

## 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  $\mu\text{A}$  of current while providing a 64 dB SNR with an analog 4.5 k $\Omega$  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.*

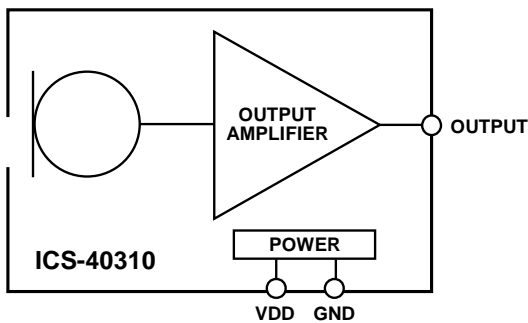
### APPLICATIONS

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

### FEATURES

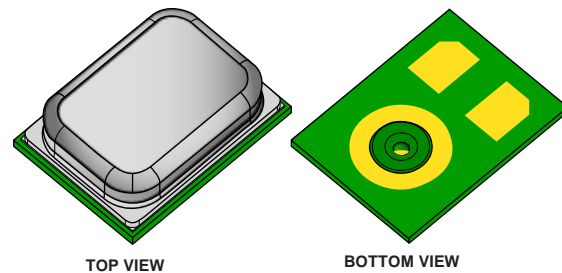
- Low Current Consumption: 16  $\mu\text{A}$
- Small Surface-Mount Package: 3.35  $\times$  2.5  $\times$  0.98 mm
- High SNR of 64 dBA
- Sensitivity of -37 dBV
- 0.9 V to 1.3 V Supply
- Single-Ended Analog Output
- Compatible with Sn/Pb and Pb-Free Solder Processes
- RoHS/WEEE Compliant

### 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<sub>A</sub> = 0 to 70°C, V<sub>DD</sub> = 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
<b>PERFORMANCE</b>						
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 <sub>DD</sub> = 1.0 V (A-weighted)		-81		dBV	
Power-Supply Rejection Ratio (PSRR)	1 kHz, 100 mVp-p sine wave superimposed on V <sub>DD</sub>		-53		dB	
Acoustic Overload Point	10% THD		112		dB SPL	
<b>POWER SUPPLY</b>						
Supply Voltage (V <sub>DD</sub> )		0.9		1.3	V	
Supply Current (I <sub>S</sub> )	V <sub>DD</sub> = 0.9 V		16	23	μA	
	V <sub>DD</sub> = 1.3 V		19.5	25	μA	
<b>OUTPUT CHARACTERISTICS</b>						
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 g
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

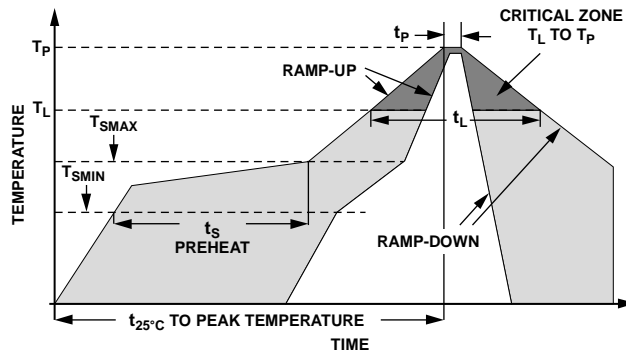


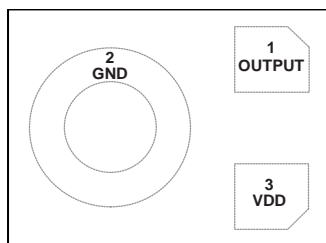
Figure 1. Recommended Soldering Profile Limits

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 ( $t_{25^\circ c}$ ) 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**



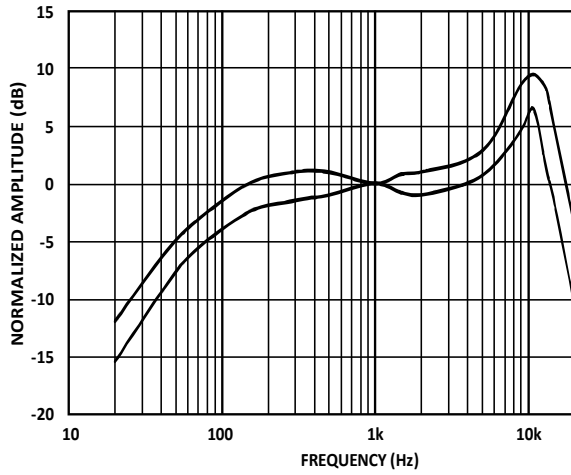
TOP VIEW  
(TERMINAL SIDE DOWN)  
Not to Scale

**Figure 2. Pin Configuration**

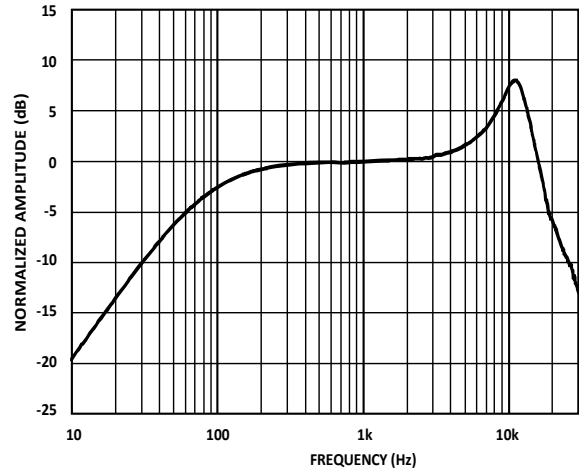
**TABLE 4. PIN FUNCTION DESCRIPTIONS**

PIN	NAME	FUNCTION
1	OUTPUT	Analog Output Signal
2	GND	Ground
3	VDD	Power Supply. Bypass to GND with a 0.1 $\mu$ F capacitor.

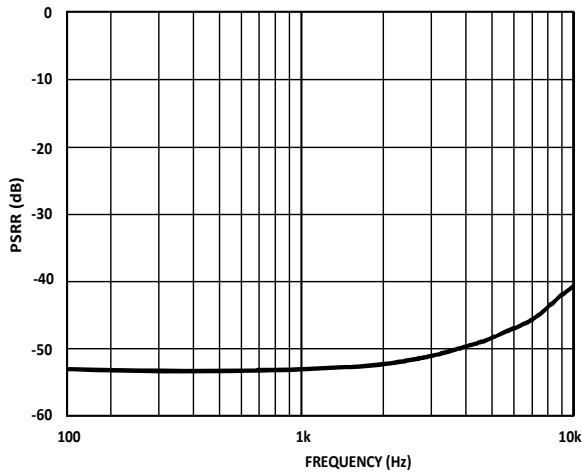
**TYPICAL PERFORMANCE CHARACTERISTICS**



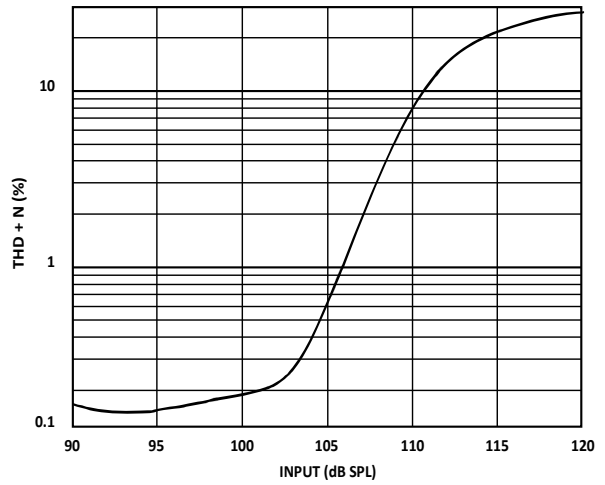
**Figure 3. Frequency Response Mask**



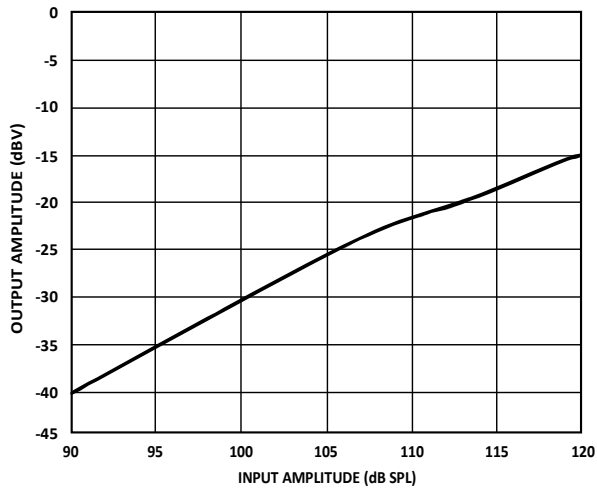
**Figure 4. Typical Frequency Response (Measured)**



**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.

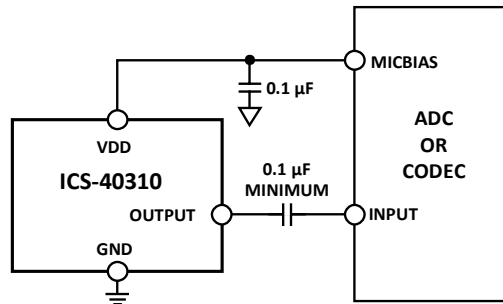


Figure 8. ICS-40310 Connected to an ADC or Codec

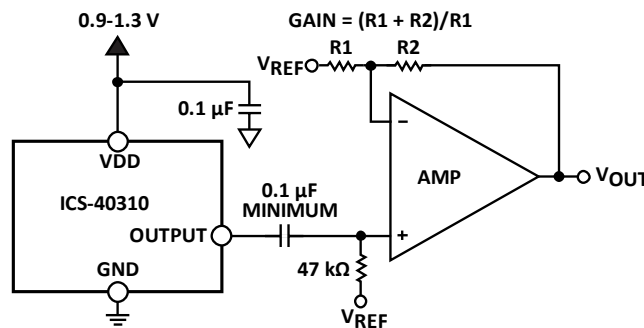


Figure 9. ICS-40310 Connected to an Op Amp



## **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*

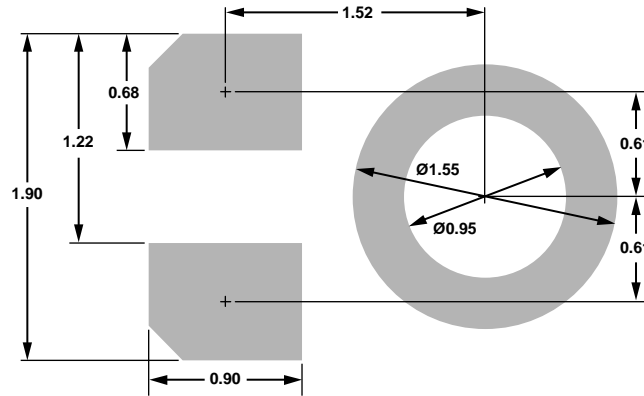
AN-1140, *Microphone Array Beamforming*

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

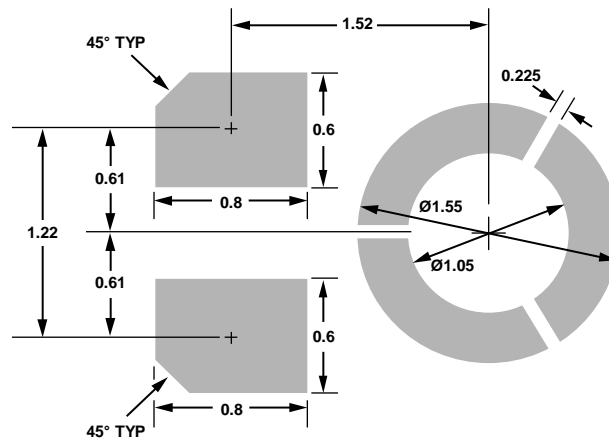
AN-1181, *Using a MEMS Microphone in a 2-Wire Microphone Circuit*

**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

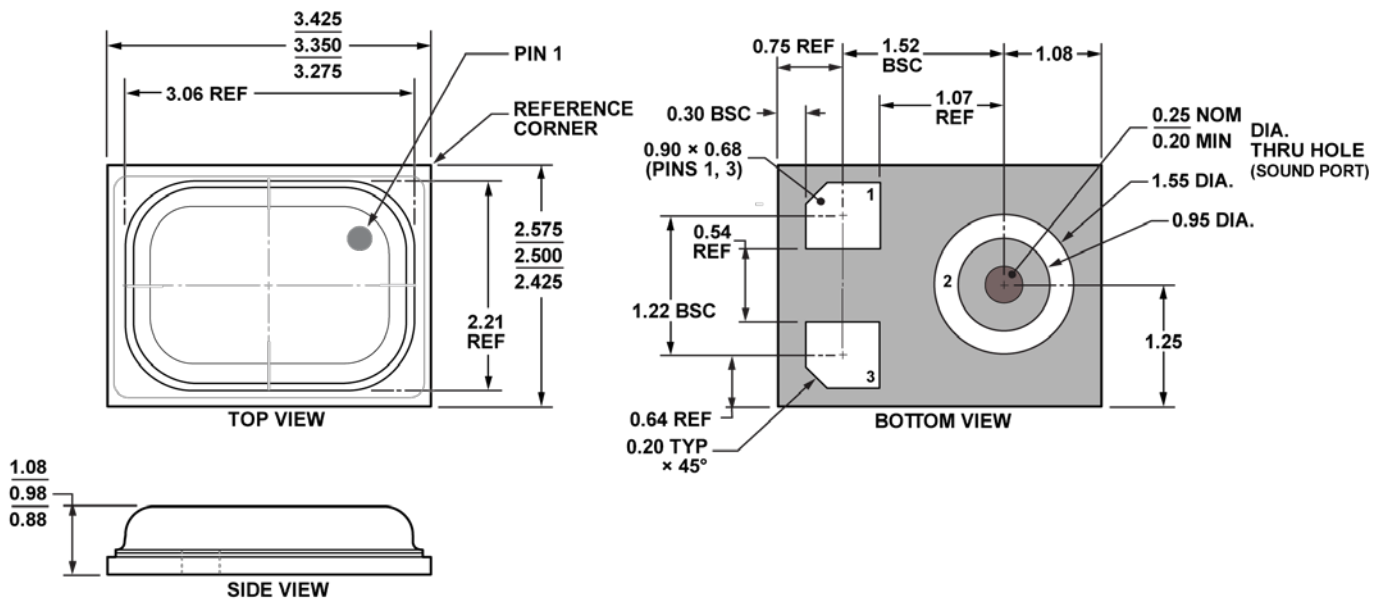


Figure 12. 3-Terminal Chip Array Small Outline No Lead Cavity  
 3.35 mm × 2.5 mm × 0.98 mm Body  
 Dimensions shown in millimeters

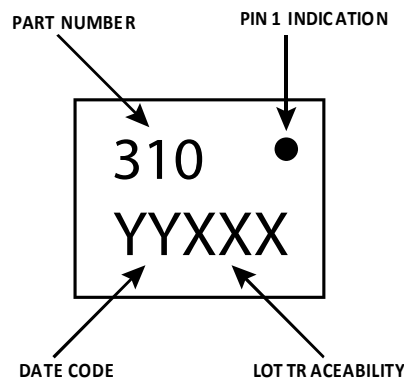


Figure 13. Package Marking Specification (Top View)

**ORDERING GUIDE**

<b>PART</b>	<b>TEMP RANGE</b>	<b>PACKAGE</b>	<b>QUANTITY</b>	<b>PACKAGING</b>
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**

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

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