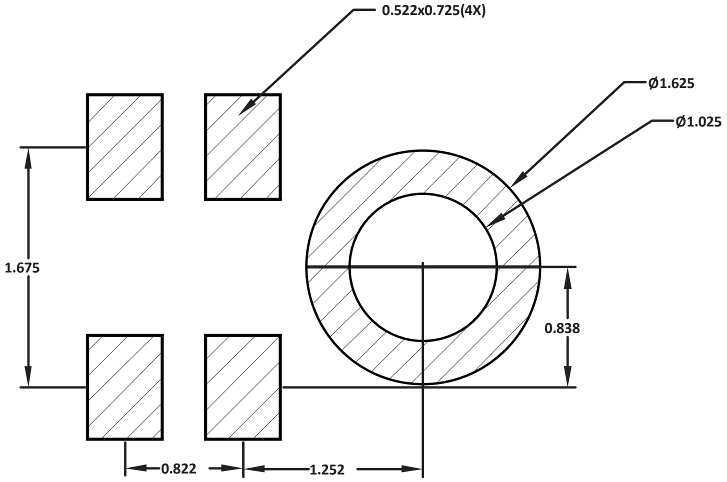


Figure 9. Recommended PCB Land Pattern Layout

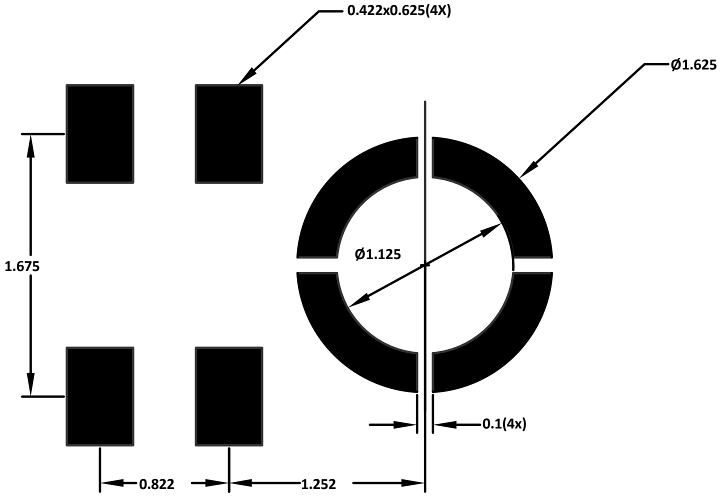


Figure 10. Recommended Solder Paste Stencil Pattern Layout

PCB MATERIAL AND THICKNESS

The performance of the ICS-40638 is not affected by PCB thickness. The ICS-40638 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.

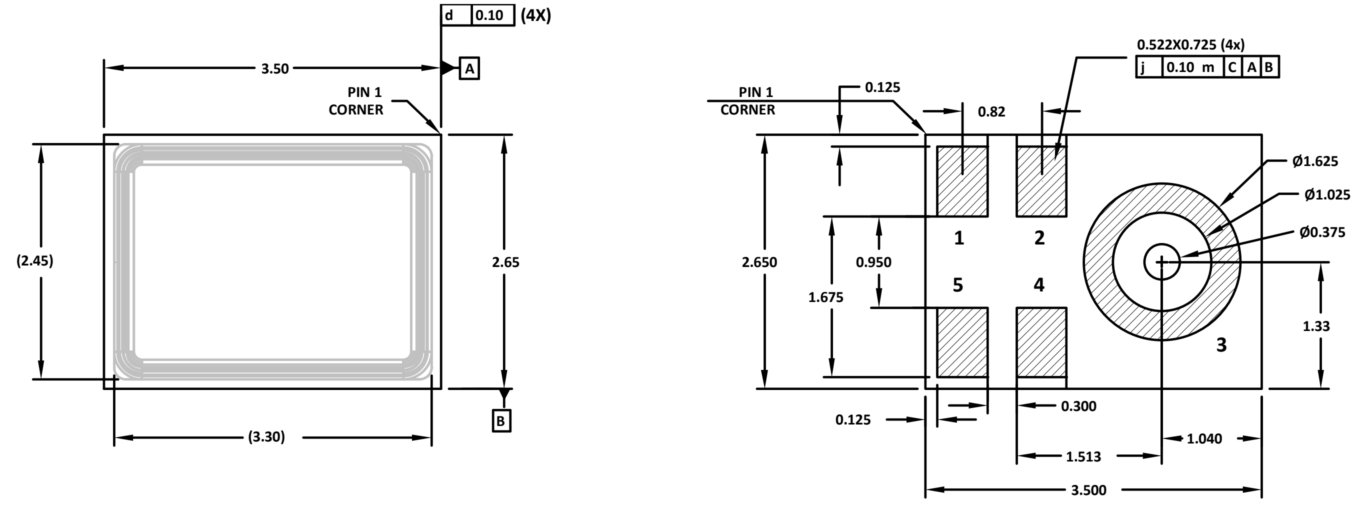
REFLOW SOLDER

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

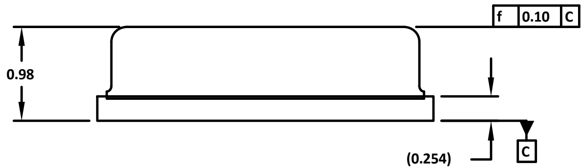
When washing the PCB, ensure that water does not make contact with the microphone port. Do not use blow-off procedures or ultrasonic cleaning.

OUTLINE DIMENSIONS



TOP VIEW

BOTTOM VIEW



SIDE VIEW

Figure 11. 5-Terminal Chip Array Small Outline No Lead Cavity
3.50 mm × 2.65 mm × 0.98 mm Body
Dimensions shown in millimeters

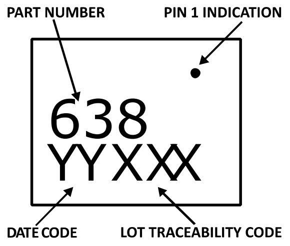


Figure 12. Package Marking Specification (Top View, not to scale)

ORDERING GUIDE

PART	TEMP RANGE	PACKAGE	QUANTITY	PACKAGING
ICS-40638	−40°C to +105°C	5-Terminal LGA_CAV	10,000	13” Tape and Reel
EV_ICS-40638-FX	—	Flexible Evaluation Board	—	

REVISION HISTORY

REVISION DATE	REVISION	DESCRIPTION
11/1/2018	0.1	Initial Preliminary Version
1/29/2020	1.0	Initial Release
4/15/2020	1.1	Corrected typos

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