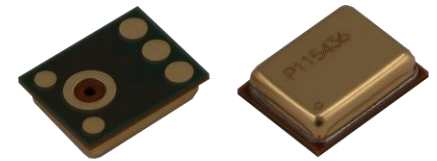


HIGH SNR, HIGH AOP ANALOG BOTTOM PORT SISONIC™ MICROPHONE

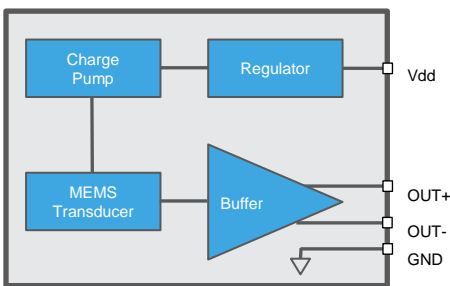


The SPM0687LR5H-1 is a high Signal-to-Noise Ratio (SNR), high Acoustic Overload Point (AOP), bottom port silicon microphone. Using Knowles' proven high performance SiSonic™ MEMS technology, the SPM0687LR5H-1 consists of an acoustic sensor, a low noise input buffer, and a differential output amplifier supporting optional single ended mode. This microphone's high SNR enables far field voice pick up for IoT applications, and its high AOP provides a large dynamic range for barge-in applications. The microphone's low phase distortion lends to superior algorithm performance. Its differential mode configuration improves noise immunity to power supply variations, allowing extension of microphone PCB traces.



PRODUCT FEATURES

- Differential/Single-Ended Output
- Low Distortion /High AOP
- High SNR
- Flat Frequency Response
- Low Current
- Sensitivity Matching
- Bottom Port
- Ultra-Stable Performance
- Omnidirectional
- Standard SMD Reflow
- LGA Package



TYPICAL APPLICATIONS

- Voice-Enabled Smart Speaker/Hub (IoT)
- Voice-Enabled Home/Industrial Accessories (Thermostat, Light Bulb, Remote Control, TV)
- Speakerphones
- Active Noise Cancellation (ANC) Headsets
- Digital Action/Still Cameras
- Portable Music Recorders

ABSOLUTE MAXIMUM RATINGS

Table 1: Absolute Maximum Ratings

| Parameter | Absolute Maximum Rating | Units |
|-----------------------|-------------------------|-------|
| Vdd to Ground | -0.5, +5.0 | V |
| OUT+, OUT- to Ground | -0.3, Vdd+0.3 | V |
| Input Current | ±5 | mA |
| Storage Temperature | -40 to +100 | °C |
| Operating Temperature | -30 to +100 | °C |

Stresses exceeding these "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation at these or any other conditions beyond those indicated under "Acoustic & Electrical Specifications" is not implied. Exposure beyond those indicated under "Acoustic & Electrical Specifications" for extended periods may affect device reliability.



ACOUSTIC & ELECTRICAL SPECIFICATIONS¹

Table 2: General Microphone Specifications

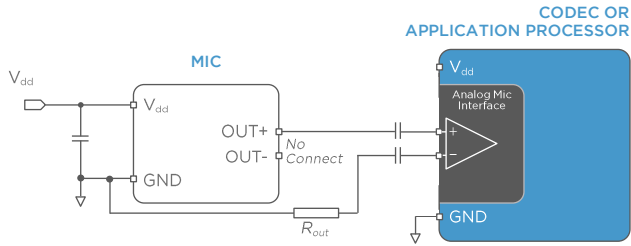
Test Conditions: 23 ±2°C, 55±20% R.H., VDD= 2.75 V, no load, unless otherwise indicated

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|------------------------------|--------|--|---------------------------|--------|-------|--------|
| Supply Voltage | Vdd | | 2.3 | 2.75 | 3.6 | V |
| Supply Current | Idd | Vdd = 3.6 V | - | 365 | - | µA |
| | | Vdd = 2.75 V | - | 295 | - | |
| Sensitivity | S | 94 dB SPL @ 1kHz, Single-Ended | -41 | -40 | -39 | dBV/Pa |
| | | 94 dB SPL @ 1kHz, Differential | -35.7 | -34.7 | -33.7 | |
| Signal to Noise Ratio | SNR | 94 dB SPL @ 1kHz, A-weighted, Single-Ended | - | 70 | - | dBV/Pa |
| | | 94 dB SPL @ 1kHz, A-weighted, Differential | - | 69.5 | - | |
| Near-Ultrasonic SNR | | 94 dB SPL, @ 19 kHz, BW = 18.5 - 20.0 kHz, SE | - | 83.9 | - | dB |
| | | 94 dB SPL, @ 19 kHz, BW = 18.5 - 20.0 kHz, D | - | 83.9 | - | |
| Total Harmonic Distortion | THD | 94 dB SPL @ 1 kHz | - | 0.2 | 0.5 | % |
| | | 115 dB SPL @ 1 kHz | - | 1.4 | - | % |
| | | 1% THD @ 1 kHz, S = typ | - | 113 | - | dB SPL |
| Acoustic Overload Point | AOP | 10% THD @ 1 kHz, S = typ | - | 130 | - | dB SPL |
| Low Frequency Rolloff | LFRO | -3dB relative to 1 kHz | - | 13 | - | Hz |
| High Frequency Flatness | | +3dB relative to 1 kHz | - | 13 | - | kHz |
| Resonant Frequency Peak | Fres | | - | 25 | - | kHz |
| Power Supply Rejection Ratio | PSRR | 200 mVpp sinewave @ 1 kHz, Single-Ended | - | 90 | - | dB |
| | | 200 mVpp sinewave @ 1 kHz, Differential | - | 85 | - | |
| Power Supply Rejection | PSR+N | 200 mVpp 7/8 duty cycle rect. waveform @ 217 Hz, A-weighted, BW = 20 kHz, SE | - | -106.5 | - | dBV(A) |
| | | 200 mVpp 7/8 duty cycle rect. waveform @ 217 Hz, A-weighted, BW = 20 kHz, Differential | - | -101.3 | - | |
| DC Output | | | 0.59 | 0.69 | 0.79 | V |
| DC Offset | | OUT+ to OUT- | - | - | ±25 | mV |
| Output Impedance | Zout | @ 1 kHz | - | 300 | 600 | Ω |
| Output Load | Rload | AC-coupled | 10 | - | - | kΩ |
| Sensitivity Drop | | Vdd(min) ≤ Vdd ≤ Vdd(max) | - | - | ±0.25 | dB |
| Directivity | | | Omnidirectional | | | |
| Polarity | | Increasing sound pressure | Increasing Output Voltage | | | |
| Startup Time | | S within 1 dB of final value, outputs AC coupled | - | - | 30 | ms |

¹Sensitivity and Supply Current are 100% tested.



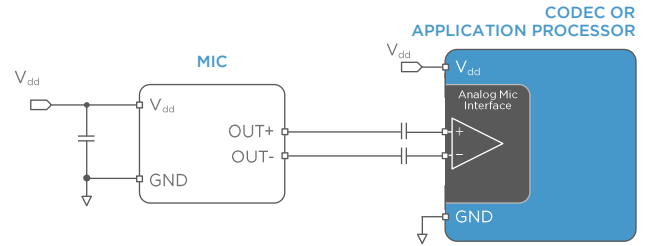
Figure 1: Typical Single-Ended Application Circuit



NOTES:

Bypass capacitors should be placed next to each Vdd pin for best performance. Capacitors near the microphone should not contain Class 2 dielectrics due to their piezoelectric effect. Follow the codec manufacturer's recommendations for circuitry and layout.

Figure 2: Typical Differential Mode Application Circuit



PERFORMANCE CURVES

Test Conditions: 23 ±2°C, 55±20% R.H., Vdd=2.75 V, no load, unless otherwise indicated

Figure 3: Typical Free Field Magnitude and Phase Response

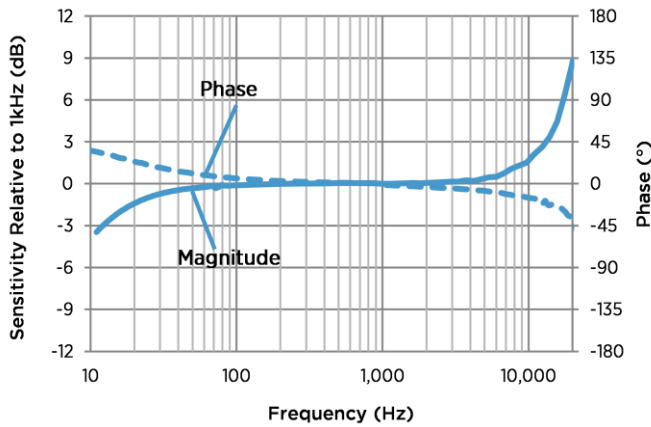


Figure 5: Typical THD vs SPL

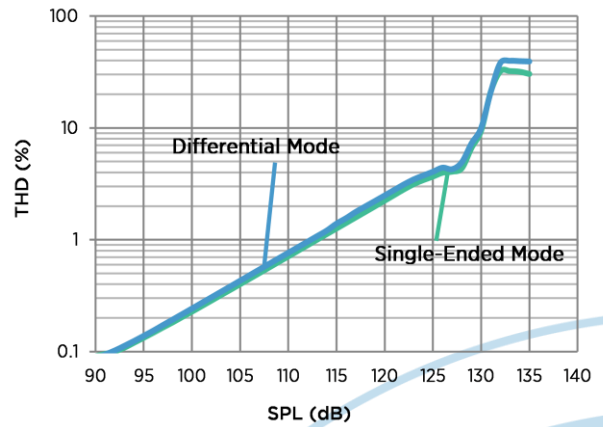


Figure 4: Typical Group Delay

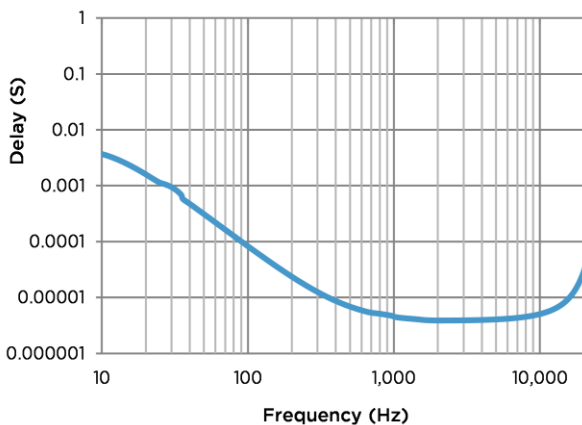


Figure 6: Typical THD vs Frequency

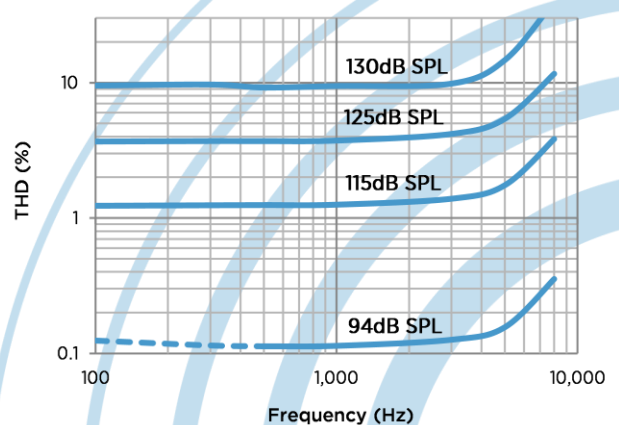


Figure 7: Typical Free Field Ultrasonic Response

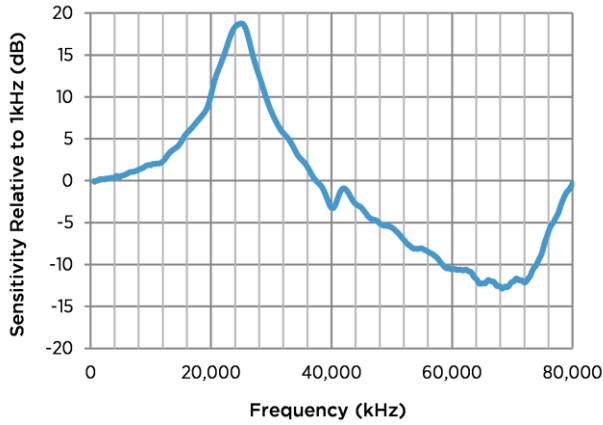


Figure 9: Noise Floor Power Spectral Density

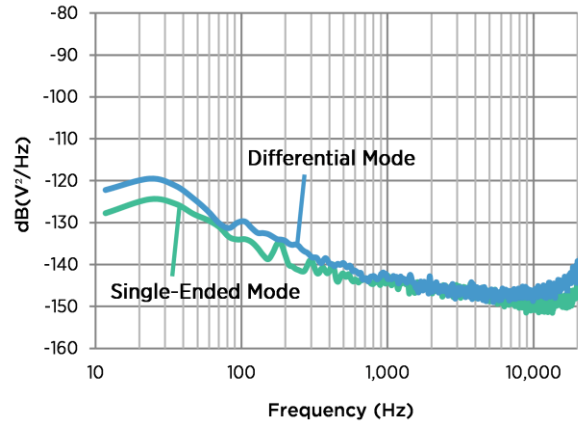


Figure 8: Typical I_{dd} vs V_{dd}

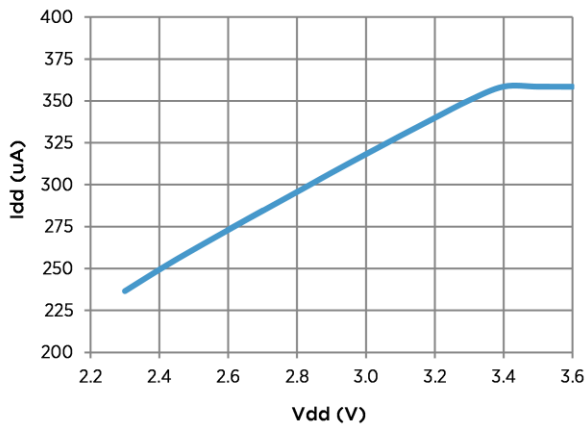
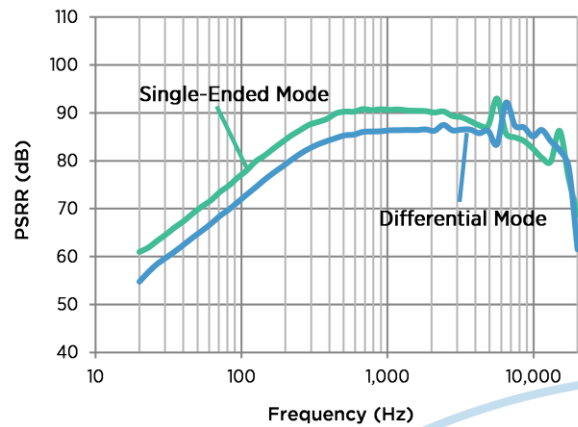
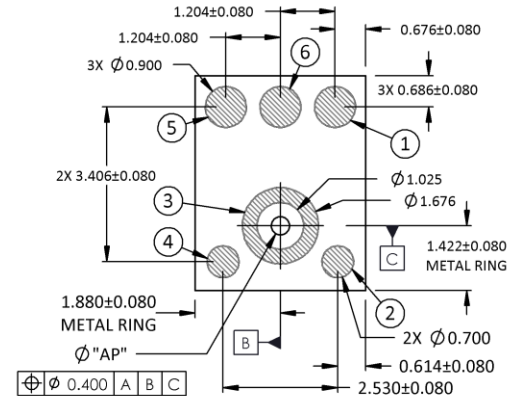
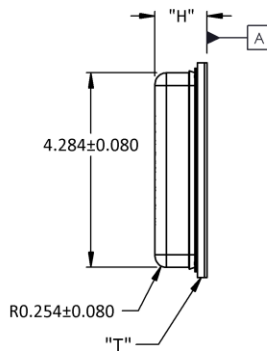
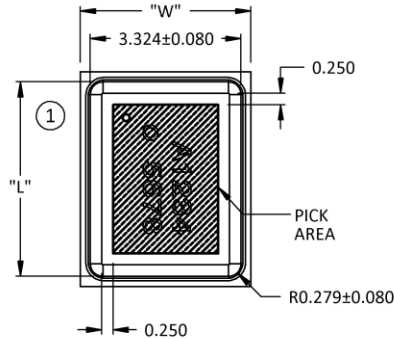


Figure 10: Typical PSRR



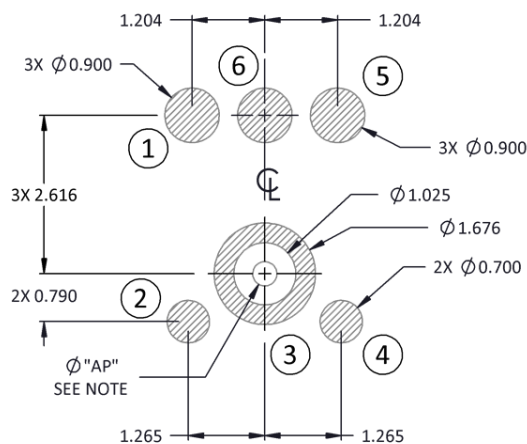
MECHANICAL SPECIFICATIONS



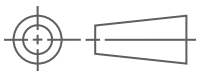
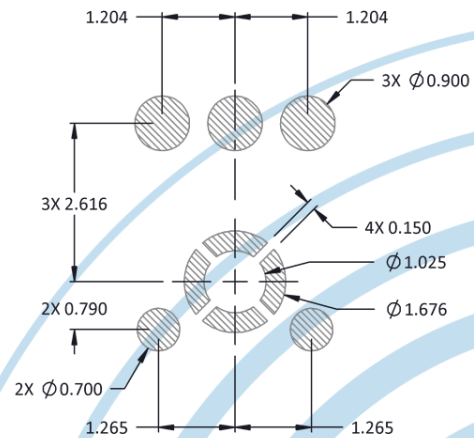
| Item | Dimension | Tolerance |
|--------------------|-----------|-----------|
| Length (L) | 4.72 | ±0.10 |
| Width (W) | 3.76 | ±0.10 |
| Height (H) | 1.15 | ±0.10 |
| Acoustic Port (AP) | Ø0.40 | ±0.05 |
| PCB Thickness (T) | 0.30 | ±0.05 |

| Pin # | Pin Name | Type | Description |
|-------|----------|--------|----------------------------|
| 1 | OUT+ | Signal | Non-Inverted Output Signal |
| 2 | GROUND | Power | Ground |
| 3 | GROUND | Power | Ground |
| 4 | GROUND | Power | Ground |
| 5 | Vdd | Power | Power Supply |
| 6 | OUT- | Signal | Inverted Output Signal |

Example Land Pattern



Example Solder Stencil Pattern

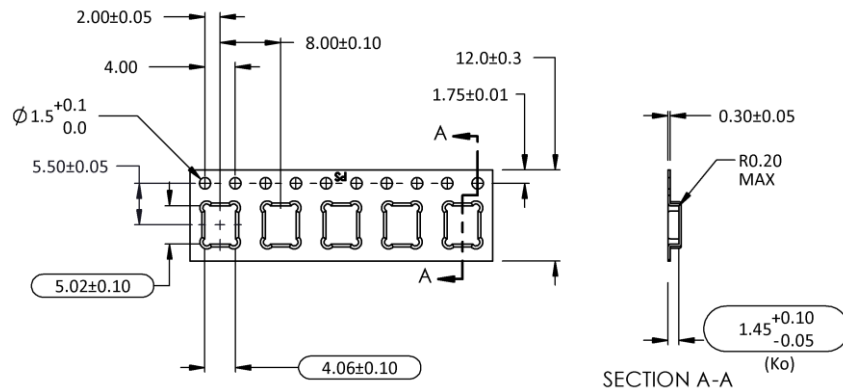


Pick Area only extends to 0.25 mm of any edge or hole unless otherwise specified.
Dimensions are in millimeters unless otherwise specified.
Tolerance is ±0.15mm unless otherwise specified.

In the acoustic path, the recommended PCB Hole Diameter is $0.7 \leq D \leq 1.0$ mm, the recommended Gasket Cavity Diameter is $D \geq 1.0$ mm and the recommended Case Hole Diameter is $1.0 \leq D \leq 1.5$ mm. Further optimizations based on application should be performed.

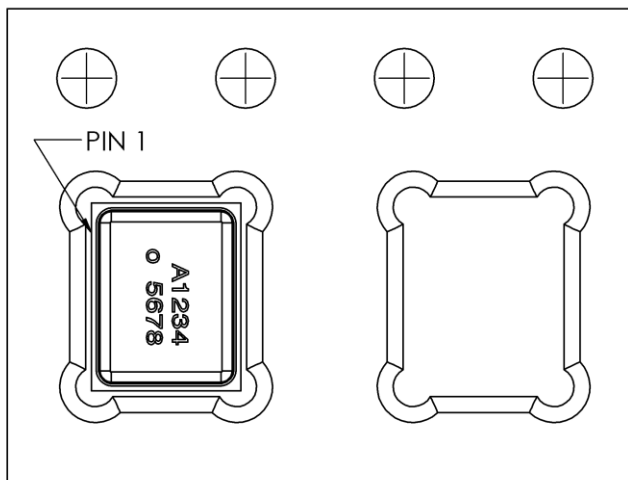


PACKAGING & MARKING DETAIL



| Model Number | Suffix | Reel Diameter | Quantity Per Reel |
|---------------|--------|---------------|-------------------|
| SPM0687LR5H-1 | -6 | 13" | 4800 |

| Component | Surface Resistance (ohms) |
|--------------|---------------------------|
| Reel | $10^5 - 10^9$ |
| Carrier Tape | $10^5 - 10^9$ |
| Cover Tape | $10^4 - 10^{10}$ |



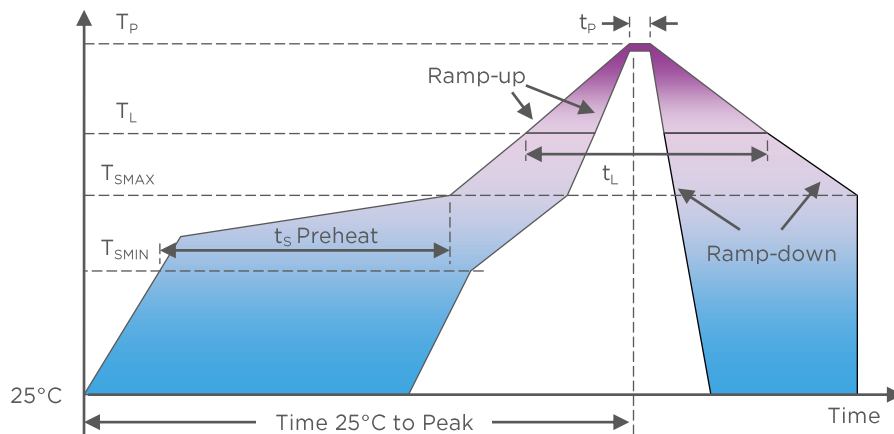
Alpha Character A:
 "S": Knowles SiSonic™ Production
 "E": Knowles Engineering Samples
 "P": Knowles Prototype Samples
 "12345678":
 Unique Job Identification Number for product traceability

NOTES:

- Dimensions are in millimeters unless otherwise specified.
- Vacuum pickup only in the pick area indicated in Mechanical Specifications.
- Tape & reel per EIA-481.
- Labels applied directly to reel and external package.
- Shelf life: Twelve (12) months when devices are stored in the factory-supplied, unopened ESD moisture sensitive bag under the maximum environmental conditions of 30°C, 70% R.H.



RECOMMENDED REFLOW PROFILE



| Profile Feature | Pb-Free |
|--|----------------------------------|
| Average Ramp-up rate ($T_{S_{MAX}}$ to T_P) | 3°C/second max. |
| Preheat <ul style="list-style-type: none"> • Temperature Min ($T_{S_{MIN}}$) • Temperature Max ($T_{S_{MAX}}$) • Time ($T_{S_{MIN}}$ to $T_{S_{MAX}}$) (t_s) | 150°C 200°C 60-180 seconds |
| Time maintained above: <ul style="list-style-type: none"> • Temperature (T_L) • Time (t_L) | 217°C 60-150 seconds |
| Peak Temperature (T_P) | 260°C |
| Time within 5°C of actual Peak Temperature (t_p) | 20-40 seconds |
| Ramp-down rate (T_P to $T_{S_{MAX}}$) | 6°C/second max |
| Time 25°C to Peak Temperature | 8 minutes max |

NOTES:

Based on IPC/JDEC J-STD-020 Revision C.

All temperatures refer to topside of the package, measured on the package body surface.

The actual reflow profile used should be optimized based on the reflow requirements of all components, board design, solder paste formulation and reflow equipment used. Details of recommended handling and manufacturing processes can be found in AN25 SMT Manufacturing Guidelines for SiSonic™ Microphones.

ADDITIONAL NOTES

- (A) MSL (moisture sensitivity level) Class 1.
- (B) Maximum of 3 reflow cycles is recommended.
- (C) In order to minimize device damage:
 - Do not board wash or clean after the reflow process.
 - Do not brush board with or without solvents after the reflow process.
 - Do not directly expose to ultrasonic processing, welding, or cleaning.
 - Do not insert any object in port hole of device at any time.
 - Do not apply over 30 psi of air pressure into the port hole.
 - Do not pull a vacuum over port hole of the microphone.
 - Do not apply a vacuum when repacking into sealed bags at a rate faster than 0.5 atm/sec.



MATERIALS STATEMENT

Meets the requirements of the European RoHS directive 2011/65/EC as amended.

Meets the requirements of the industry standard IEC 61249-2-21:2003 for halogenated substances and Knowles Green Materials Standards Policy section on Halogen-Free.

Product is Beryllium Free according to limits specified on the Knowles Hazardous Material List (HSL for Products).

Ozone depleting substances are not used in the product or the processes used to make the product, including compounds listed in Annex A, B, and C of the "Montreal Protocol on Substances That Deplete the Ozone Layer."

RELIABILITY SPECIFICATIONS

| Test | Description |
|---------------------------|--|
| Thermal Shock | 100 cycles of air-air thermal shock from -40°C to +125°C with 15 minute soaks (IEC 68-2-4) |
| High Temperature Storage | +105°C environment for 1,000 hours (IEC 68-2-2 Test Ba) |
| Low Temperature Storage | -40°C environment for 1,000 hours (IEC 68-2-1 Test Aa) |
| High Temperature Bias | +105°C environment while under bias for 1,000 hours (IEC 68-2-2 Test Ba) |
| Low Temperature Bias | -40°C environment while under bias for 1,000 hours (IEC 68-2-1 Test Aa) |
| Temperature/Humidity Bias | +85°C/85% R.H. environment while under bias for 1,000 hours (JESD22-A101A-B) |
| Vibration | 12 minutes in each X, Y, Z axis from 20 to 2,000 Hz with peak acceleration of 20 G (MIL 883E, Method 2007.2,A) |
| ESD-HBM | 3 discharges at ±2kV direct contact to I/O pins (MIL 883E, Method 3015.7) |
| ESD-LID/GND | 3 discharges at ±8kV direct contact to lid when unit is grounded (IEC 61000-4-2) |
| ESD-MM | 3 discharges at ±200V direct contact to IO pins (ESD STM5.2) |
| Reflow | 5 reflow cycles with peak temperature of +260°C |
| Mechanical Shock | 3 pulses of 10,000 G in each of the X, Y, and Z directions (IEC 68-2-27 Test Ea) |

NOTES:

Microphones meet all acoustic and electrical specifications before and after reliability testing, except sensitivity which can deviate up to 3dB.

After 3 reflow cycles, the sensitivity of the microphones shall not deviate more than 1 dB from its initial value.



SPECIFICATION REVISIONS

| Revision | Specification Changes | Date |
|----------|-------------------------------|----------|
| A | Initial Release (ECR 18-2389) | 06/06/18 |
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